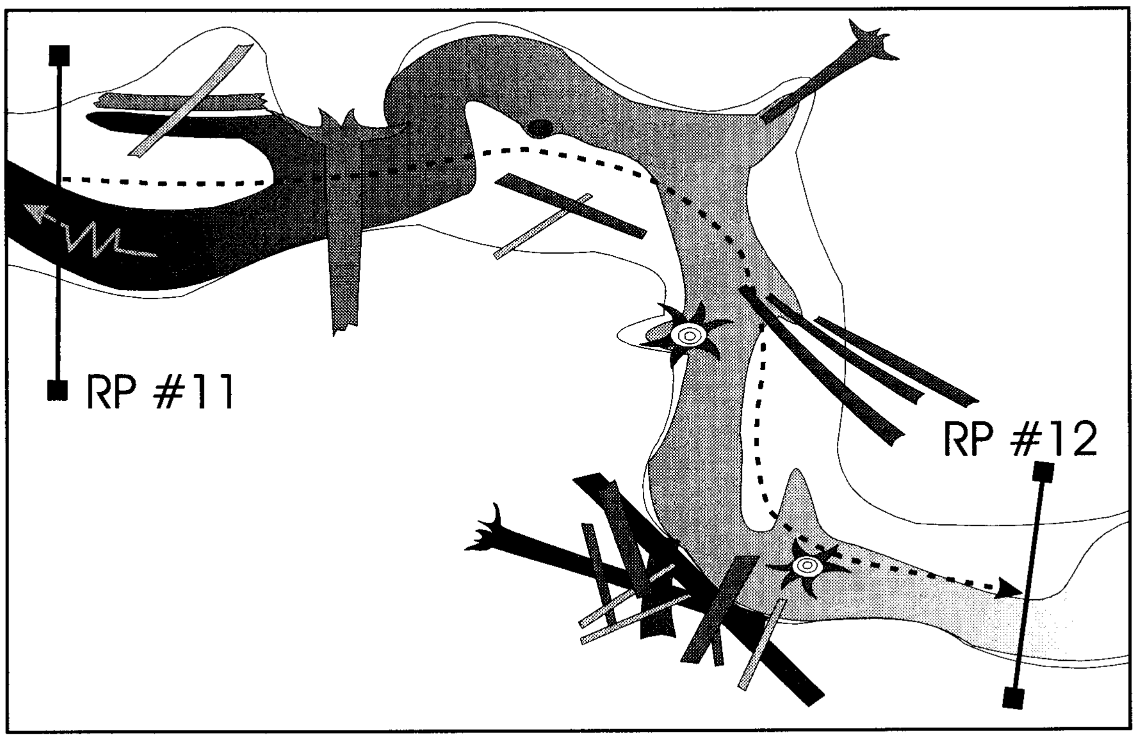
TFW-AM9-98-002

TFW Monitoring Program

METHOD MANUAL

for the

REFERENCE POINT SURVEY



by:
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NW Indian Fisheries Commission

May 1998

Timber Fish & Wildlife

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Abstract

This manual provides a standard method for establishing stable reference point sites for monitoring stream segments over time. Reference points are established at regular intervals along a previously defined stream segment and monumented to be easily relocated. Stream parameters collected during this survey include: 1) segment length; 2) bankfull width; 3) bankfull depth; 4) canopy closure; and 5) optional reference photographs. The manual is divided into pre-survey preparation, field methods, post-field documentation, and data management sections. An extensive appendix section includes a survey task checklist copy master, a materials and equipment source list, field form copy masters, examples of completed field forms, a data report example, and a glossary of terms.

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Acknowledgements

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Copying of the Method Manual

All TFW Monitoring Program method manuals are public documents. No permission is required to copy any part. The only requirement is that they be properly cited. Copies of the methods manuals are available from the TFW Monitoring Program at the Northwest Indian Fisheries Commission or from the Washington Dept. of Natural Resources.

By the end of 1999, copies will also be available through our internet site at:

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Reference Point Survey

1. Introduction

The Timber-Fish-Wildlife Monitoring Program (TFW-MP) provides standard methods for stream monitoring that reliably detect changes and trends in stream channel morphology and characteristics over time. In the TFW-MP system, the Reference Point (RP) Survey is useful as the next layer of stratification after the Stream Segment Identification Method. The RP Survey breaks stream segments into smaller units that provide a structure for attaching and relating monitoring information. This method has been approved by TFW's Cooperative Monitoring, Evaluation and Research Committee (CMER) and is accepted as a standard method for stream monitoring on forest lands in Washington state by tribal governments, state natural resource agencies, timber industries, environmental organizations, and others.

The Reference Point Survey, May 1998 version, incorporates revisions designed to help cooperators conduct the survey with greater ease, accuracy and consistency. These changes are part of the program's adaptive management process to improve the science of monitoring and respond to cooperator needs. This introduction section describes the purpose of the Reference Point Survey, reviews scientific background information, discusses the monitoring approach, and describes the services provided by the TFW Monitoring Program. Following the introduction, there are sections that include tasks and procedures involved with pre-survey preparation, field survey methods, post-survey finalization of field forms, and data management. An extensive appendix is also provided that includes a task checklist, equipment and resource information contacts, copy masters of field forms, examples of completed field forms, a glossary of terms, and a database report example.

1.1 Purpose

The purpose of the Reference Point Survey is to:

1. Establish stable locations along the segment to reference current channel features, attach information from other surveys, and provide comparisons of consistently gathered data over time.
2. Establish discrete 100 meter reaches used to characterize segment variation and allow future sub-sampling of stream segments.
3. Collect bankfull channel width/depth information.
4. Collect canopy closure information.
5. Collect reference photographs of channel conditions.

1.2 Background

This section provides information on the principles behind the use of reference points in monitoring study designs, and the influence of forest practices on the parameters gathered using this survey.

1.2.1 Use of Reference Points in Monitoring Study Designs

An important principle of monitoring is to clearly identify the sampling population to be studied (MacDonald et al., 1991). Another important principle is to be able to find the same sampling place again and again. The value of establishing stable reference points at segment boundaries and at regular intervals along the segment length is often underestimated. Segment boundaries are finite points along the stream where changes between them can be observed over time. Without stable and well-documented boundary identification, it is impossible to differentiate between changes caused by actual channel changes or due to changes in survey coverage. Reference points placed on both banks at boundaries and 100 meter intervals in a stream segment provide: 1) stable locations delineating sample reaches; 2) a statistical design for sampling; and 3) a format for analysis of baseline and trends in frequency and distribution of parameters. For use in a statistical design, reference points can be used as the basis for random, systematic, and stratified sampling between and within stream segments. Within-segment stratification of data is an important function of 100 meter interval reference points for analysis of frequency and distribution of channel indices. For example, if a segment has 500 pieces of Large Woody Debris (LWD), attaching each piece to a downstream reference point identifies if the wood is evenly distributed throughout the segment or clumped in one small area. The use of reference points allows observation of trends in distribution, migration of LWD through a system, LWD jam formation and destruction, localized land use impacts, and more. Without this structure, the range of information that can be used in data analysis is reduced to segment means.

1.2.2 Influence of Forest Practices and Natural Disturbances on Bankfull Channel Width, Depth, and Canopy Closure

The dimensions of the bankfull channel of a stream can be changed as a result of forest practices. Dunne and Leopold (1978) describes the bankfull channel as being constructed by flows that have a recurrence interval of approximately every one and one-half years. Bankfull flows provide the most effective energy that both controls the development of the floodplain and maintains the relationship of channel bed to floodplain elevation (Wolman and Miller, 1960). Summer low flows, although frequent, do not have the energy to cause significant channel changes. Larger 10-, 20-, or 50-year events often produce significant channel changes, but only occur infrequently, so their effectiveness is less than bankfull flows over time. Leopold (1994) describes the edge of the bankfull channel as the threshold mark between the channel and the floodplain or hillslope where the eroding force (shear stress) of the one and one-half year flow has been balanced by the resistance of bank composition at that point in time.

The bankfull channel width:depth ratio provides an important link between forest management activities and their impacts to stream channels. It is related to a balance of water and sediment inputs, and the resistance of the channel banks to erosion (Richards, 1982). In a watershed, the normal erosional process is for water and hillslope materials to enter and be routed through the stream channel network (WFPB, 1995a). Forest practices can affect channel morphology where inadequate harvest, road building, and road maintenance practices disrupt the balance of sediment input and removal (Sullivan et al., 1987). The stream channel often widens and decreases in depth as a morphological adjustment to increased inputs of water from higher peak flows, and coarse and fine sediments from mass wasting events and bank erosion (Schumm, 1977; Grant, 1988; MacDonald et al., 1991). Wider and shallower channels tend to have fewer and shallower pool habitat, increased summer water temperatures, decreased winter water temperatures, and reduced riparian organic inputs such as large woody debris (Madej, 1996).

Note: Analysis of Quality Assurance Review data indicates that the width:depth ratio is most sensitive to small changes in mean bankfull depth, especially on smaller channels. In one example, a 20 percent difference in ratios could be attributed to either a 0.05-meter variation in mean bankfull depth (constant mean bankfull width) or a 4.5-meter variation in mean bankfull width (constant mean bankfull depth) (Pleus, 1998 unpublished data).

Bankfull channel is a geomorphic term that describes the dimensions to which a channel is capable of containing most flows. It is the drainage system through which water, sediment and LWD inputs are actively transported and deposited. Bankfull width and bankfull depth refer to the width and average depth of the channel created by bankfull stage or flow. These dimensions are used on the segment scale to characterize the relative size of the stream channel and to calculate the mean bankfull width:depth.

Widening channels and timber harvest in riparian zones can also be identified and documented through collection of canopy closure information (MacDonald et al., 1991). Canopy closure is a measurement of riparian and topographic factors that act as blocking, reflective, and refractive structures to sunlight along the wetted primary channel at the time of the survey. A lack of canopy closure can increase water temperatures and negatively affect fish. The TFW-MP method is designed to provide segment characteristic information for canopy closure factors including leaves, branches, tree stems, and natural topographic features. The best application of this measurement is during the summer season after full deciduous vegetation leaf-out. This parameter is used as an assessment tool for identifying segments that are candidates for stream temperature monitoring, and for assessment and trend analysis of forest practices including Watershed Analysis prescription effectiveness (Sullivan et al., 1990; WFPB, 1995a; WFPB, 1995b).

The spherical densiometer (Lemmon 1956) is the standard instrument used to measure canopy closure as it provides a way to measure a wide range of canopy and other factors that influence stream temperature and riparian conditions. The densiometer is a simple instrument that uses a grid system etched on a spherical mirror which reflects canopy conditions above and to the side of the densiometer. Closure is then measured in four channel directions by counting the number of sample points within the grid system that are covered by reflected vegetative and other factors. The percentage of mean canopy closure in four directions is calculated by use of a corrective formula.

1.2.3 Use of Supplemental Reference Photographs in Monitoring Study Designs

The Reference Point Survey provides an opportune time to collect supplemental visual information to help document channel conditions tied to specific stream locations (Harrelson et al., 1994). Reference points can also provide stable stations for taking photographs that can be compared over time to supplement data analysis and presentation of survey results. Reference photographs can be used to document unique channel features found in the intervals between reference points. This can include photos of human modifications to the channel, fish passage barriers, side channel conditions, off-channel habitat, point-sources of pollution, and land use.

1.3 Monitoring Approach

The Reference Point Survey involves establishing stable monuments, called reference points (RPs), on both sides of the stream at segment boundaries and at regular intervals throughout a stream segment. These RPs are used to select sampling reaches, relocate reaches in the future, and analyze the frequency and distribution of monitoring parameters collected with other surveys. RPs also provide regular locations for collecting bankfull width, bankfull depth, and canopy closure parameters, and taking optional reference photographs.

Monitoring requires the highest level of consistency in both methods and in crew application of those methods. The RP Survey provides a rigorous approach to ensure that reference points and survey parameters collected by various cooperators are consistent and comparable. To accomplish this, the survey provides an objective method for identifying and documenting reference point locations, and for measuring channel dimensions. It also provides a systematic process for organizing this information into a manageable monitoring framework.

Stable structures for monitoring data analysis:

- monumentation of segment boundaries for observing channel trends over time;
- monumentation of reference points established at regular intervals along the channel length between the segment boundaries for locating and referencing channel features and information from other TFW-MP surveys;
- identification of interval reaches for characterizing segment variation and facilitating sub-sampling of stream segments using other surveys.

Information on segment characteristics:

- mean bankfull channel width;
- mean bankfull channel depth;
- mean canopy closure;
- optional reference photograph stations.

Information to direct other TFW-MP and Watershed Analysis (WSA) studies:

- mean bankfull channel width used as criteria for other TFW-MP surveys;
- mean bankfull channel width and depth for use in the WSA Stream Channel Assessment Module;
- mean canopy closure to identify candidate segments for using the TFW-MP Stream Temperature Survey and use in the WSA Riparian Assessment Module.

The products of this method include:

- Data on mean segment bankfull width, bankfull depth, and canopy closure;
- Information to relocate and reconstruct reference points;
- Photographs of channel conditions at each reference point.

1.4 Cooperator Services

The TFW Monitoring Program provides a comprehensive suite of services to support TFW cooperators. Services include study design assistance, pre-season training through annual workshops and on-site visits, pre-season quality assurance reviews, data entry systems, summary reports of monitoring results, and database/ data archiving services. These services are offered free of charge. To find out more about these services and the TFW Monitoring Program, contact us or visit our link on the NWIFC homepage. The address is:

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http:///www.nwifc.wa.gov

2. Office: Pre-Survey Preparation

This section provides step-by step procedures for all the tasks that must be completed for each stream segment prior to conducting the field component of the Reference Point Survey. An RP Survey task checklist is provided as a quick reference guide (Appendix A). The TFW Monitoring Stream Segment Identification Method must be completed prior to conducting a Reference Point Survey. Segment data documented on Form 1 and USGS topographic maps is required for data tracking and provides important information for identifying segment boundary locations and access points. If this has not been done, stop now and complete a Form 1 for each segment before continuing.

The core materials are the minimum required to conduct the RP Survey. Supplemental information provides increased resolution for locating segment and sub-segment boundaries and documenting unique stream features not identified on the Water Resource Inventory Area (WRIA) or topo maps. However, acquisition of supplemental information takes time, so pre-planning is essential. These materials are also useful when designing a monitoring project. This list does not cover all possible materials/equipment that can be useful for RP Survey purposes. Refer to Appendix B for equipment suppliers and supplemental resource contact information. The TFW-MP database is designed to use metric units so metric measurement equipment should be used.

Core Materials and Equipment

- Copy master of Reference Point Survey Forms 2H, 2T, and 2D (Appendix C)
- Hip-chain/distance measurement instrument
- Measurement tape (30 - 100 m)
- Measuring staff (5 - 7.5 m)
- Densiometer
- Torpedo level
- Wading gear
- Reference point tags
- Reference point tag anchors
- Hammer
- Bankfull channel anchoring pins & spring clips
- Camera & Film
- Standard field gear (Appendix D)

Supplemental Materials and Equipment

- Reference point survey equipment carrying case
- Tripod and tally counter for densiometer
- Aerial photographs in waterproof/clear case
- Timber/Landowner road or resource maps
- GPS equipment
- Water type maps
- Watershed Analysis Segment maps and reports
- Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) information
- County/City flood, water and sensitive area resource maps/information
- Survey data from other resource agencies
- Standard vehicle gear (Appendix D)

Step 1: Complete specified information on the Reference Point Survey "Header Information" Form 2H.

Use the Form 2H copy master from Appendix C to make one copy on regular white paper for office files (Figure 1). Most of the header information can be copied directly from the segment's completed Form 1. The "Study Design Information" and "Survey Summary Field Notes" sections will be covered in Section 4 of this manual. The WRIA #, unlisted trib, Segment #,

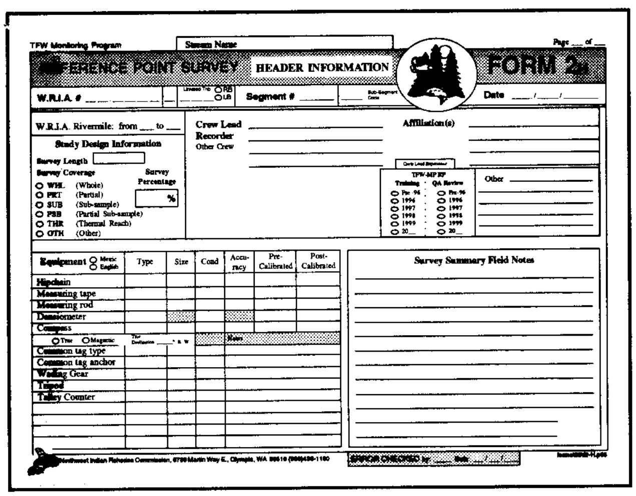


Figure 1. Reference Point Survey Form 2H.

Sub-Segment Code, and Date are key fields used to identify unique monitoring segments for the TFW-MP database, so they must be filled in on every form copy used. Refer to Appendix E for examples of completed field forms. NOTE: Any changes in crew lead, recorder, or equipment requires documentation of that specific information on another copy of Form 2H.

WRIA #: Record the six digit Water Resource Inventory Area (WRIA) number (00.0000) and code letter if applicable.

Unlisted Trib: Record the three digit cooperator-designated unlisted trib number (001 - 999) and mark the appropriate RB/LB circle (leave blank otherwise).

Segment #: Record the one to three digit segment number (1 - 999).

Sub-Segment Code: Record the one or two letter character sub-segment code (a - z; aa - zz).

Date: Enter the date the form is being filled-out. The date documents the time line of this portion of your monitoring plan. It also is a reference to the manual version used to survey the stream.

Stream Name: Record the WRIA-designated stream name. Use "Unnamed" where appropriate.

WRIA River Mile: (Also called stream mile on some map legends - This may be diffenent from Form 1 information.) Record the WRIA river mile locations of the lower and upper survey boundaries to the nearest tenth of a mile (0.0 - 9999.9). One or both of these locations may be different from the lower and upper segment boundary river miles if only conducting a partial survey.

Crew Lead: Record the first and last name of the lead crew person who is responsible for crew decision-making and the collection of quality data.

Recorder: Record the first and last name of the crew who is responsible for recording the data and maintenance of quality documentation.

Other Crew: Record the first and last name(s) of any other crew persons assisting in conducting the RP Survey.

Affiliation(s): Record the employment affiliation of each crew member on the line immediately to the right of their name. This can be a tribe, government agency, industry, environmental group, consulting company, etc.

Crew Lead Experience: Mark the appropriate circle(s) corresponding to the year(s) the lead crew person received official TFW Monitoring Program on-site or annual workshop Reference Point Survey training or a QA Review. Note any other relevant training or field experience.

Equipment: As equipment is selected for conducting the Reference Point Survey, document the equipment type, size, condition, manufacturer's accuracy and pre-survey calibration dates as indicated. Mark the appropriate circle corresponding to whether equipment measurements will be made in metric or English units. Document whether using true or magnetic compass readings. If using true, record the magnetic declination in degrees. Document the common tag and tag anchor types and sizes (e.g., alum./3/4" x 1"; alum. nail/16d). Document the type of wading gear used (wet/knee/hip/chest/dry/swim/etc.). Document whether a tripod and/or tally counter were used for canopy closure. Document any other measurement equipment used during the survey.

Step 2: Complete header information and make copies of the Reference Point Survey "Triangulation Documentation" Form 2T.

Use the Form 2T copy master from Appendix C to make one copy on regular white paper for office files (Figure 2). Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code* as documented on Form 2H. Record the initials of the crew lead and recorder in the spaces provided in the upper right hand corner. Mark the appropriate circle to identify that the measurements on the form are in meters or feet. Leave the "*Page __ of __*" and "*Date*" fields blank and record this information as the sheet is used in the field during the survey.

Use this copy to make multiple field copies onto waterproof paper such as "Rite in the Rain" brand. Copies can be made single-sided or duplex. The number of copies depends on whether only the lower and upper segment boundary reference points will be documented or if some/all 100 meter reference points will be docu-

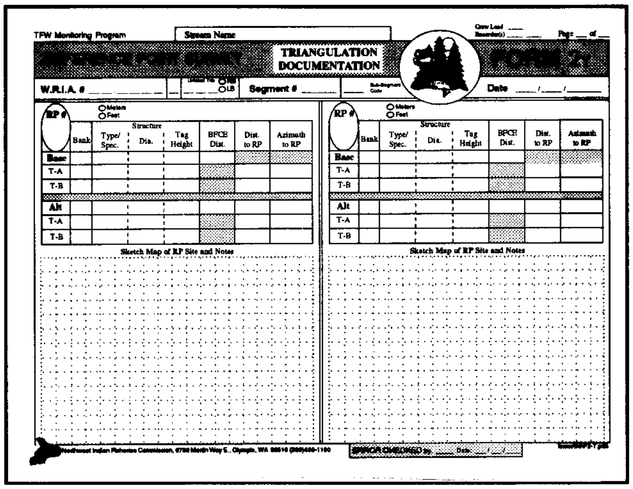

TFW Monitoring Program
Stream Name
TRIANGULATION DOCUMENTATION
W.R.I.A. #
Segment #
Date
Sketch Map of RP Site and Notes

Figure 2. Reference Point Survey Form 2T.

mented as well. This process eliminates the need to fill out all header information on each form.

Step 3: Complete header information and make copies of the Reference Point Survey "Field Data" Form 2D.

Use the Form 2D copy master from Appendix C to make one copy on regular white paper for office files (Figure 3). Record the *Stream Name/W.R.I.A. #/Unlisted Trib/Segment #/Sub-Segment Code* as documented on Form 2H. Record the first and last name initials of the crew lead and recorder in the spaces provided in the upper right hand corner. Mark the appropriate circle to identify that the measurements on the form are in meters or feet. Leave the *"Page __ of __"* and *"Date"* fields blank as they must be recorded as the sheet is used in the field during the survey.

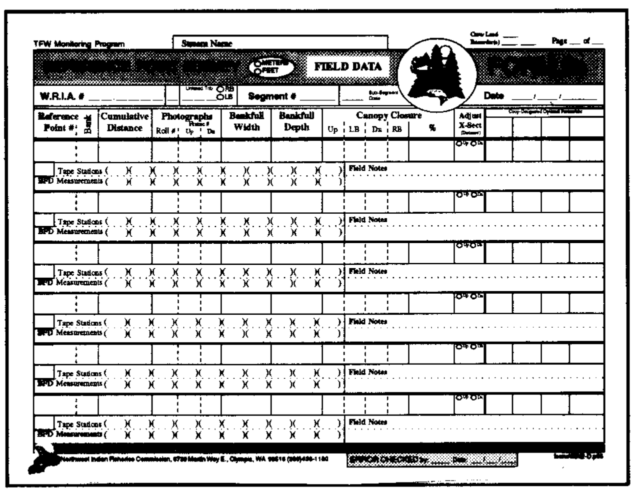

TFW Monitoring Program
Stream Name
FIELD DATA
W.R.I.A. #
Segment #
Date
Reference Point # | Cumulative Distance | Photographs | Bankfull Width | Bankfull Depth | Canopy Closure
Tape Stations
BFD Measurements
Field Notes

Figure 3. Reference Point Survey Form 2D.

Use this copy to make MULTIPLE field copies onto waterproof paper such as "Rite in the Rain" brand. Copies can be made single-sided or duplex. The number of copies depends on the actual or estimated survey length. This process eliminates the need to fill out all header information on each form.

Step 4: Select field survey equipment appropriate for local stream and site conditions.

The use of metric measurement equipment complies with standard scientific methods. The cost of purchasing metric equipment is often offset by savings in personnel time and effort required to convert from English to Metric units, and results in the highest quality data due to avoidance of errors during conversion of large data sets. Mixing unit types within a survey is strongly discouraged due to potential for multiple conversion errors. All measurements must be converted to metric units before entry into the TFW-MP database.

Hip-chain Options: Minimum measurement accuracy is ± 0.5 meters. Hip-chain instruments are the most commonly used equipment to measure channel length distances. All measure distances by tying line to a starting point and walking in the direction of measurement and reading off a mechanical tally counter. TFW-MP recommends using 100 percent degradable line and always picking up used line in the field. Other distance measurement options in order of accuracy and dependability are fiberglass tapes, electronic distance measurers, and optical range finders.

Measurement Tape Options: Minimum measurement accuracy is ± 0.1 meters. Fiberglass tapes are the best equipment for accurate and consistent bankfull width measurements and establishing bankfull depth cross sections. These tapes have the strength to make a taut cross section with minimum sag and flexibility for wrapping and tying-off on tape anchors. The most common lengths are in 30 and 50 meters. A backup fiberglass tape is recommended as it can function for all length measurement needs in case of other equipment failure. Other options are surveyor's rope/utility tape and steel tapes.

Measurement Staff Options: Minimum measurement accuracy is ± 0.01 meters. Telescoping fiberglass leveling rods (stadia rods) are the best equipment for accurate and consistent bankfull depth measurements. This is because they are accurate, durable, lightweight, and easily leveled plumb (vertically) even in flowing water. The most common lengths are in 5 and 7.5 meters. Other options are engineer's leveling rods and homemade wooden or PVC measurement rods.

Fiberglass Tape Anchoring Equipment Options: (four to six anchors total) The ability to securely anchor the cross-section tape is fundamental to accurate and consistent bankfull width and depth measurements. The most common and versatile type are surveyor chaining pins (Figure 4). Also called steel arrows, they are made out of hardened round steel, painted red and white, lightweight, durable, easy to tie to, and provide good anchoring in a variety of bank conditions. Heavy-duty plastic survey stakes (16"-18") are most useful in sandy banks. Two 3-inch spring clips commonly available in hardware stores are useful for securing the tape around anchoring pins without damaging them by tying. Other anchoring options are wooden stakes or sticks.

Spherical Densiometer Options: Canopy closure measurements can be taken using either a convex (Model A) or concave (Model C) spherical densiometer. The choice of densiometer model is based on personal preference and availability. However, the optics of Model C produces a smaller hemispherical view sample than Model A when used at similar distances below and in front of the sighting eye. In one test, the view between the front and back endpoints along the grid centerline differed by more than 10 degrees. Once selected, the model type must be consistently applied over the entire monitoring study for best consistency between observers and for detecting actual changes in channel condition. The variability associated with both densiometer models is currently being researched by TFW-MP.

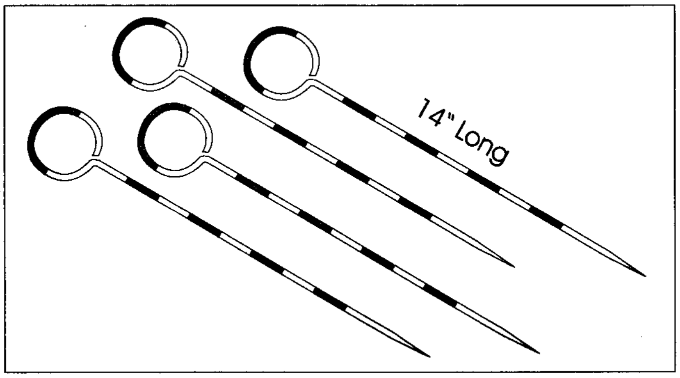


Figure 4. Surveyor chaining pins.

TFW-MP recommends using the following three techniques to reduce variability associated with the spherical densiometer:

- using an adjustable tripod for leveling stability and maintaining a set instrument height above the water surface (Figure 5);
- carefully placing four "equi-spaced" dots in each grid square with permanent marker (Figure 6); and
- using an inexpensive tally counter for counting dots.

Camera and Film Options: Choose a 35 mm or digital camera that is water/dust-proof or resistant. Ideal lens focal lengths are from 28 to 50 mm. Focal lengths less than 28 mm will cause significant distortion of the image. Color film with an EI/ASA of 200 to 400 is recommended for stream conditions as they have the greatest ability to capture details in shadows and sunlight conditions. Use of a tripod can dramatically enhance the quality of the pictures, especially in low light conditions. Color slide film has been generally used to document field studies. Color prints can be more easily

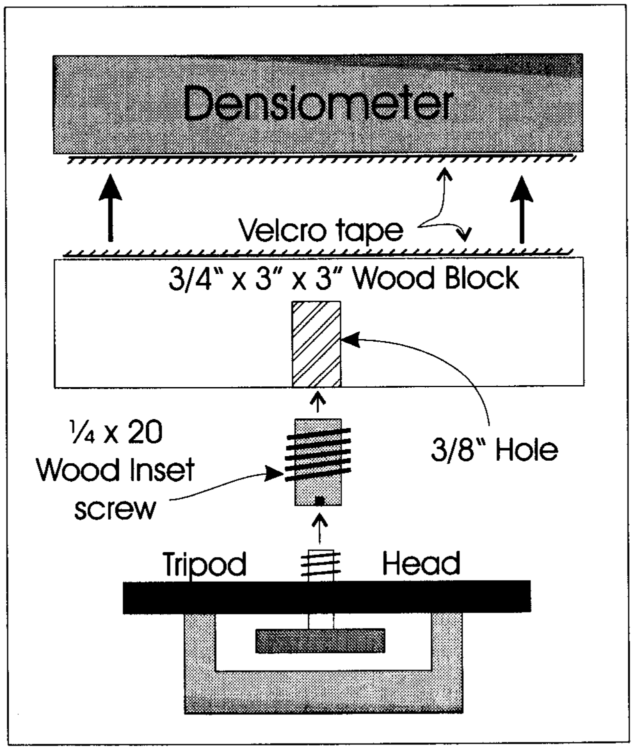


Figure 5. Skematic diagram of a tripod mount adaptor for the spherical densiometer

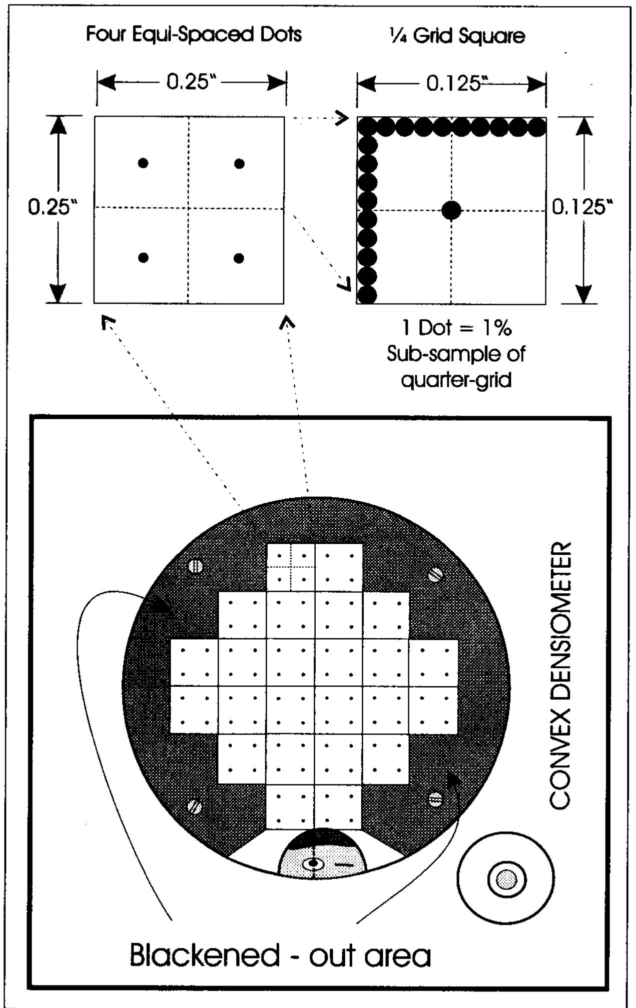


Figure 6. Placement and size of "equi-spaced" dots and shading modifications for the spherical densiometer.

ditions. Color slide film has been generally used to document field studies. Color prints can be more easily scanned into computers for inclusion in reports. Record camera, lens, and film type on Form 2H.

Wading Gear Options: Select wading gear to accommodate stream and survey conditions. On most streams, having one crew with chest waders is important for access to, and taking measurements along the deeper parts of the channels. Having only knee or hip boots for a larger stream can result in under-estimation of bankfull channel dimensions and biasing canopy closure. However, it is important to note that use of chest waders in fast flowing streams can be dangerous. Also consider future repeatability of each option. For example, wading wet or swimming may be acceptable to crews one year, but may not be an option the next time.

Step 5: Check all measurement equipment for damage and calibrate to document accuracy.

TFW-MP recommends that all measurement equipment is calibrated to a known accurate standard both pre- and post-survey to meet quality assurance plan monitoring requirements.

Step 6: Select reference point tag and tag anchoring materials and equipment.

Landowners should be consulted on which type of anchors and tags are acceptable for reference points (RP). Having a good knowledge of the types available and safety measures to reduce landowner concerns will go a long way toward maintaining good relations and establishing durable reference points.

RP Tag Options: There are a variety of styles and materials that can be used for reference point tags. The most effective and durable tags are those where the information can be embossed into the material rather than written upon. Tags made of thin aluminum are the most common and easiest to use and can be embossed with a standard pencil. They vary in size from 3/4" x 3" up to 3" x 5" with some types permitting writing on both sides. Thick aluminum tags (round or "racetrack-shaped") can be purchased pre-numbered or blank. The thick aluminum tags are difficult to mark effectively in the field and most information is lost after a couple years through surface oxidation. Plastic tags are durable and do not have the surface oxidation problem of the thick aluminum tags, but most inks and paint will fade or deteriorate quickly. Cloth tags are easy to mark with permanent pen, but they will biodegrade quickly. For long-term projects, it may be worthwhile to invest in pre-manufactured and printed metal or plastic tags and plates that include a project description and contact numbers.

Most of the thin aluminum tags are supplied with wire ties for attachment to existing structures or anchors such as nails. Nylon locking electrical ties are also effective, versatile and come in a variety of styles, sizes and colors. In both cases, a combination pliers/wire cutter may be required for securing tags to anchors.

RP Tag Anchor Options: Tags must be securely attached to a stable object. Commonly used objects for anchoring tags includes trees, bridges, bedrock walls, and stakes driven into the ground. The most commonly used anchors in forested areas are aluminum nails and eyed lag screws. In bedrock or canyon areas, masonry or cement nails are often effective alternatives. Rebar rods and stakes are used as both the anchor and reference point structure where stable structures are not available. Work with the landowner to discuss options.

- Nails - If there is a large, sturdy tree at the proper location, attaching the tag with a nail is the easiest option. Aluminum nails can be purchased at most hardware stores or ordered through suppliers of forestry products. Aluminum nails are the safest anchor as they do not cause problems if they are accidentally hit by a chain saw or during milling processes. Use 16d size nails if possible and leave at least 2 inches of nail exposed to allow for tree growth, especially on rapid growth species such as alder. Fasten the tags to the nails using wire or nylon ties rather than by driving the nail through a tag. Masonry and cement nails can be used as tag anchors for bedrock canyon walls, bridge abutments, and where the other techniques are not possible. This generally requires a heavier hammer and use of goggles to protect the eyes.

- Eyed Lag Screws - Galvanized 5- to 6-inch eyed lag screws are recommended for monitoring projects that are expected to last more than two years. The advantage to this type of anchor is that they are easy to see and can be unscrewed over successive years to accommodate for tree growth.

- Rebar and stakes - Rebar rods, plastic and wooden stakes make good reference point anchors when there are no trees in the proper location, or where there are concerns about nailing tags in trees. Rods and stakes should be at least 24 inches long to be 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. Place flagging on nearby branches to make it easier to find the rods in the future. The danger of using rebar and stakes is that they can be hazardous to equipment, livestock and humans if run over, fallen on, stepped on, or tripped over. They are also more difficult to relocate during subsequent surveys and should be triangulated using the method to be described in Section 3 for proper documentation. Safety caps for rods and stakes can be made from PVC pipe and "T" fittings painted a bright color and then fastened by wiring, glueing or nailing. Another visual safety attachment is surveyor's stake chaser flags that can be nailed or wired on.

EXAMPLE
Creativity may be required in some situations to meet a landowner's aesthetic needs while providing a durable reference point that will be easy to relocate for many years. One option might be purchasing or constructing low cost wood duck, bird, or bat houses to which a reference point tag can be adhered. This provides wildlife enhancement and a structure that most people will not vandalize or complain about. Depending on your budget, two can be placed at each segment boundary or 100 meter reference point location.

Step 7: Gather, arrange, and organize stream site access information.

Select and document stream access points. Obtain directions and maps. Contact landowners and secure permission to access property. Acquire necessary permits and passes. Determine if the access roads are gated and get gate keys or make necessary arrangements with landowner to open access. Determine the type of vehicle and safety gear required.

3. Reference Point Survey Method

This section provides procedures and examples for conducting the RP Survey and describes how to document additional information on segment characteristics. It is organized in a sequential format to facilitate accurate and consistent application of the methods. This section can be copied for crews to take out into the field for referencing specific procedures. Forms 2T and 2D have been designed to record, organize, and track the information gathered using these methods.

The section is divided into two parts. The first part covers establishment and documentation of reference points, and the second part covers data collection at reference points. The RP Survey procedure will be explained as if a crew were conducting the survey for the first time on one stream segment within a watershed. A stream segment for TFW-MP purposes is identified as having one unique WRIA reference and segment or sub-segment number. This procedure can be applied on a watershed level by systematically following the same methods segment by segment.

Good documentation of this survey produces valuable information about the entire stream system that is important for analysis and guiding future surveys. Familiarity with and interpretation of USGS topographic maps is a valuable skill and can significantly improve segment boundary identification and documentation accuracy. Refer to Appendix B for map interpretation resources.

3.1 Establish and Document Reference Points

TFW-MP recommends that two reference point tags (Base and Alternate) be placed at each segment boundary and 100 meter interval. Monitoring strategies using this system are considered to have a quality assurance plan that provides the highest level of consistency for data comparison and for accurate reconstruction or relocation of lost reference points.

The criteria for placement of reference points are:

- *Lower and Upper Boundaries:* at or as close as possible to channel breaks based on tributary junctions, non-fluvial features, and/or changes in channel gradient and confinement categories;
- *100 Meter Intervals:* at 100 meter intervals as measured along the center of the bankfull channel;
- at a 90 degree angle to the centerline of the bankfull channel;
- where markers are least likely to be lost and if lost, most easily reconstructed; and
- *100 Meter Intervals & Upper Boundary:* using a 50 meter minimum and 149 meter maximum interval distance criteria.

Steps 1 through 7 provide the procedures to establish and document reference points at segment boundaries and 100 meter intervals. Step 1 is divided into lower boundary, 100 meter interval, and upper boundary instructions. Steps 2 through 5 and 7 use the same procedures regardless of reference point location. Step 6 is optional for 100 meter interval reference points. After completion of this section, conduct the bankfull channel data collection as described in Section 3.2. The format is to work back and forth between Sections 3.1 and 3.2 at each successive reference point location until the upper boundary of the segment has been surveyed.

Step 1: *Lower Boundary:* Identify and mark lower boundary location.

To begin establishing reference points, first locate the lower boundary of the stream segment or sub-segment. This is accomplished by locating the upper segment boundary reference point of a previously surveyed segment or by using the maps and descriptions produced during Stream Segment Identification. If segment boundaries have not been field verified, review the Stream Segment Identification Method section on field verification. Place a weighted flag to identify the boundary point along the centerline of the bankfull channel. [Skip the rest of Step 1 and go to Step 2]

- *100 Meter Interval:* Identify and mark the next sequential 100 meter interval reference point location.

Once a reference point has been established and channel cross section information collected, begin the process of locating the next sequential reference point. If at the lower boundary, zero-out the hip-chain counter, pull out a length of string and secure the zero-point of the hip-chain line to an existing or placed object in the center of the bankfull channel. Walk up the center of the bankfull channel and anchor the hip-chain line to objects so that line distance corresponds to the relative curvature of the meander bends. This method does not consistently follow the thalweg or wetted portion of the channel. Crew safety always has priority over accuracy. When the counter reaches 100 meters, mark this point along the center of the channel with a weighted or wire flag. [Skip the rest of Step 1 and go to Step 2]

- *Upper Boundary:* Identify and mark the upper boundary location.

This is accomplished by locating the lower segment boundary reference point of a previously surveyed segment or by using segment information produced from the Stream Segment Identification Method. Place a weighted flag to identify the boundary point along the centerline of the bankfull channel. The distance between the last 100 meter interval and the upper segment boundary must be 50 meters or greater. In situations where the distance is less than 50 meters, move the last reference point up to the segment boundary (maximum 149 meter distance). Record the next sequential reference point number and the cumulative distance (in meters) from the last reference point to the upper boundary. This number should reflect the total length of the segment.

Step 2: Identify and flag the reference point cross section at a 90 degree orientation to the channel centerline.

Use an extended stadia rod or other straight pole held in front of the body and perpendicular to the direction of movement. Start 5- to 10-meters below the boundary or 100 meter interval reference point marker and walk upstream along the center of the bankfull channel (Figure 7). When the stadia rod crosses the centerline flag, stop and use the rod as a sighting tool to identify and mark a cross section point on one bank. Repeat this process by starting above the centerline marker and walking downstream and mark the cross-section point on the same bank if different from the first. If the difference is large, repeat the entire process. Use the midpoint between the two for the centerline placement point if the differences can not be resolved. A line drawn from the bank marker through the centerline point forms the basis of a cross section that is oriented at a 90 degree angle to the channel centerline.

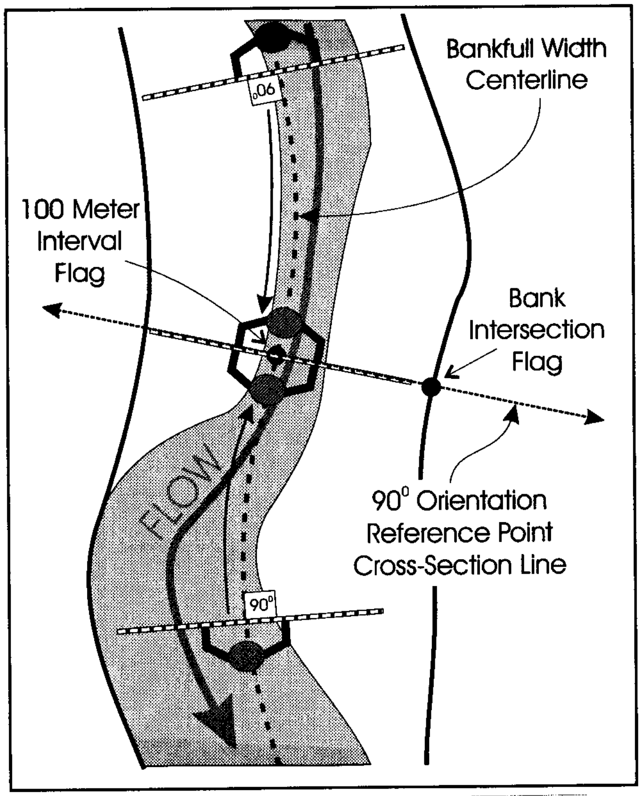


Figure 7. Identifying the reference point cross section at a 90 degree orientation to the channel centerline.

Re-creation of the cross section using original reference point information: Reconstructing a 90 degree channel cross section is simple and accurate in situations where the original crew placed reference points on both banks at each reference point. A line intersecting both tags provides clear placement information. Reconstructing the cross section in situations where reference points were placed on only one bank requires the techniques described in Section 3.1, Step 3: "Identify and flag the RP cross section at a 90 degree orientation to the channel centerline."

Step 3: Identify and flag the "Base" reference point structure.

Determine which side of the channel is most likely to remain stable over time. In situations where there is some flexibility in reference point location, look for stable structures at a distance from the channel

(3 meters) to help minimize the potential loss by floods or bank erosion over time, but that can also be easily seen from the channel. Live, firmly rooted, and mature trees are the preferred reference point structures. Where landowners allow, rebar or other type stakes can also be used as reference point structures. The reference point placed on this bank will be designated as the "Base."

Step 4: Identify and flag the "Alternate" reference point structure.

Using the Base RP and the centerline flag, project the cross-section line onto the opposite bank to identify the location of the "Alternate" RP. Again, look for stable structures back from the edge of the bankfull channel (three meters) to help minimize the potential loss by floods or bank erosion over time, but that can also be easily seen from the channel.

Step 5: Attach reference point tags and document locations on Form 2T.

Tags are placed one meter or more above the ground so that they can be easily relocated when viewed from the channel. If establishing reference points during the winter or spring, choose places where the leaves of brush and small trees will not hide the tags during the summer.

Minimum information recommended on each Base RP tag includes: tag affiliation; segment or sub-segment number; month/year; and reference point number. Minimum information on each Alternate reference point tags include the word "Alt" and the reference point number. Side channels that have not been sub-segmented require reference tags that are labled with the word "Side/Base" and "Side/Alt" with the RP number that corresponds to the main channel number.

Reference points are laid out and numbered sequentially (0, 1, 2, 3, ...) beginning at the lower boundary of each segment or sub-segment working upstream to the upper boundary (Figure 8). In most situations, the reference point at the lower segment boundary is assigned the number "0." In situations where the Reference Point Survey is conducted on two adjacent segments, the base reference points at the end of one segment and the beginning of another will have two reference point tags with two sets of information. One will correspond to

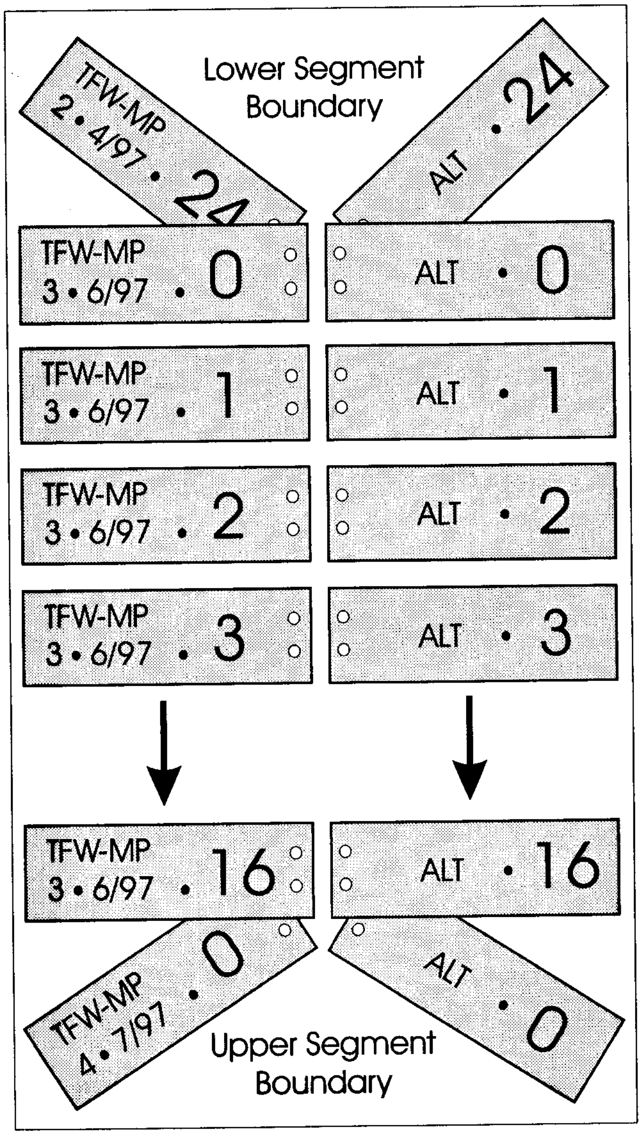
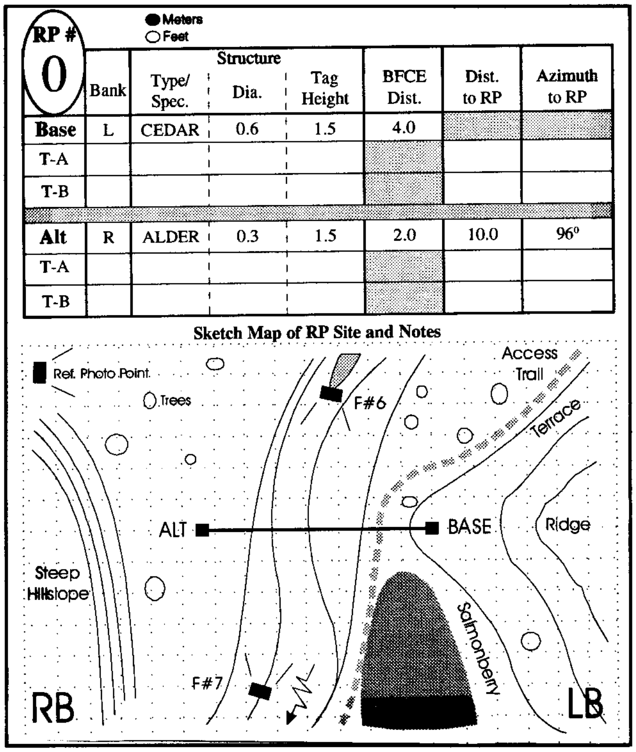


Figure 8. Tag marking technique and sequential numbering for the main channel of "Segment 3".

the end of the numbering sequence for the downstream segment, the other will correspond to the starting number ("0") for the upstream segment.

On Form 2T, record the date the information is being collected and the RP number in one of the documentation boxes. Identify which bank the Base RP is located on as "R" (right bank) or "L" (left bank). Bank orientation is determined facing downstream. Record the following information: RP structure type (e.g., rebar, alder, cedar, or deciduous/conifer), estimate the diameter of structure (e.g., 1/2" or 0.30 m); tag height above the ground; and distance to the bankfull channel edge (BFCE). Repeat the same process and record the information about the Alternate RP. In addition, take a compass azimuth back to the Base RP.

Make a rough sketch map of the reference point area including the locations of Base and Alternate structures, and channel banks. Identify any unique features of the channel, reference point structures, and adjacent land forms (Figure 9). The sketch map box should provide the minimum information that a person unfamiliar to the site would require to relocate the reference point five to 10 years after the survey.



	Bank	Structure Type/Spec.	Structure Dia.	Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base	L	CEDAR	0.6	1.5	4.0		
T-A							
T-B							
Alt	R	ALDER	0.3	1.5	2.0	10.0	96°
T-A							
T-B							

Figure 9. Detail from Form 2T showing Base and Alternate RP documentation at "RP 0."

If the same or another crew will be coming back later to conduct an additional survey, place temporary flagging with the reference point number written on it and placed at the channel edge to save time in relocating reference points. Always remove temporary flagging by the end of the season.

Step 6: Triangulate and document reference point locations on Form 2T.

This step is required for lower and upper segment boundary reference points, but optional at the 100 meter interval level. Triangulation of Base and Alternate RP locations ensures that reference points can be accurately reconstructed if one or both reference point tags or structures are lost over time. Documentation of RP sites minimizes the time required to relocate them in remote or densely vegetated areas. This also ensures that accurate and consistently repeatable survey information is collected over time for monitoring purposes.

At the Base reference point, anchor the zero end of a fiberglass tape on the nail holding the RP tag and walk 5 to 30 meters further off-channel to another stable and easily identified reference point structure. Having at least one of the triangulation points outside of the floodplain is optimal, but make sure it is not in an area likely to be harvested or disturbed. Mark and tag the structure with the letters T-A for "triangulation point - A."

Record the following triangulation point information on Form 2T: stream bank; RP structure type or identify the tree species if known or at least whether it is deciduous or conifer, estimate the diameter of structure; tag height above the ground; distance to Base RP; and compass azimuth to the Base RP (Figure 10). Repeat this procedure at a different angle from the Base reference point and call this one "T-B." In situations where confidence in Base RP stability is low, triangulate and document the location of the Alternate RP on the opposite bank using the same format. Add the triangulation point information to the sketch map of the reference point area.

Step 7: Record the "Reference Point #," "Bank," and "Cumulative Distance" info on Form 2D.

The reference point number corresponds to the tag number and is generally a "0" for the lower segment boundary. There are three choices for bank: right bank (R), left bank (L), and both banks (B). If only one reference point tag was place on one bank, record either an "R" or an "L." If reference point tags were placed on both sides of the channel, record a "B" in that data column. Cumulative distance for the lower segment boundary is always "0" meters.

RP # 0

● Meters
○ Feet

RP # 0	Bank	Structure Type/ Spec.	Structure Dia.	Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base	L	CEDAR	0.6	1.5	4.0		
T-A	L	D-Fir Stump	0.3	0.5		12.0	318°
T-B	L	ALDER	0.4	1.0		9.0	212°
Alt	R	ALDER	0.3	1.5	2.0	10.0	96°
T-A	R	ALDER	0.2	1.0		4.0	68°
T-B	R	ALDER	0.4	0.5		6.0	134°

Sketch Map of RP Site and Notes

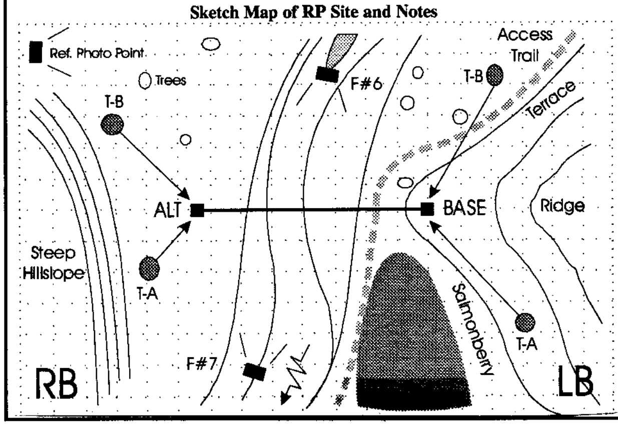


Figure 10. Detail from Form 2T showing triangulation documentation of "RP 0."

Record the next sequential reference point number and the cumulative distance (in meters) from the lower boundary to the next 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 exactly 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. at 294 meters; RP # 4 cum. dist. at 400 meters).

Box Note: Remove hip-chain line from the channel after a survey is completed and dispose of properly. Hip-chain line that is left in the channel after surveys has been documented by many biologists to trap and kill animals and birds up to the size of an owl. Even "biodegradable" line takes over a year to become safe.

Difficult Reference Point Situations

Tributary junctions: When segment boundaries occur at tributary junctions in larger streams, it is often difficult to determine the appropriate boundary location due to overlapping bankfull channel areas. In these situations, walk up the center of the bankfull channel and mark the 90 degree cross section line which intersects the junction of the main bankfull channel and the upper side of the tributary bankfull channel. This junction incorporates the effects of winter bankfull forces on the main channel. The Base reference point is located on the opposite bank from the tributary junction along the cross section line. If possible, mark and tag the Alternate reference point, although it is not expected to last for more than one season.

Lack of reference point structures: In situations where reference point structures are not available at the designated segment boundary and placement of rebar or other structures is not an option, a temporary reference point is established and triangulated back to stable structures. This technique can be useful for estuaries, stream mouths, grassy flats and other similar areas.

Follow the procedure for identifying and marking the 90 degree cross section line which intersects the junction of the main bankfull channel and the upper side of the tributary bankfull channel. Locate the Base reference point on the opposite side of the tributary junction and three meters from the bankfull edge. Then follow the procedure for triangulating to the nearest stable structures and taking a compass azimuth to the Alternate reference point. Flag the boundary and remove the temporary Base. If possible, mark and tag the bankfull channel junction with an Alternate reference point, although it is not expected to last for more than one season. Subsequent surveys will require re-establishment of the temporary Base if the Alternate reference point is lost.

Bank anomalies, obstructions, and unsafe areas: Minor adjustments to the location of a segment boundary or 100 meter interval reference point are allowed in situations where significant bank anomalies or obstructions prevent accurate or reproducible placement. For example, large woody debris jams, bedrock canyons and unstable slopes can create measurement obstructions or conditions that are hazardous to field crews. These locations require creativity using the techniques listed above and sometimes avoidance. If a 100 meter interval fell on a road over a culvert, the reference point would generally be placed at the upstream or inlet side unless distance and stability of available reference point structures is a factor. In situations where safety concerns prohibit boundary placement, the project manager should consider whether sub-segments are an acceptable alternative to the monitoring strategy before dropping the segment from the study altogether.

Side channels: Side channels found within a larger segment (not distinct sub-segments) must be separated from the main channel by an island and require RP tags that correspond to adjacent main channel information. An island is defined as meeting the following criteria: 1) the length of the landform above the bankfull channel must be equal to or greater than twice the estimated bankfull width; and 2) more than one individual perennial vegetation that is greater than 2 meters in height.

In many situations, the main channel's RP cross section line of sight can be used as a guide for locating corresponding side channel reference points. One crew stands in the main channel and guides another crew across the island holding a stadia rod in the air and keeps them at the same cross section angle until they intersect the center of the side's bankfull channel. This point is then marked with flagging and Steps 2 through 7 completed for the side channel.

In situations where the main channel line of sight is not a practical technique, return to the first reference point downstream of the side channel entry point. Use the standard location of interval reference point procedure and walk 100 meters up the center of the main and then side bankfull channels. This point is then marked with flagging and Steps 2 through 7 completed for the side channel.

Unstable and high disturbance areas: Creativity is required in situations where there is potential human disturbance of the reference tags. Examples include: where the cutting of reference trees is possible, it is recommended that a duplicate tag be placed near the base of the roots; where vandalism is possible, tags can be placed on the sides of the trees or structures facing away from common human pathways; and larger tags with lettering readable from the ground can be placed out of reach. Tree paint can be used for quick identification of reference point structures with landowner permission.

Triangulation techniques are recommended to relocate reference point locations in situations where 100 meter interval reference point structures are: a) not available or permitted by a landowner; b) rebar rods or stakes that are more prone to loss or difficult to relocate; and c) in areas of high natural or human disturbance. In locations where suitable reference point structures are not possible, a temporary reference point can be established and triangulated back to stable structures. Follow the triangulation procedure discussed in Step 6 of this section. Subsequent surveys will require re-establishment of the temporary reference points.

GPS documentation: Global Positioning System (GPS) instruments with an accuracy of ± 1 meter can be used to document the location of original and reconstruction (original GPS accuracy ± 1 m) of lost reference point tags and structures. Less accurate GPS instruments are useful to supplement to standard documentation procedures, especially in unstable and high disturbance channel areas. GPS information is also valuable to locate segment boundaries and reference points in Geographic Information System (GIS) layers.

3.2 Data Collection at Reference Points

This section provides the procedures and criteria for data collection of bankfull width, bankfull depth, canopy closure, and supplemental reference photographs at each reference point location. After completion of this section, return to Section 3.1 for establishing the next successive reference point. The format is to work back and forth between Sections 3.1 and 3.2 at each successive reference point location until the upper boundary of the segment has been surveyed.

3.2.1 Bankfull Width Measurement

Bankfull width is the distance between bankfull channel edges (BFCE) and measured at cross sections perpendicular to the center of the channel. Bankfull width measurements are recorded to the nearest 0.1 meter and taken at each segment boundary and reference point. The location of the wetted channel, direction of flow, or the absence of water at the time of the survey does not affect this measurement. The bankfull width tape is not removed until all other parameters have been measured.

The criteria for placement of the bankfull width cross section is:

- at or as close as possible to the reference point cross section;

- at a 90 degree angle to the centerline of the bankfull channel; and
- where there are no or minimal obstructions affecting the accuracy of bankfull width, bankfull depth and canopy closure measurements.

Step 1: Identify the location of the bankfull width measurement cross section.

The ideal location for taking repeatable measurements is at the reference point cross section. However, the location can be moved downstream or upstream from the reference point to the nearest location where accurate measurements can be taken. Adjustment of the channel measurement cross section can be related to physical measurement obstructions or crew safety issues that prevent an accurate measurement of any one parameter. For example, a reference point cross section that intersects a deep pool may allow an accurate bankfull width measurement, but would prevent access that biased or required estimation of some bankfull depth measurements. Other factors that require movement of the cross-section include undercut banks, bridges and culverts, mouths of tributary junctions, and a complete lack of BFCE indicators such as in marsh and large beaver pond areas. Cross sections must be located within segment boundaries.

In these situations, record in the "Adjust X-Sect" column on Form 2D the location of the bankfull width cross section relative to the reference point. Mark the appropriate circle representing upstream or downstream location and distance from RP along the centerline of the bankfull channel. Adjustments at segment boundaries can only be made upstream of the lower and downstream of the upper reference points. Identify the location of adjusted bankfull width cross sections in the sketch map box (Form 2T) for that reference point.

Multiple channels require separate bankfull width cross-sections along the same bankfull channel orientation. This includes wetted or dry channels that are connected to the primary low flow channel by ingress and/or egress access, but separated by gravel bars or islands that are higher than bankfull height. Complete all measurements and documentation at the primary channel before going to an adjacent or side channel. Each channel measurement is recorded on separate Form 2D rows, but associated with the same reference point by using a letter code (e.g., 14a, 14b, 14c, etc.). Multiple channels require additional calculations before entry into the database that are best documented by leaving a blank data collection row after recording all channel information. Using the example above, this row would be identified as "MC-14."

Step 2: Identify the bankfull channel edge using indicators including floodplain, bank morphology and composition, and vegetation along the bankfull width cross section.

The next step is to identify the BFCE. The TFW Monitoring Program uses a combination of three primary indicators developed by Dunne and Leopold (1978) to help identify the BFCE: 1) floodplain; 2) bank morphology and composition; and 3) vegetation (Figure 11).

It is important to treat each BFCE placement as unique and weight all the indicators present equally. Also, it is useful to observe indicators along the length of the bank and look for similarities. There are no key indicators applicable to all situations because most stream systems are in a continual cycle of change.

Floodplain indicators: A floodplain is defined as the relatively flat area adjoining a channel that has been constructed by the stream through lateral migration (erosion and deposition) in the present climate. Portions of the floodplain are flooded at a recurrence interval of approximately one and one-half years. It provides temporary storage for sediment and flood waters. In channels with natural (un-diked) riparian areas and a low, flat floodplain, the boundary of the BFCE is located near the top of the low bank. The boundary marks the point where the energy of the water is no longer sufficient to significantly erode or scour away the bank.

Floodplains tend to be very confusing since they may be discontinuous, often only evident on one border of the channel, or completely absent (Stream Notes, 1993). Along many small streams in forested parts of the state, floodplain indicators will not be present, particularly when the channel is confined between steep hillslopes or is incised into an elevated terrace that is not frequently flooded. This indicator is also not appropriate for streams that have been artificially diked or channelized.

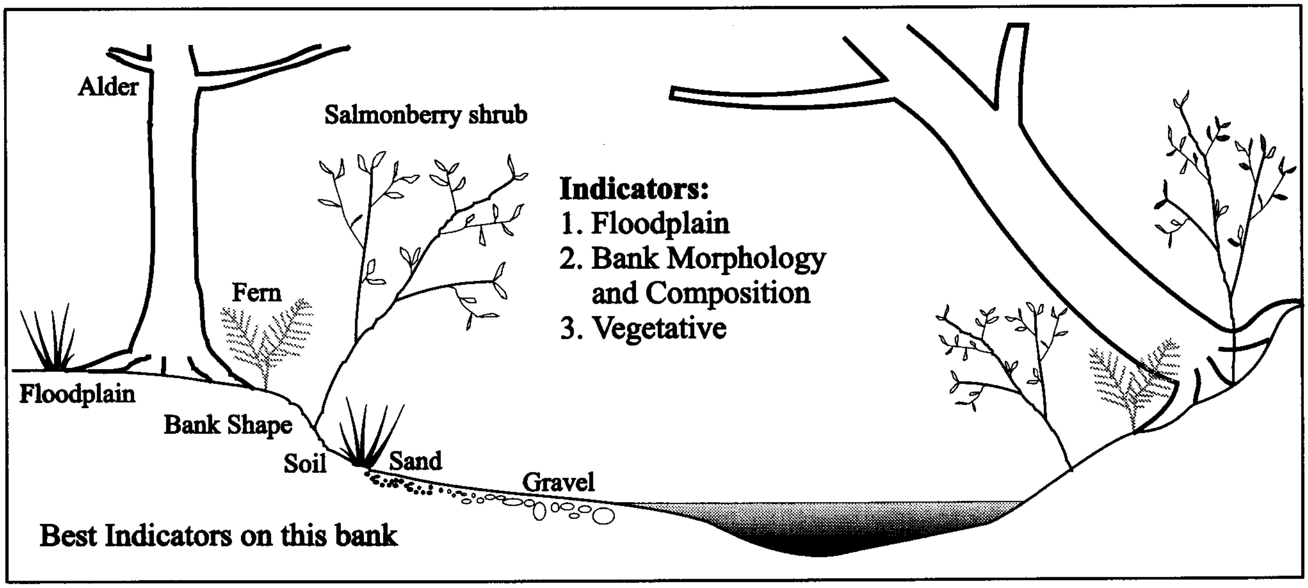


Figure 11. Common indicators used to identify bankfull channel edges (BFCE) including floodplain, bank morphology and composition, and vegetative factors.

Bank morphology and composition indicators: The shape of the bank and changes in substrate size can be indicators of BFCE boundaries in lower gradient stream segments. 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 flat terrace or floodplain then abruptly make a cut at a near vertical angle into the active channel. The point where this change takes place can be a useful indicator except in undercut or slumping bank areas.

On highly erodible banks, look for changes in substrate size such as where cobble changes to sand and then to soil. Also observe areas where the morphology of loose substrate changes. If no other indicators are present, the tops of freely formed point bars can be used to identify the minimum height of the BFCE. Freely formed point bars are located on the inside of meander bends and are caused by sediment deposition unrelated to LWD or other in-channel obstructions.

Vegetative indicators: The BFCE is often marked by a demarcation line in the vegetation between lower areas that are either bare or have aquatic and annual vegetation, and higher areas with perennial vegetation such as shrubs, ferns, and trees. Perennial vegetation found along the BFCE is an indicator of where the forces of bankfull flow are being balanced by bank stability, allowing vegetation to grow for more than one or two seasons. It is important to remember that the general vegetation line is almost always in a transitional state, retreating due to disturbance during larger storm events, and advancing again during periods of drought.

For example, the vegetation line can be deceptive in areas of bank slumping or where willow and alder are actively colonizing areas in years of dryer weather. An often confusing situation is when willow and alder trees are suspected to be growing within the bankfull channel. The most common reasons are from channel migration or that they were eroded from an upstream site, deposited in a gravel bar within the bankfull channel, and then became re-established and continue to grow. When using vegetative indicators, rely most heavily on perennial species that are greater than 2 meters in height. One exception to the height guideline would be ferns. Isolated pools or other floodplain features not directly connected to the main bankfull channel are not measured, but may be noted as off-channel habitat in the field notes.

In boulder or bedrock confined channels, the BFCE may be near markings made by mineral stain lines with the demarcation line between bare rock and lichen or moss. These indicators are best used with the default method to identify the lower or "active channel" side only when others are not present and interpret them in the broadest possible context.

Step 3: Apply the default method to establish bankfull width measurement points on both banks.

The default method provides a systematic way of identifying the location of the BFCE based on the indicators listed above in most channel situations. Use of this technique has been shown to significantly improve crew consistency and reduce biases towards under- or over-estimation of BFCE elevation (Pleus, 1998 unpublished data). The greatest value is that this technique works well with both experienced and less-experienced crews.

Start on the bank with the best BFCE indicators. Begin by observing indicators from within the bankfull channel towards its suspected edge and mark the point on the bank with a wire flag or stick where you no longer have 100 percent confidence in being within or below the BFCE elevation. Then, walk around outside of the channel to observe indicators from the floodplain or outside the bankfull channel towards the channel's suspected edge and similarly mark the point on the bank where you no longer have 100 percent confidence in being on the floodplain or above the BFCE elevation. Reassess the indicators and confidence levels and make any adjustments. The default BFCE is the point in elevation midway between the other two markings.

Next, follow the same procedure on the opposite bank and mark its BFCE. In situations where it is not possible to accurately identify the BFCE along the opposite bank, use a torpedo level to extend a level line horizontally across the channel from the bank with good indicators to determine the BFCE on the bank lacking indicators. This often occurs on the outside bank of a meander bend.

Step 4: Secure measurement tape and record the bankfull width measurement on Form 2D.

Bankfull width is measured by securely attaching the zero end of a fiberglass tape at one BFCE and extending the tape across to the opposite BFCE along the 90 degree cross section line. Stretch the tape tightly (no sag or deflections) and securely attach the measurement end of the fiberglass tape to the second anchor point (Figure 12). Record the distance between BFCE points to the nearest 0.1 meter in the Bankfull Width column. Do not remove the bankfull width tape until bankfull depth and canopy closure have been measured and reference photographs taken.

3.2.2 Bankfull Depth Measurement

Bankfull depth is measured to the nearest 0.01 meter and taken at each reference point along each bankfull width cross section. Bankfull depth is the distance from the *channel bed* to the top of the bankfull channel, represented by the elevation of the tape stretched between the BFCEs. Water depth or the absence of water at the time of the survey does not affect this measurement.

Step 1: Calculate and record on Form 2D the depth measurement interval sequence using the 10 percent cell method.

The cell method divides the bankfull width into 10 evenly spaced cells or sections. Depth measurements are then taken at stations in the center of each cell. To determine station intervals along the bankfull width tape:

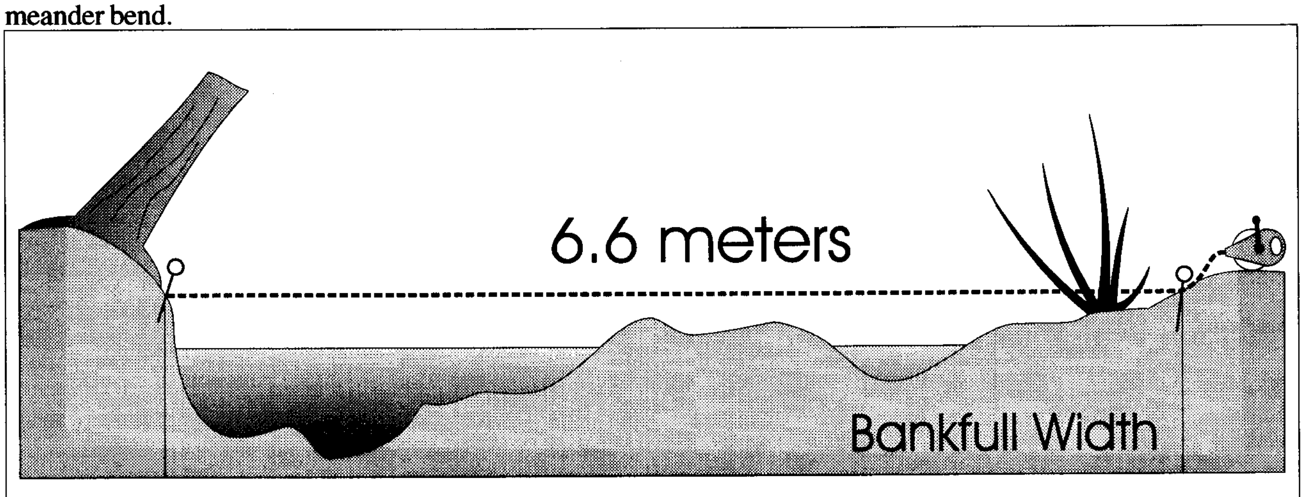


Figure 12. Stretch the tape tightly (no sag or deflections) and securely attach it at both anchor points.

- Calculate the cell interval by dividing the bankfull width by 10 (move the decimal place left one) and record the result to the nearest 0.01 meter in the box left of the "Tape Stations" caption (Figure 13).
- Calculate the first tape station by dividing the cell interval in half and adding this number to the BFW tape reading at the tape's zero end. Record the tape station interval to the nearest 0.01 meter in first bracket of the "Tape Stations" set of brackets for that RP cross section.
- Calculate the subsequent nine intervals by adding one full interval distance to the previous adjacent station along the tape. Record the tape station intervals to the nearest 0.01 meter in their proper sequence in the "Tape Stations" set of brackets for that RP cross section (Figure14).

Refer to Appendix F for a table of pre-calculated tape stations for streams with bankfull widths from 1.0 to 25.0 meters at 0.1 meter increments. This table can be used to locate tape stations in the field or for error checking tape station calculations.

Step 2: Take and record bankfull depth measurements on Form 2D.

Bankfull depths are measured plumb (vertically level) from each tape station to the channel bed. The channel bed is defined as the measurable point below the bankfull width tape at which water would no longer flow due to obstructions such as sediment particles, bedrock, and large woody debris. That is, depth measurements are

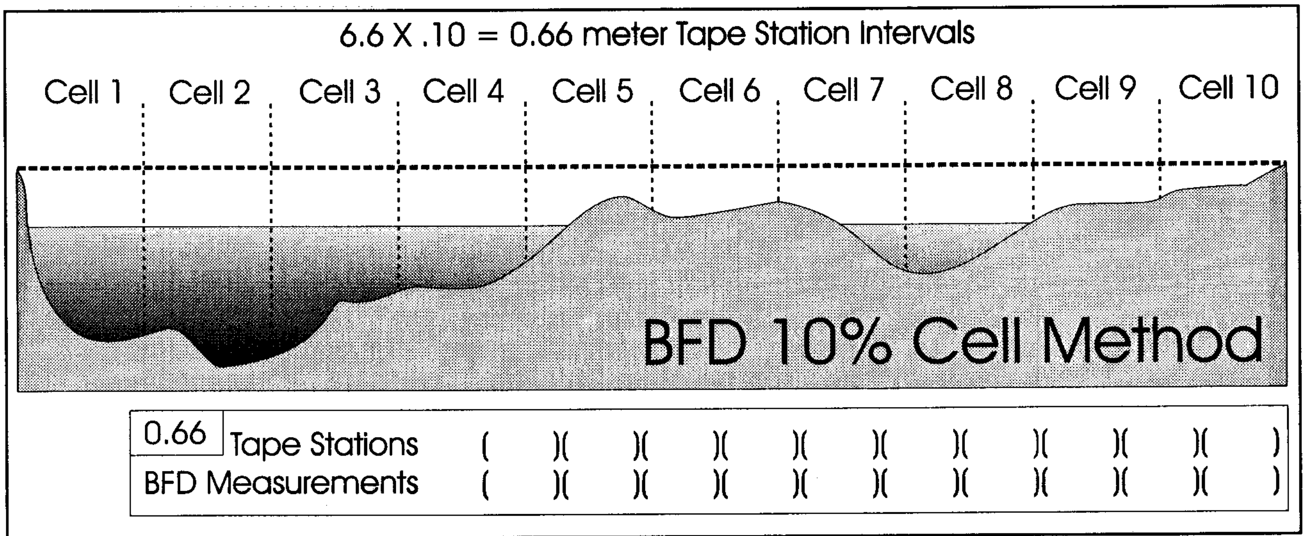


Figure 13. Calculate the cell interval and record the result in the box left of the "Tape Stations" caption.

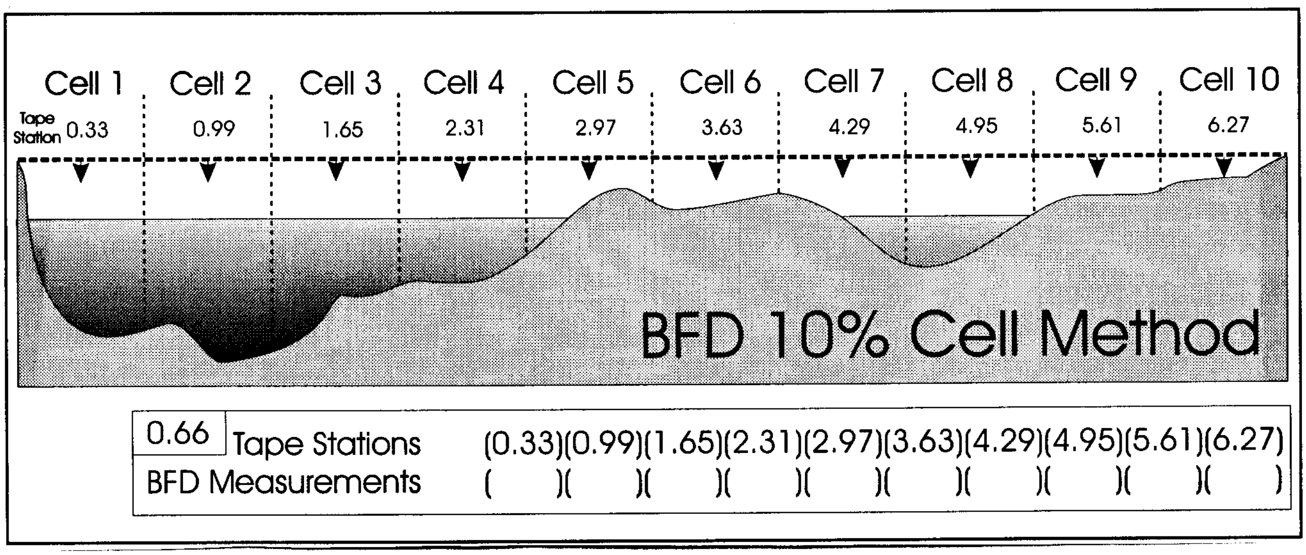


Figure 14. Calculate the subsequent nine intervals and record the tape station intervals in their proper sequence in the "Tape Stations" set of brackets.

made to where they intersect the top of an obstruction - NOT the average stream bottom (Figure 15). Subtract the depth of intersected stable spanning debris. Disregard live root systems less than 0.1 meter in diameter and debris that would freely move in the water column during larger flows.

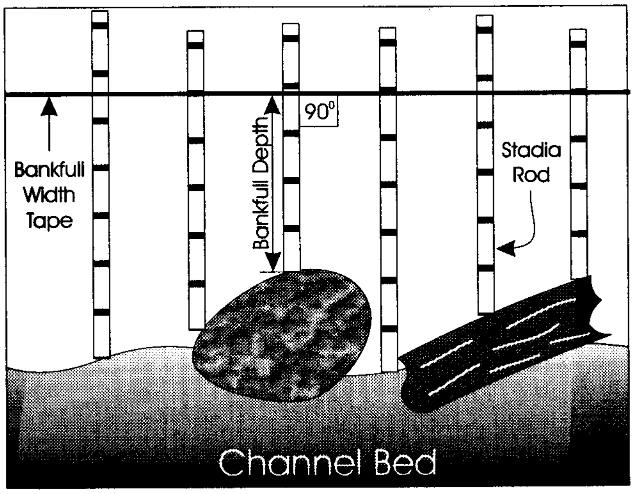


Figure 15. Bankfull depth measurements are made to where they intersect the top of an obstruction.

Make sure the tape is still stretched tightly and measure the distance between the channel bed and the tape at each interval station. Hold the measurement rod vertically level and positioned so that it intersects the interval station. While maintaining the tape position, lower the rod and make any leveling adjustments necessary until the zero end first touches an element of the channel bed. The stadia rod is consistently placed on either the upstream or downstream side of the tape and measurements are consistently read off the stadia from either the top or bottom of the tape. Record each station's depth measurement to the nearest 0.01 meter in order on the "BFD measurements" set of brackets for that RP cross section on Form 2D (Figure 16). Use the field notes section to briefly document channel bed conditions that affect the measurements.

Step 3: Calculate and record the mean bankfull depth on Form 2D.

When all bankfull depth measurements have been taken, calculate the mean bankfull depth by adding all the depth measurements together and then dividing the sum by 10 (the number of depth measurements taken). Record this number in the Bankfull Depth column for the specific RP cross section. Do not remove the bankfull width tape until canopy closure has been measured and reference photos have been taken.

Note: Analysis of QA Review data has shown that a significant portion of errors in mean bankfull depth were caused by calculation problems, including math errors, rounding errors, and errors caused by poor legibility. The results show that data quality can suffer as much from these types of errors as it can from improper application of field methods. These variability problems can be significantly reduced by regular error checking of field forms.

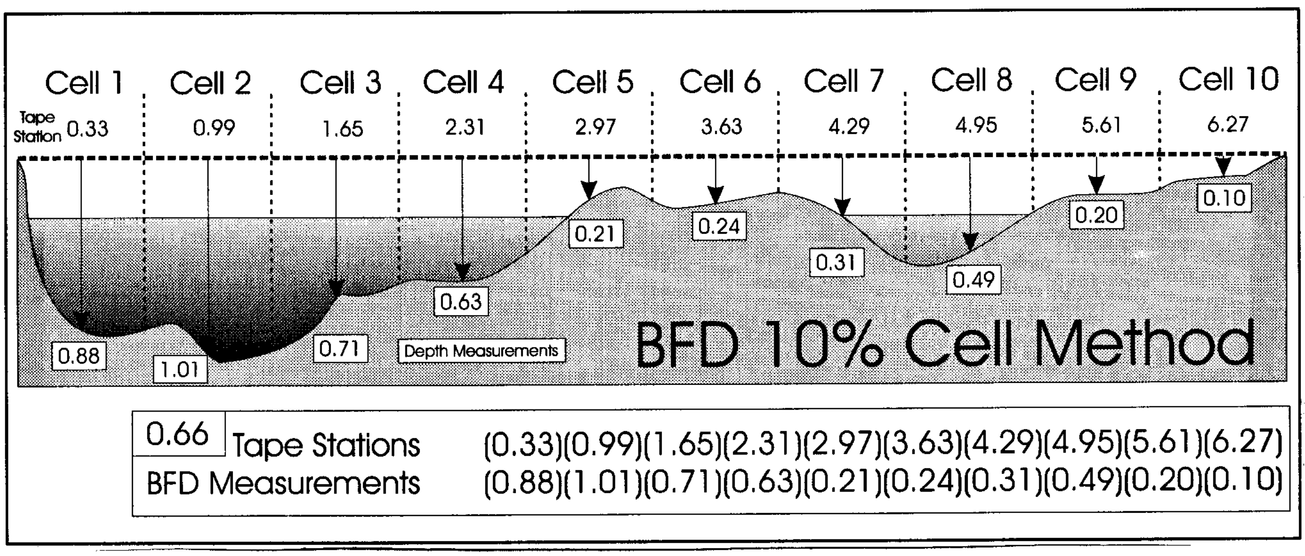


Figure 16. Record each station's depth measurement to the nearest 0.01 meter in order on the "BFD measurements" set of brackets for that RP cross section on Form 2D.

3.2.3 Canopy Closure Measurement

Canopy closure is measured to the nearest 1 percent and taken at each reference point. The criteria for canopy closure measurement location is to place them:

- along the 90 degree bankfull width and depth measurement channel cross section;
- at or as close as possible to the center of the primary summer low flow channel (main channel wetted width);
- using a leveled spherical densiometer positioned at a constant elevation above the water surface (record distance in field notes);
- using the densiometer as the axis of rotation;
- where there are no or minimal obstructions affecting the instrument's immediate field of view.

Step 1: Identify the location for taking canopy closure measurements along the bankfull width cross section.

Begin by finding the center of the primary low flow (PLF) or main (> 50 percent of wetted width) channel along the tape used for the bankfull width and depth measurements. It is assumed that the bankfull width and depth measurement cross section was selected with consideration to canopy closure measurement accuracy in mind. However, if access to the center position is not possible or would cause significant measurement accuracy problems, select an alternate measurement position by moving to:

- the closest point within ± 2 meters of the center of the PLF along the tape, but still within the channel's wetted width;
- the closest point within ± 2 meters upstream or downstream of the PLF center position; and
- if the bankfull width and depth measurement cross section was adjusted, then take the canopy measurements back at the PLF center position of the original RP cross section.

Record any deviations in the "Field Notes" section.

Step 2: Position, stabilize, and level the densiometer in proper orientation to the bankfull width cross section tape.

Position the densiometer with its center gridline pointed in the up-channel direction at an angle perpendicular to the bankfull width tape. Using a tripod, stabilize the instrument by adjusting the legs for uneven channel beds. Adjust the densiometer's height and level it using the densiometer's bubble level.

Step 3: Take and sequentially record on Form 2D the upstream, left bank, downstream, and right bank channel direction canopy closure measurements.

With one eye closed, look down on the surface of the densiometer mirror and adjust your head until the reflection of the top of your forehead (<u>not</u> bangs, top of hair or hat) just touches the outside of the grid and your sighting eye is directly in line with the grid centerline (Figure17). While maintaining this position, count the number of sampling points that have canopy closure factors covering more than 50 percent of the dot and record this number on Form 2D. Use of a mechanical tally counter simplifies this procedure and provides more consistent measurements.

Using the densiometer as the axis of rotation, repeat this procedure for Left Bank (grid centerline parallel to tape), Downstream (grid centerline perpendicular to tape), and Right Bank (grid centerline parallel to tape) directions (Figure 18). Record the closure points sequentially in the "Up," "LB," "Dn," and "RB" columns on the Form 2D. The maximum count is 96 and the minimum count is zero.

Step 4: Calculate and record mean canopy closure percentage on Form 2D.

The percent canopy closure is then calculated in the field by adding together the four directional closure sample point totals, dividing the sum by four, and multiplying the result by 1.04. Round the result to the nearest 1 percent and record the canopy closure in the "%" column on Form 2D (Table 1).

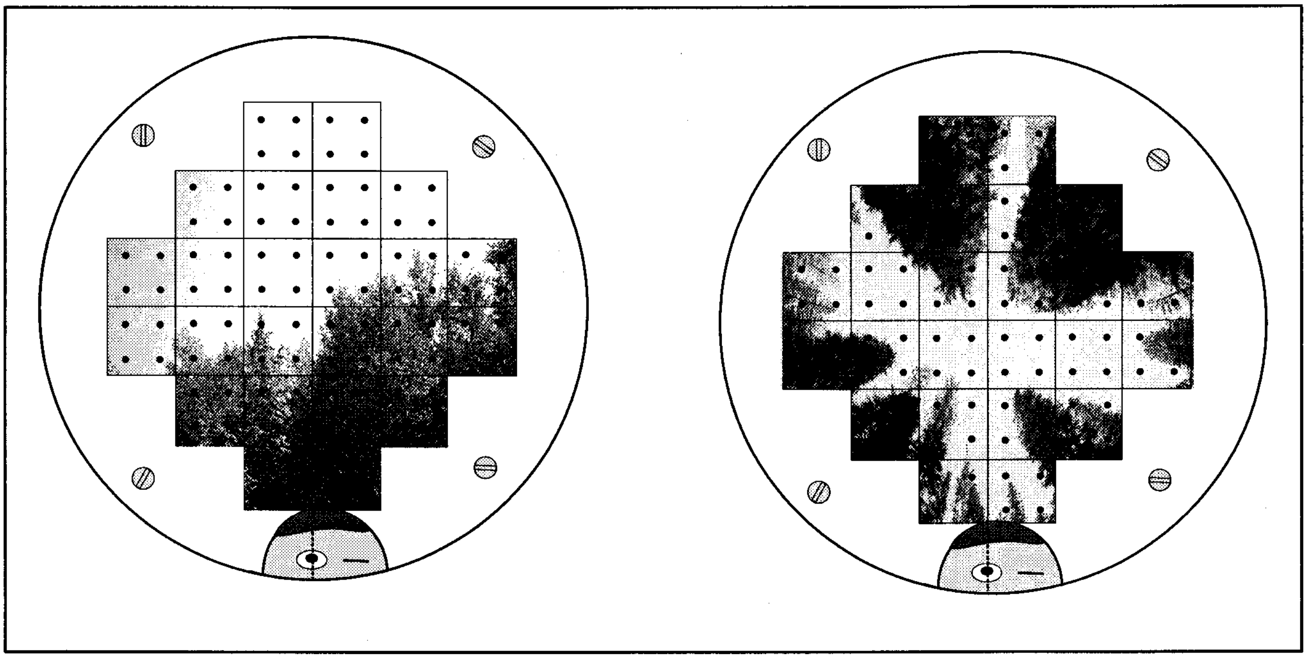


Figure 17. Two examples of using the convex spherical densiometer with proper eye position along the grid centerline. The example on the left shows 45 canopy closure points and the one on the right shows 48 points.

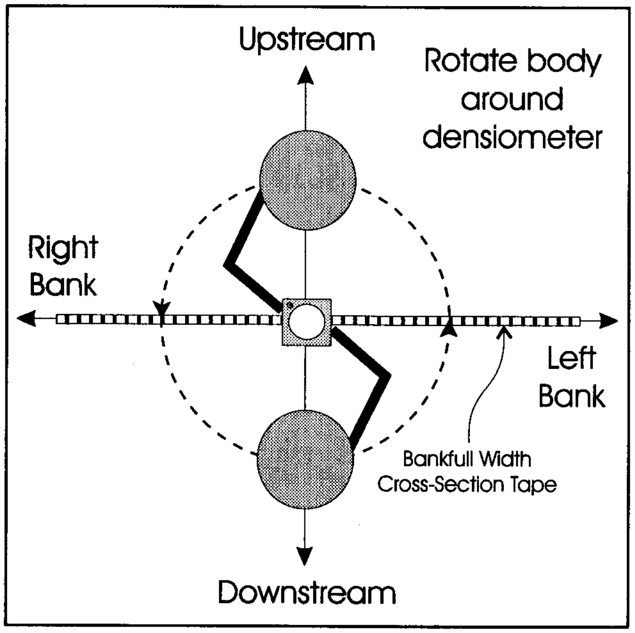


Figure 18. Use the densiometer as the axis of rotation and the cross section tape as the direction guide.

Difficult Situations

Always record any divergences from the above standard methods in the notes section of Form 2D.

Off-season canopy: Summer is the appropriate time to take canopy closure measurements that best describe stream temperature factors on channels with deciduous vegetation. Estimation of leaf-out in situations where leaves are not fully mature or present, is not recommend for monitoring purposes.

Small stream channels with low brush and grass: Where these stream situations are related to forest practice issues, use the methodology as described above.

Table 1. Three examples of canopy closure measurements and calculation of percent canopy closure.

UP (+)	LB (+)	DN (+)	RB (=)	Sub-Total	Divide by 4	Multiply by 1.04	Rounded Canopy Closure
96	85	91	69	341	85.25	88.66	**89%**
32	45	23	62	162	40.5	42.12	**42%**
56	78	67	83	284	71.0	73.84	**74%**

Sun glare: Sun glare off the mirror surface can be reduced by blocking the reflection using a finger on a free hand. This can reduce most of the glare except in the immediate vicinity of the sun reflection.

Windy conditions: If possible, count closure between gusts of wind. When this is not possible, use best judgment of the closure point number on a grid-by-grid basis.

3.2.4 Optional Reference Photographs

Reference photographs are optional, but can provide useful visual documentation of channel and riparian conditions over time. Photographs are also useful for documenting unique channel conditions between reference points such as channel modifications (i.e., rip-rap, culverts, and bridges) or disturbances (i.e., mass wasting, bank erosion, fish passage barriers). At a minimum, reference photographs are taken in upstream and downstream directions at segment boundaries and at each 100 meter interval reference point. The repeatability and comparability of photographs is directly related to quality of documenting factors such as roll and frame numbers, camera position, angle of view, and subject matter.

At the beginning of a Reference Point Survey or a new roll of film, photograph a sheet of paper with the following minimum information: Stream Name; WRIA #, Segment #; Roll and Frame number; and Date. Streams with low light levels or high contrast conditions with sun and shade requires using a film with an EI/ASA of at least 200 and preferably 400. A tripod is also recommended to prevent motion blur and allow a greater depth of field (can be same one used for densiometer). Refer to Appendix E for examples of reference photo documentation on completed Forms 2H, 2T, and 2D.

Step 1: Identify the channel location of the "Upstream" view photo point.

Walk downstream from the reference point along the channel centerline to locate the optimal position for taking a photograph in the upstream direction. Reference photographs are taken from a position within the bankfull channel that includes as much information about the channel conditions between each Base and Alternate reference point as possible. This position is not moved to coincide with the adjusted locations of the bankfull width measurement cross section. Where obstructions are present, adjust the photographic position to the best vantage point that captures the most channel information. Where possible, temporarily tie back brush or branches close to the camera to prevent their visual obstruction of channel information.

Those cooperators interested in the highest repeatability and comparability of reference photographs can use enhanced documentation techniques. This includes triangulation of the photo point from off-channel structures (Base and Alt RP's work well) and taking a compass azimuth to note camera direction. The following list is provided as an aide to think about what information can be captured in a reference photograph. In most cases, only one or two of the conditions may be of interest at any one reference point site. Channel information to consider for reference photographs include:

- channel bed roughness
- bankfull channel profile
- view of primary low flow channel
- bank/overstory vegetation
- presence/absence of LWD
- stream habitat
- land use

Step 2: Identify the channel location of the "Downstream" view photo point.

Walk upstream from the reference point along the channel centerline to locate the optimal position for taking a photograph in the downstream direction. Similar to upstream view reference photograph, downstream view photos are taken from a position within the bankfull channel that includes as much information about the channel conditions between each Base and Alternate reference point as possible. Where obstructions are present, adjust the photographic position to the best vantage point that captures the most channel information. Apply enhanced documentation techniques as needed.

Step 3: Record on Form 2D the roll and frame numbers and notes related to photo point loca tions including specific frame contents.

At each reference point, note the roll and frame number for each shot on Form 2D and provide a brief description of the photo contents and location taken in the Field Notes section. The location and angle of view for each photograph can be recorded in the sketch map box on Form 2T.

3.3 Reconstruction and Relocation of Lost Reference Points

Reference point structures and tags may be lost over time due to factors such as poor documentation, tagging and anchoring, channel migration, reference point structure loss, and vandalism. This causes difficulties when the Reference Point Survey is repeated in future years, or when other surveys that use existing reference points are conducted.

If the loss of a reference point is discovered while conducting surveys other than the Reference Point Survey, then that survey should be suspended until the missing reference points have been reconstructed or relocated. Reconstruction is defined as re-establishment of reference point cross sections within ± 1 meter of its original location and is assumed to be the same as the original reference point. Relocation is defined as any situation where re-establishment of reference point cross sections are not possible within ± 1 meter of its original location, so a new reference point is established. These procedures are described below.

Make a quick assessment of the segment to determine the extent of disturbance to other reference points. Minor reconstruction situations may only require simple re-establishment and documentation for updating original database data. Do not resume the suspended survey until all affected reference points within the segment have been reconstructed or relocated and documented.

3.3.1 Reconstruction at original reference point locations

Proper documentation of original Base and Alternate reference point locations is the most valuable tool used for reconstruction. Lost tags are replaced with duplicate information and lost reference point structures can be replaced with rebar or moved to another location along the original cross section orientation and then properly documented.

The location of lost Base and Alternate reference points are reconstructed by applying original documentation information including: a) use of triangulation information; b) reversal of Alternate reference point compass azimuths; and c) use of GPS information, distances from nearest intact reference point, and site sketch maps.

Use of triangulation information: The location of lost Base reference points can be reconstructed by using distance and compass azimuth from triangulation points. Once located, cross-check site reference and tag information with original documentation and note compass azimuth and distance. One crew member places their back at the triangulation point and uses the compass azimuth to establish a line of sight. Another crew attaches the zero end of a fiberglass tape to the triangulation tag and measures out the original distance with corrections in direction provided by the first crew member. The intersection of the azimuth and the distance provides an acceptable reconstruction of the original reference point location, so attach flagging here.

Use of a second triangulation point will provide the highest reconstruction accuracy. Follow the procedures above at the second triangulation structure to repeat the distance and compass azimuth procedure. The intersection of the second triangulation distance with the first reconstructs the most accurate location of the original reference point.

Alternate reference point compass azimuth: The location of the cross section that intersected the lost Base reference point can be reconstructed by using the original compass azimuth and distance taken from the Alternate to the Base reference point. Use this line of sight to select another Base or to replace with an artificial reference point structure.

GPS, interval distance, and sketch map information: GPS information can be used to reconstruct lost Base or Alternate reference points if the accuracy of both original and follow-up GPS readings is within ± 1 meter. Currently, this accuracy is not consistently possible in forested areas. Less accurate GPS information provides valuable assistance in relocating the general area of lost reference point structures or tags.

Reconstruction based on interval distance and sketch map information is generally limited to replacing lost tags from intact original reference point structures and locating the approximate position of lost RP structures. Neither sketch maps, unless very detailed, or re-measurement of interval distances from the nearest intact original or reconstructed reference point are accurate enough for reconstruction purposes.

3.3.2 Relocation of new reference points due to channel changes

Relocation is required in situations where both reference point structures and tags have been lost through poor documentation or disturbance, or where reconstruction is not possible to within ± 1 meters along the original cross section location. The relocation of reference points must be properly documented.

Relocation of lost segment and sub-segment boundary reference points must meet the original hydrologic, geomorphic and other specific boundary requirements. Base and Alternate reference points are relocated following the same principles and priorities as described for original placement and documentation. Refer to the Stream Segment Identification Method section of the manual and the original Form 1 to determine if the relocation requires changes in segment classification. Any boundary relocation requires filling out a new Form 1 even if the USGS topographic map boundary location information does not change.

Relocation of lost 100 meter interval reference points follow the same principles and priorities as described for original placement. Lengths along the center of the bankfull channel are measured in the same upstream direction as the original survey. Use the following relocation rules for determining placement and numbering:

1) Retain all intact original or reconstructible reference points and their sequence number;

2) Use standard Reference Point Survey methods and the 50 - 149 meter interval distance criteria to relocate 100 meter interval reference points upstream from, and to intact original or reconstructable reference points.

3) Numbering of relocated reference points corresponds to original sequence placement. Numbering of a relocated lower segment boundary remains zero. Numbering of a relocated upper segment boundary may vary. In situations where new reference point intervals are added within the original sequence, apply decimal versions to the last number before the break in the sequence.

4. Post-Field Documentation: Finalizing Forms 2H, 2T, and 2D

After completion of the field portion of the Reference Point Survey, field forms need to be organized, supplemental information and calculations completed, and all forms and information error checked before the data is ready to be entered into the database. The objective of this section is to organize the data to ensure that this survey can be repeated the same way in the future by different crews.

4.1 Organize and Complete Information on Forms 2H, 2T, and 2D

All Forms: Page numbering is related to form type. Count the number of total pages separately for Form 2H, Form 2T, and Form 2D.

- The page number should be filled in as used during the survey (e.g., Page 1 of __, Page 2 of __, Page 3 of __, etc.). Forms that have been copied on both side of one sheet of paper will count as two separate pages.
- The total number of pages for each type of form is filled in at the end of the survey (e.g., Page 1 of 6, Page 2 of 6, Page 3 of 6, etc.).
- Organize the field forms by type and then by page number for easy reference. It is common to have different totals for each type.

Form 2H

Study Design Information Section:

- Survey Length: Record the total survey length (meters/feet) as noted in the final reference point "Cumulative Distance" box at the end of the survey.
- Survey Coverage: Fill-in the survey coverage circle that best applies to your Reference Point Survey. Mark "WHL" if the whole or entire segment or sub-segment was surveyed. Mark "PRT" if the survey was applied on a consecutive length of a partial segment/sub-segment. For example, the first 500 meters of a 2,000-meter-length segment. Mark "SUB" if the survey was applied using a random or systematic placement sub-sampling strategy. For example, if 100 meter interval reaches were randomly located to represent a percentage of the total segment length. Mark "PSB" if a combination of PRT and SUB was applied. Mark "THR" if the reference point survey corresponds to information gathered to supplement a temperature study along a thermal reach. Mark "OTH" if your study design differs from the above.
- Survey Percentage: Record the percentage of the segment or sub-segment length surveyed. WHL and THR segments typically correspond to a 100 percent coverage. In all other situations, record the percentage to the nearest 1 percent of the total segment length covered during the survey.

Survey Summary Field Notes Section:

- This section is provided to make brief notes related to unique survey conditions and problems encountered. Additional information can be included on the back of the form or on separate sheets of paper. If separate sheets are used, they need to be included in the Page __ of __ information and have the key header information listed at the top of each page.

Form 2D

- Calculate any mean bankfull depths and canopy closure percentages not completed in the field.
- Calculate total bankfull channel width for multiple channel cross sections by adding together each cross section's bankfull width and recording this number in the right-hand portion of the primary channel's split "Bankfull Width" column (Figure 19).
- Calculate mean bankfull depth for multiple channel cross sections. This task requires a more complex calculation: a) calculate the area for each channel cross section by multiplying its bankfull width by its bankfull depth; b) calculate the total bankfull channel area by adding the areas together; c) calculate the mean bankfull depth for the total bankfull channel area by dividing the total bankfull channel area by the total bankfull channel width; d) record this number to the nearest 0.01 meter in the right-hand portion of the primary channel's split "Bankfull Depth" column.
- Optional: Calculate mean canopy closure percent age for multiple channel situations. Procedures are based on individual cooperator needs.

4.2 Error Checking

Error checking of field forms is a very important task and sufficient time should be taken to complete it. It is best done during or immediately after data collection. It becomes more difficult to reconcile discrepancies and track down correct information the more time passes since the survey was completed. Where information cannot be corrected, the data may not be useful for monitoring purposes.

Review Forms 2H, 2T, 2D and all other documents compiled during the Reference Point Survey. Have a second person look them over for completeness, legibility and errors. Every page of every form requires error checking for legibility, complete and consistent header information, obvious measurement and transcription errors, and calculation errors. Work systematically through each section and when completed, put your initials and date in the "Error Checked by" box at the bottom of each page. If the person error checking the data is not a crew member, their full name and task should be recorded in the "Survey Summary Field Notes" section of Form 2H.

The following are some common error checking tasks on Form 2H:

- The Stream Name, WRIA #, Segment #/Sub-Segment Code, and WRIA River Mile are consistent and filled out on every page.
- New forms and dates correspond to changes in crew, equipment or other factors.
- Crew names, responsibilities, and affiliations are complete and legible. Crew lead experience has been noted. If no TFW-MP or other experience, put the word "None" in the "Other" section.
- All measurement equipment has been documented and information completed corresponding to each.

The following are some common error checking tasks on Form 2T:

- The Stream Name, WRIA #, and Segment #/Sub-Segment Code are consistent and filled out on every page.
- New forms and dates correspond to changes in day of data collection, crew, equipment or other factors.
- Crew Lead and Recorder initials are noted on every page.
- Reference Point numbers (RP#) start with "0" at the lower segment boundary (unless this is a sub-segment), are in sequence, and do not have missing or duplicate numbers.
- Minimum "Base" and "Alt" documentation information is recorded for each reference point site.
- A sketch map is completed and legible for each reference point site.

The following are some common error checking tasks on Form 2D:

- The Stream Name, WRIA #, and Segment #/Sub-Segment Code are consistent and filled out on every page.
- New forms and dates correspond to changes in day of data collection, crew, equipment or other factors.
- Crew Lead and Recorder intitials are noted on every page.
- Reference Point #'s start with "0" at the lower segment boundary (unless this is a sub-segment), are in sequence, and do not have missing or duplicate numbers.
- Cumulative Distances start with "0" at the lower segment boundary, there are no missing or duplicate numbers, the distances are cumulative and any calculations are accurate, and the last cumulative distance corresponds to the total survey length.
- Bankfull width measurements are rounded properly to the nearest 0.1 meter, and calculations for multiple cross sections are accurate and clearly noted.
- Bankfull depth interval calculation is accurate, tape stations are accurate, individual depths are properly rounded to the nearest 0.01 meter, mean bankfull depth calculation is accurate and rounded properly to the nearest 0.01 meter, and calculations for multiple cross sections are accurate and clearly noted.
- Canopy Closure direction measurements are rounded properly to the nearest 1 percent and represent *closure* not open sky readings, there are no missing measurements, and the mean canopy closure calculation is accurate and rounded properly to the nearest 1 percent.
- "Adjust X-Sect," if applied, has one direction circle filled-out and a distance measurement recorded to the nearest meter. If the bankfull width cross section was place at the reference point, then place an "X" in the box to indicate that no adjustment was made.
- Field Notes are legible and related to one of the parameters.

5. Data Management

The TFW Monitoring Program offers data management services to help cooperators quickly analyze data collected with the program's standard methods and to produce standard monitoring reports. The heart of the service is a database system housed at the Northwest Indian Fisheries Commission. This database is available to do calculations, produce reports and archive electronic versions of the data. The database is also an important archive of monitoring data that can be used for developing study designs and identifying control or reference sites.

5.1 Data Preparation

Before data entry can occur for the Reference Point Survey, some preparation must be done. The following materials are needed:

- completed and error-checked Form 2H and 2D for each segment,
- a data entry system;
- a set of data entry system instructions; and
- an "Ambsys" data dictionary.

Before the data entry process can begin, an entry system must be selected. Choose a data entry system from the list below and request a free copy from the TFW Monitoring Program. The database has three entry system options for Reference Point Survey data. These are:

- Microsoft Excel 4.0 pre-formatted spreadsheet;
- Lotus 1-2-3 (vers. 3) pre-formatted spreadsheet; and
- Microsoft Access 2.0.

Refer to Appendix G for an example of the Excel preformatted spreadsheet. Select a spreadsheet format if your data requires conversion from English to metric units. Read the instructions for the data entry system and the Ambsys data dictionary, noting the field types and data constraints (what type of data can be entered into each field).

5.2 Data Processing, Products and Archiving

Open the section of the entry system pertaining to the Reference Point Survey on your computer. Following the entry system instructions, key in the data from Forms 2H and 2D. After you have completed keying in the data and saved the session, have another person compare the data recorded on Forms 2H and 2D to the data on the screen. Once they have verified the accuracy of the entered data, it can be saved to a floppy disk. The disk is now ready to send to the TFW Monitoring Program if no measurement unit conversions are required.

Data can be sent to the TFW Monitoring Program using several different methods. A few are described here. Gather together: a) copies of the field forms; b) USGS topographic maps with the stream segment locations marked; and c) the floppy disk with the electronic version of the data. This package can be delivered in person to the Northwest Indian Fisheries Commission, or sent through the mail. The electronic versions can be sent via e-mail, and hard copies can be faxed. After the program receives the disk, the data is imported into the database by a TFW-MP staff person.

Reports can be generated for each survey imported into the database. A Reference Point Survey Report presents information from Forms 2H and 2D (see Appendix G). Other surveys such as the Habitat Unit and Large Woody Debris Surveys use the most current Reference Point Survey data to calculate parameters such as number of units per channel width and kilometer, and LWD pieces per channel width and kilometer.

Safe and efficient archiving is also provided through Data Management Services. The data generated by individual cooperators is archived electronically in the database system. Hard copies of the field forms, topographic maps and supplemental information can also be archived at our facilities to meet quality assurance needs and to reduce the chance of loss due to personnel changes or destruction. Access to cooperator data can be limited by request.

6. References

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7. Appendixes

Appendix A

Reference Point Survey Task Checklist Copy Masters

A-1: Section 2 - Office: Pre-Survey Preparation
A-2: Section 3 - Reference Point Survey Method
A-3: Section 4 & 5 - Post-Field Documentation: Finalizing Forms 2H, 2T, 2D, and Data Management

(Keep original copy masters with manual)

Reference Point Survey Task Checklist

Stream Name ______________________
Date ___ / ___ / ______

Office: Pre-Survey Preparation

✔ *Section 2.0* *Office: Pre-Survey Preparation*

- ☐ Step 1: Complete specified information on the Reference Point Survey "Header Information" Form 2H.
- ☐ Step 2: Complete header information and make copies of the Reference Point Survey "Triangulation Documentation" Form 2T.
- ☐ Step 3: Complete header information and make copies of the Reference Point Survey "Field Data" Form 2D.
- ☐ Step 4: Select field survey equipment appropriate for local stream and site conditions.
- ☐ Step 5: Check all measurement equipment for damage and calibrate to document accuracy.
- ☐ Step 6: Select reference point tag and tag anchoring materials and equipment.
- ☐ Step 7: Gather, arrange, and organize stream site access information.

Reference Point Survey Task Checklist

Stream Name ______________________
Date ___ / ___ / _______

Reference Point Survey Method

✔*Section 3.1* *Establish and Document Reference Points*

□ Step 1: Lower Boundary: Identify and mark lower boundary location
100 Meter Interval: Identify and mark the next sequential 100 meter interval reference point location
Upper Boundary: Identify and mark the upper boundary location.

□ Step 2: Identify and flag the reference point cross section at a 90 degree orientation to the channel centerline.

□ Step 3: Identify and flag the "Base" reference point structure.

□ Step 4: Identify and flag the "Alternate" reference point structure.

□ Step 5: Attach reference point tags and document locations on Form 2T.

□ Step 6: Triangulate and document reference point locations on Form 2T.

□ Step 7: Record the "Reference Point #", "Bank", and "Cumulative Distance" info on Form 2D.

✔*Section 3.2* *Data Collection at Reference Points*

Bankfull Width Measurements

□ Step 1: Identify the location of the bankfull width measurement cross section.

□ Step 2: Identify the bankfull channel edge using indicators including floodplain, bank morphology and composition, and vegetation along the bankfull width cross section.

□ Step 3: Apply the default method to establish bankfull width measurement points on both banks.

□ Step 4: Secure measurement tape and record the bankfull width measurement on Form 2D.

*Bankfull Depth Measurement*s

□ Step 1: Calculate and record on Form 2D the depth measurement interval sequence using the 10% cell method.

□ Step 2: Take and record bankfull depth measurements on Form 2D.

□ Step 3: Calculate and record the mean bankfull depth on Form 2D.

*Canopy Closure Measurement*s

□ Step 1: Identify the location for taking canopy closure measurements along the bankfull width cross section.

□ Step 2: Position, stabilize, and level the densiometer in proper orientation to the bankfull width cross section tape.

□ Step 3: Take and sequentially record on Form 2D the upstream, left bank, downstream, and right bank channel direction canopy closure measurements.

□ Step 4: Calculate and record the mean canopy closure percentage on Form 2D.

Optional Reference Photographs

□ Step 1: Identify the channel location of the "Upstream" view photo point.

□ Step 2: Identify the channel location of the "Downstream" view photo point.

□ Step 3: Record on Form 2D the roll and frame numbers and notes related to photo point locations including specific frame contents.

Reference Point Survey Task Checklist

Stream Name ____________________

Date ___/___/______

Post-Field Documentation: Finalizing Form 2H, 2T, 2D Information & Data Management

✔*Section 4.1 Organize and Complete Information on Forms 2H, 2T, and 2D*

All Forms

- ☐ Page of Page Numbering

Form 2H:

- ☐ Study Design Information: Survey Length
- ☐ Study Design Information: Survey Coverage
- ☐ Study Design Information: Survey Percentage
- ☐ Survey Summary Field notes

Form 2D:

- ☐ Calculate any mean bankfull depths and mean canopy closures percentages not completed in the field
- ☐ Calculate the total bankfull width for multiple channel situations.
- ☐ Calculate mean bankfull depths for multiple channel situations.
- ☐ Optional: Calculate mean canopy closure for multiple channel situations.

✔*Section 4.2 Error Checking*

Form 2H

- ☐ Stream Name
- ☐ W.R.I.A. #
- ☐ Segment #/Sub-Segment Code
- ☐ W.R.I.A. River Mile
- ☐ New Forms &Dates
- ☐ Crew Information
- ☐ Equipment Documentation

Form 2T

- ☐ Stream Name
- ☐ W.R.I.A. #
- ☐ Segment #/Sub-Segment Code
- ☐ Crew initials
- ☐ Reference Point numbering
- ☐ Minimum "Base" and "Alt" RP documentation
- ☐ Sketch map

✔*Section 4.2 Error Checking (cont.)*

Form 2D

- ☐ Stream Name
- ☐ W.R.I.A. #
- ☐ Segment #/Sub-Segment Code
- ☐ Crew initials
- ☐ Reference Point numbering
- ☐ Cumulative Distance
- ☐ Bankfull width rounding & calculations
- ☐ Bankfull depth calculations & rounding
- ☐ Canopy closure calculations & rounding
- ☐ "Adjust X-Sect" information
- ☐ Field Notes information

✔*Section 5.1 Preparation*

- ☐ Completed and error-checked Forms 2H/2D
- ☐ Data entry system
- ☐ Data entry instructions and an "Ambsys" data dictionary

✔*Section 5.2 Data Processing, Products and Archiving*

- ☐ Key in the data from Forms 2H and 2D
- ☐ Error check data with original field forms
- ☐ Send completed data disk to TFW Monitoring Program
- ☐ Reference Point Survey Report sent back
- ☐ Monitoring data and reference point survey information archived

Appendix B

Monitoring Materials, Equipment, and Information Sources

Maps
Aerial Photos
Equipment
Sources for Previously Segmented Streams
Publications

Monitoring Materials, Equipment, and Information Sources

The use of trade and company names is for the benefit of the reader. Such use does not constitute an official endorsement or approval of any service or product by the TFW Monitoring Program to the exclusion of others that may be suitable.

Topographic Maps

Purchasing:
To order USGS topographic maps direct from USGS write or call:

U.S. Geological Survey
Western Distribution Branch
Box 25286, Federal Center
Denver, CO 80225
1-800-HELP-MAPS (for local map dealer information)
http://www.usgs.gov

U.S. Geological Survey
Earth Science Information Center
U.S. Postal Office Building, Rm. 135
904 W. Riverside Ave.
Spokane, WA 99201

U.S. Geological Survey
Earth Science Information Center
345 Middlefield Road
Menlo Park, CA 94025

USGS topographic maps can also be purchased from the Washington State Department of Natural Resources:

WDNR Map and Photo Sales
1111 Washington St.
Olympia, WA 98504
(360)902-1234

Topographic Map Interpretation:
State specific Indexes may also be purchased from USGS at the above addresses. These are booklets that represent the entire state and help to identify the names of the 7.5 minute topographic maps that cover any specific area or feature (possibly excepting National Parks).

- *Maps for America* - M. M. Thompson 1988: published by and available from USGS
- *Finding Your Way With Map and Compass*: Download from USGS home page
- *Topographic Map Symbols*: USGS pamphlet obtainable from a local field office.

Aerial Photographs

Purchasing:
- Through USGS at the same addresses given for map purchases.
- WDNR Photo & Map Sales at the same address given for map purchases.
- Also, you can search and order through the internet:
  http://edcwww.cr.usgs.gov/webglis/glisbin/search.pl?NAPP
- USGS EROS
  Data Center Customer Services
  Sioux Falls, SD 57198
  ph: (605)594-6151
  fax: (605)594-6589
  e-mail: custserv@edcmail.cr.usgs.gov

Borrowing: Check with county offices, military, or large local landowners such as timber companies or Indian tribes.

Interpretation of: Avery T. E. and G. L. Berlin. 1985. Interpretation of Aerial Photographs. Macmillan Publishing Company, New York.

Equipment

Purchasing: Equipment can often be purchased locally. Stores listed under the yellow page headings of: Surveying Instruments & Suppliers, Hardware, Sporting Goods, Engineering Equipment & Supplies will often stock this type of equipment.

Ivor McCray's Inc.
417 Union Ave. S.E.
Olympia, WA 98501
ph: (360)357-6707
fax: (360)357-2521

Equipment can also be purchased through the following catalogs:

Forestry Suppliers, Inc.
205 W. Rankin St.
P.O. Box 8397
Jackson, MS 39284-8397
ph: 1-800-647-5368
fax: 1-800-543-4203

Terra Tech, Inc. Int'l Reforestation Suppliers
P. O. Box 5547
Eugene, OR 97405-0547
ph: 1-800-321-1037
fax: 1-800-933-4569
website: www.terratech.net

GeoLine Positioning Systems, Inc.
1555 132nd Avenue North East
Bellevue, WA 98005-2265
ph: 1-800-523-6408
fax: (206)451-4152
e-mail: geoline@ix.netcom.com
website: www.geoline.com

Sources for Previously Segmented Streams

Primary source: Contact the Salmon and Steelhead Inventory and Assessment Project (SSHIAP) to determine whether stream segmenting has been done for your area of interest and to find out where those segment breaks are located. Contact:

Randy McIntosh
Northwest Indian Fisheries Commission
6730 Martin Way East
Olympia, WA 98516
ph: (360)438-1180
Fax: (360)753-8659
e-mail: rmcintos@nwifc.wa.gov

Secondary sources: To find out if a watershed analysis has been done for the area of interest, contact:

Carol Miller
Forest Practices Division
Washington Department of Natural Resources
Olympia, WA 98504
(360)902-1422.

For a current status list of Watershed Analyses or a complete list of Watershed Administrative Unit (WAU) numbers contact:

Tami Grant
Washington Department of Natural Resources
Forest Practices Division
Olympia, WA 98504
(360)902-1394.

Sources for Historical Stream (supplemental) Information:
Bureau of Reclamation
Bureau of Land Management
Local Landowners, especially Timber Companies and Indian Tribes

Publications

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. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 166 pp. *Contact: Seattle EPA office at 1-800-424-4372; ask for the document by title.*

Harrelson, C. C., C. L. Rawlins, J. P. Potyondy. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. U. S. D. A. Forest Service. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 61 pp. *Contact: Rocky Mountain Forest and Range Experiment Station publications department at (970)498 - 1719.*

Appendix C

Form 2H, 2T, and 2D Copy Masters

(Keep original copy masters with manual)

Stream Name ______

REFERENCE POINT SURVEY — HEADER INFORMATION — FORM 2H

WRIA # ___ . ______ | ___ | Unlisted Trib ___ ○ RB ○ LB | **Segment #** ______ | ___ Sub-Segment Code | **Date** ___/___/___

WRIA River Mile: from ___ to ___

Study Design Information

Survey Length [ ]

Survey Coverage

- ○ WHL (Whole)
- ○ PRT (Partial)
- ○ SUB (Sub-sample)
- ○ PSB (Partial Sub-sample)
- ○ THR (Thermal Reach)
- ○ OTH (Other)

Survey Percentage ___ %

Crew Lead ______

Recorder ______

Other Crew ______

Affiliation(s) ______

Crew Lead Experience

TFW-MP RP Training	QA Review
○ Pre -96	○ Pre-96
○ 1996	○ 1996
○ 1997	○ 1997
○ 1998	○ 1998
○ 1999	○ 1999
○ 20__	○ 20__

Other ______

Equipment ○ Metric ○ English	Type	Size	Cond	Accu-racy	Pre-Calibrated	Post-Calibrated
Hipchain						
Measuring tape						
Measuring rod						
Densiometer						
Compass						
○ True ○ Magnetic	True Declination ___° E W			Notes		
Common tag type						
Common tag anchor						
Wading Gear						
Tripod						
Tally Counter						

Survey Summary Field Notes

______

ERROR CHECKED by: ____ Date: ___/___/___

TFW Monitoring Program

Stream Name ______

Crew Lead ____
Recorder(s) ____ ____

Page ___ of ___

REFERENCE POINT SURVEY

TRIANGULATION DOCUMENTATION

FORM 2T

WRIA # ___ . ______ __   Unlisted Trib ______ ○ RB ○ LB   **Segment #** ______ ______ Sub-Segment Code   **Date** ___/___/___

RP # ○ Meters ○ Feet

RP #	Bank	Structure Type/ Spec.	Structure Dia.	Structure Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base							
T-A							
T-B							
Alt							
T-A							
T-B							

Sketch Map of RP Site and Notes

RP # ○ Meters ○ Feet

RP #	Bank	Structure Type/ Spec.	Structure Dia.	Structure Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base							
T-A							
T-B							
Alt							
T-A							
T-B							

Sketch Map of RP Site and Notes

TFW Monitoring Program

Stream Name

Crew Lead ____
Recorder(s) ____ ____

REFERENCE POINT SURVEY ○METERS ○FEET FIELD DATA FORM 2D

WRIA # __ __ . __ __ __ __ | __ | Unlisted Trib __ __ __ ○RB ○LB | **Segment #** ______ | ______ Sub-Segment Code | **Date** ____ / ____ / ______

Reference Point #	Bank	Cumulative Distance	Photographs Roll #	Photographs Frame # Up	Photographs Frame # Dn	Bankfull Width	Bankfull Depth	Canopy Closure Up	Canopy Closure LB	Canopy Closure Dn	Canopy Closure RB	Canopy Closure %	Adjust X-Sect (Distance)	Coop-Designated Optional Parameters			
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	
													○Up ○Dn				
Tape Stations ( )( )( )( )( )( )( )( )( )( )									Field Notes								
BFD Measurements ( )( )( )( )( )( )( )( )( )( )																	

Appendix D

Standard Field and Vehicle Gear Checklist Copy Master

(Keep original copy masters with manual)

✔ STANDARD FIELD GEAR

- ☐ Field clip board/form holder
- ☐ Survey Forms (on waterproof paper)
- ☐ Copy of survey methods
- ☐ Maps- topographic and road
- ☐ Pencils & erasers
- ☐ Permanent ink marker
- ☐ Calculator
- ☐ 150 mm ruler
- ☐ Pocket field notebook

- ☐ Survey Vest
- ☐ Compass
- ☐ Safety whistle
- ☐ Spring clips (2)
- ☐ Vinyl flagging
- ☐ Pocket knife/multi-purpose tool

- ☐ Backpack or canvas tote bag
- ☐ First aid kit
- ☐ Water bottle and/or filtration system
- ☐ Food/energy bars
- ☐ Rain gear
- ☐ Leather gloves
- ☐ Safety glasses
- ☐ Bug repellant
- ☐ Sun screen
- ☐ Small flashlight or headlamp
- ☐ Matches/fire starter
- ☐ Emergency blanket
- ☐ Snake bite kit (eastern Washington)

✔ STANDARD VEHICLE GEAR

- ☐ Waterproof plastic tote box
- ☐ Backup fiberglass tape
- ☐ Comprehensive first aid kit
- ☐ Rain tarp
- ☐ Rope (100 ft.)
- ☐ Extra water
- ☐ Extra food
- ☐ Extra dry clothes
- ☐ Extra batteries

- ☐ Spare tire/jack/tire iron
- ☐ Tire sealant/inflator
- ☐ Tow strap
- ☐ Come-along winch
- ☐ Fire shovel
- ☐ Fire extinguisher
- ☐ CB radio (to monitor logging activity)
- ☐ Cell phone/VHF radio
- ☐ Brush cutter
- ☐ Ax/bow saw/chain saw
- ☐ Tire chains

✔ For remote work, extra survival & safety gear is recommended.

This gear list is provided as a guideline for outfitting field crews and is not intended to cover all situations. Local conditions may require additional or different gear.

Appendix E

Completed Examples of Form 2H, 2T, and 2D

Stream Name DESCHUTES RIVER

REFERENCE POINT SURVEY — HEADER INFORMATION — FORM 2H

W.R.I.A. # 13.0028 | Unlisted Trib ○RB ○LB | **Segment #** 12 | b Sub-Segment Code | **Date** 6/2/97

W.R.I.A. Rivermile: from 4.7 to 5.4

Crew Lead AMY MORGAN
Recorder DEVIN SMITH
Other Crew

Affiliation(s) TFW MONITORING PROGRAM
"

Study Design Information

Survey Length 1750 m

Survey Coverage
- ● WHL (Whole)
- ○ PRT (Partial)
- ○ SUB (Sub-sample)
- ○ PSB (Partial Sub-sample)
- ○ THR (Thermal Reach)
- ○ OTH (Other)

Survey Percentage 100 %

Crew Lead Experience

TFW-MP RP Training	QA Review
● Pre-96	○ Pre-96
● 1996	● 1996
● 1997	● 1997
○ 1998	○ 1998
○ 1999	○ 1999
○ 20__	○ 20__

Other

Equipment (● Metric ○ English)	Type	Size	Cond	Accuracy	Pre-Calibrated	Post-Calibrated
Hipchain 10# H4	CHAINMAN II	STND	GOOD	+/- 2%	5/4/97	7/20/97
Measuring tape 037	KESON FIBERGLASS	50	"	+/- 0.01	"	"
Measuring rod 007	MOUND CITY STADIA	5.0	"	"	"	"
Densiometer SHEROS	CONVEX		"		"	"
Compass 249	SUUNTO MC-1	POCKET	"	+/- 2°	"	"
● True ○ Magnetic	True Declination 21° Ⓔ W			Notes		
Common tag type	O.F SOFT ALUM	7/8 x 3"	NEW	WIRE TIES / EMBOSSED		
Common tag anchor	ALUM NAIL	16d	NEW			
Wading Gear	CHEST	—	GOOD			
Tripod			GOOD			
Talley Counter			NEW			
CAMERA	MINOLTA WEATERMATIC	35mm	GOOD	30mm lens		
FILM	COLOR SLIDE	36 exp	400 EI			
REBAR	24"	1/2"	RUSTY	PVC "T" SAFETY CAPS PAINTED ORANGE		

Survey Summary Field Notes

- SUMMER LOW-FLOW CONDITIONS
- D. SMITH MEASURED ALL CANOPY CLOSURE & TOOK REFERENCE PHOTOGRAPHS
- RP 6 WAS ADJUSTED DUE TO INTERSECTION WITH SIDE CHANNEL RE-ENTRY POINT
- LB SIDE CHANNEL BETWEEN RP 6 & 8 - GOOD HABITAT
- RP 9 & 12 WERE ADJUSTED DUE TO UNSAFE LWD JAM CONDITIONS
- EVIDENCE OF LWD REMOVAL NEAR RP 15

ERROR CHECKED by: AP Date: 7/21/97

TFW Monitoring Program

Stream Name DESCHUTES RIVER

Crew Lead AM
Recorder(s) DS

REFERENCE POINT SURVEY

TRIANGULATION DOCUMENTATION

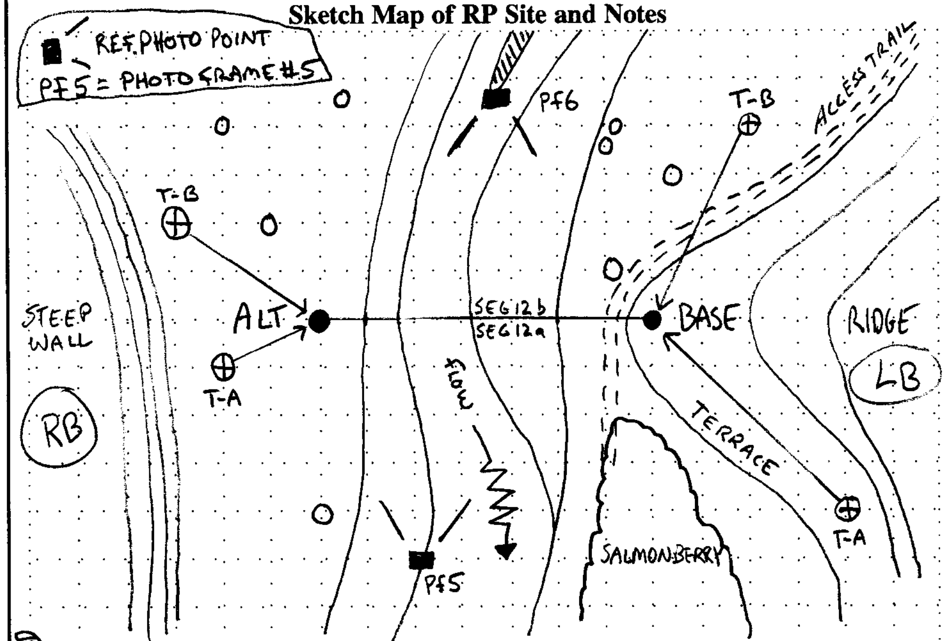
FORM 2T

W.R.I.A. # 13.0028 | Unlisted Trib ○RB ○LB | **Segment #** 12 | 6 Sub-Segment Code | **Date** 6/17/97

RP # 0 — ● Meters ○ Feet

RP	Bank	Structure Type/Spec.	Structure Dia.	Structure Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base	L	CEDAR	0.6	1.5	4.0		
T-A	L	D. FIR STUMP	0.3	0.5		12.0	318°
T-B	L	ALDER	0.4	1.0		9.0	212°
Alt	R	ALDER	0.3	1.5	2.0	10.0	96°
T-A	R	〃	0.2	1.0		4.0	68°
T-B	R	〃	0.4	0.5		6.0	134°

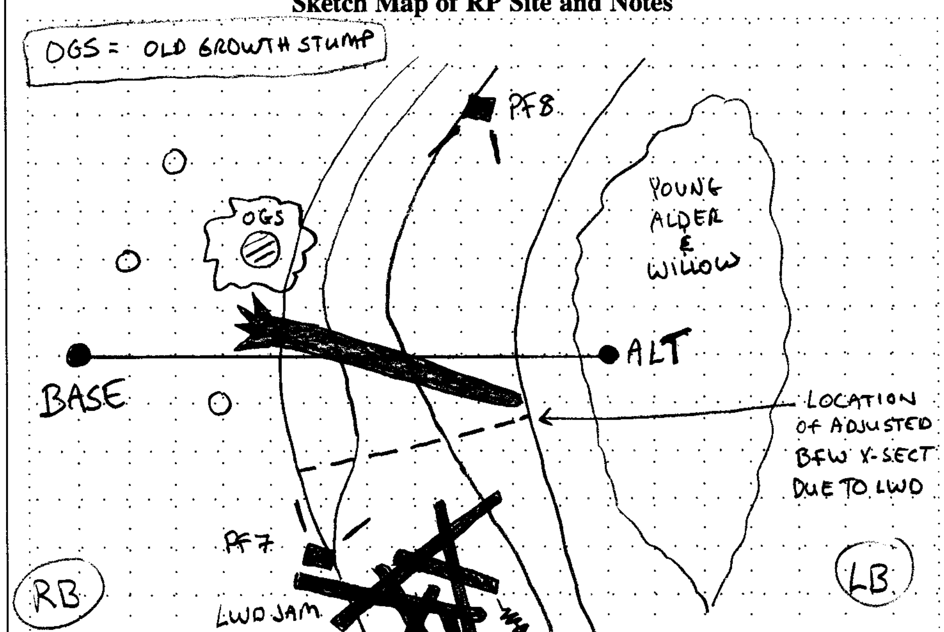
Sketch Map of RP Site and Notes



RP # 1 — ● Meters ○ Feet

RP	Bank	Structure Type/Spec.	Structure Dia.	Structure Tag Height	BFCE Dist.	Dist. to RP	Azimuth to RP
Base	R	MAPLE	0.3	1.5	6.0		
T-A		—					
T-B		—					
Alt	L	CAPPED REBAR	1/2"	0.1m	2.0	14.0	272°
T-A		—					
T-B		—					

Sketch Map of RP Site and Notes



ERROR CHECKED by: AP Date: 6/20/97

TFW Monitoring Program

Stream Name DESCHUTES RIVER

Crew Lead AM
Recorder(s) DS

REFERENCE POINT SURVEY

● METERS ○ FEET

FIELD DATA

FORM 2D

W.R.I.A. # 13.0028 | Unlisted Trib ○RB ○LB | Segment # 12 | 6 Sub-Segment Code | Date 6/17/97

Reference Point #	Bank	Cumulative Distance	Photographs Roll #	Frame # Up	Frame # Dn	Bankfull Width	Bankfull Depth	Canopy Closure Up	LB	Dn	RB	%	Adjust X-Sect (Distance)	Coop-Designated Optional Parameters			
7(a)	B	700	005	25	26	17.9	0.80	45	86	70	16	56	○Up ○Dn /				
7(b)	B	700	005	27	28	4.2	0.27	85	86	84	86	87	●Up ○Dn 2.0	DUE TO LWD			
MC 7	B	700	—	—	—	22.1	0.70	—	—	—	—	56	○Up ○Dn —				
8	B	800	005	29	30	19.6	0.79	27	66	89	81	68	○Up ○Dn —				
9	B	910	005	35	36	21.5	0.84	25	73	48	01	38	●Up ○Dn 10.0	DUE TO LWD JAM			
10	B	1000	006	02	03	20.3	0.76	68	78	31	20	51	○Up ○Dn —				

7(a)
1.79 Tape Stations (0.90)(2.69)(4.48)(6.27)(8.06)(9.85)(11.64)(13.43)(15.22)(17.01)
BFD Measurements (0.57)(0.77)(0.87)(0.86)(0.83)(0.82)(0.87)(0.90)(0.91)(0.62)
Field Notes (MAIN CHANNEL) BF AREA = 17.9 X 0.80 = 14.32 m²

7(b)
0.42 Tape Stations ( )( )( )( )( )( )( )( )( )( )
BFD Measurements ( )( )( )( )( )( )( )( )( )( )
Field Notes (SIDE CHANNEL) BF AREA = 4.2 X 0.27 = 1.13 m²
PF # 27 - TIED BACK BRUSH FOR BETTER VIEW

MC 7
Tape Stations ( )( )( )( )( )( )( )( )( )( )
BFD Measurements ( )( )( )( )( )( )( )( )( )( )
Field Notes MC BF AREA = 14.32 + 1.13 = 15.45
MC BFD = 15.45 / 22.10 = 0.699
CANOPY = 7(a) NO MC CALC

8
1.96 Tape Stations (0.96)(2.94)(4.90)(6.86)(8.82)(10.78)(12.74)(14.70)(16.66)(18.62)
BFD Measurements (0.45)(0.93)(1.17)(1.08)(1.13)(0.95)(0.81)(0.64)(0.47)(0.31)
Field Notes
PF# 31-34 OF LB BANK EROSION AREA ~20 m LONG

9
2.15 Tape Stations (1.08)(3.23)(5.38)(7.53)(9.68)(11.83)(13.98)(16.13)(18.28)(20.43)
BFD Measurements (0.52)(1.02)(0.99)(1.10)(0.95)(0.89)(0.85)(0.78)(0.67)(0.66)
Field Notes

10
2.03 Tape Stations (1.02)(3.05)(5.08)(7.11)(9.14)(11.17)(13.20)(15.23)(17.26)(19.29)
BFD Measurements (0.25)(0.43)(0.77)(1.01)(1.27)(1.08)(0.86)(0.62)(0.83)(0.43)
Field Notes
PF# 006/01 = ROLL ID SHEET

Appendix F

Bankfull Depth Cell Method Interval Matrix

Bankfull Depth Tape Station Matrix (METRIC)

Cell/Tape Station

BFW	1	2	3	4	5	6	7	8	9	10
1.0	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
1.1	0.06	0.17	0.28	0.39	0.50	0.61	0.72	0.83	0.94	1.05
1.2	0.06	0.18	0.30	0.42	0.54	0.66	0.78	0.90	1.02	1.14
1.3	0.07	0.20	0.33	0.46	0.59	0.72	0.85	0.98	1.11	1.24
1.4	0.07	0.21	0.35	0.49	0.63	0.77	0.91	1.05	1.19	1.33
1.5	0.08	0.23	0.38	0.53	0.68	0.83	0.98	1.13	1.28	1.43
1.6	0.08	0.24	0.40	0.56	0.72	0.88	1.04	1.20	1.36	1.52
1.7	0.09	0.26	0.43	0.60	0.77	0.94	1.11	1.28	1.45	1.62
1.8	0.09	0.27	0.45	0.63	0.81	0.99	1.17	1.35	1.53	1.71
1.9	0.10	0.29	0.48	0.67	0.86	1.05	1.24	1.43	1.62	1.81
2.0	0.10	0.30	0.50	0.70	0.90	1.10	1.30	1.50	1.70	1.90
2.1	0.11	0.32	0.53	0.74	0.95	1.16	1.37	1.58	1.79	2.00
2.2	0.11	0.33	0.55	0.77	0.99	1.21	1.43	1.65	1.87	2.09
2.3	0.12	0.35	0.58	0.81	1.04	1.27	1.50	1.73	1.96	2.19
2.4	0.12	0.36	0.60	0.84	1.08	1.32	1.56	1.80	2.04	2.28
2.5	0.13	0.38	0.63	0.88	1.13	1.38	1.63	1.88	2.13	2.38
2.6	0.13	0.39	0.65	0.91	1.17	1.43	1.69	1.95	2.21	2.47
2.7	0.14	0.41	0.68	0.95	1.22	1.49	1.76	2.03	2.30	2.57
2.8	0.14	0.42	0.70	0.98	1.26	1.54	1.82	2.10	2.38	2.66
2.9	0.15	0.44	0.73	1.02	1.31	1.60	1.89	2.18	2.47	2.76
3.0	0.15	0.45	0.75	1.05	1.35	1.65	1.95	2.25	2.55	2.85
3.1	0.16	0.47	0.78	1.09	1.40	1.71	2.02	2.33	2.64	2.95
3.2	0.16	0.48	0.80	1.12	1.44	1.76	2.08	2.40	2.72	3.04
3.3	0.17	0.50	0.83	1.16	1.49	1.82	2.15	2.48	2.81	3.14
3.4	0.17	0.51	0.85	1.19	1.53	1.87	2.21	2.55	2.89	3.23
3.5	0.18	0.53	0.88	1.23	1.58	1.93	2.28	2.63	2.98	3.33
3.6	0.18	0.54	0.90	1.26	1.62	1.98	2.34	2.70	3.06	3.42
3.7	0.19	0.56	0.93	1.30	1.67	2.04	2.41	2.78	3.15	3.52
3.8	0.19	0.57	0.95	1.33	1.71	2.09	2.47	2.85	3.23	3.61
3.9	0.20	0.59	0.98	1.37	1.76	2.15	2.54	2.93	3.32	3.71
4.0	0.20	0.60	1.00	1.40	1.80	2.20	2.60	3.00	3.40	3.80
4.1	0.21	0.62	1.03	1.44	1.85	2.26	2.67	3.08	3.49	3.90
4.2	0.21	0.63	1.05	1.47	1.89	2.31	2.73	3.15	3.57	3.99
4.3	0.22	0.65	1.08	1.51	1.94	2.37	2.80	3.23	3.66	4.09
4.4	0.22	0.66	1.10	1.54	1.98	2.42	2.86	3.30	3.74	4.18
4.5	0.23	0.68	1.13	1.58	2.03	2.48	2.93	3.38	3.83	4.28
4.6	0.23	0.69	1.15	1.61	2.07	2.53	2.99	3.45	3.91	4.37
4.7	0.24	0.71	1.18	1.65	2.12	2.59	3.06	3.53	4.00	4.47
4.8	0.24	0.72	1.20	1.68	2.16	2.64	3.12	3.60	4.08	4.56
4.9	0.25	0.74	1.23	1.72	2.21	2.70	3.19	3.68	4.17	4.66

Cell/Tape Station

BFW	1	2	3	4	5	6	7	8	9	10
5.0	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75
5.1	0.26	0.77	1.28	1.79	2.30	2.81	3.32	3.83	4.34	4.85
5.2	0.26	0.78	1.30	1.82	2.34	2.86	3.38	3.90	4.42	4.94
5.3	0.27	0.80	1.33	1.86	2.39	2.92	3.45	3.98	4.51	5.04
5.4	0.27	0.81	1.35	1.89	2.43	2.97	3.51	4.05	4.59	5.13
5.5	0.28	0.83	1.38	1.93	2.48	3.03	3.58	4.13	4.68	5.23
5.6	0.28	0.84	1.40	1.96	2.52	3.08	3.64	4.20	4.76	5.32
5.7	0.29	0.86	1.43	2.00	2.57	3.14	3.71	4.28	4.85	5.42
5.8	0.29	0.87	1.45	2.03	2.61	3.19	3.77	4.35	4.93	5.51
5.9	0.30	0.89	1.48	2.07	2.66	3.25	3.84	4.43	5.02	5.61
6.0	0.30	0.90	1.50	2.10	2.70	3.30	3.90	4.50	5.10	5.70
6.1	0.31	0.92	1.53	2.14	2.75	3.36	3.97	4.58	5.19	5.80
6.2	0.31	0.93	1.55	2.17	2.79	3.41	4.03	4.65	5.27	5.89
6.3	0.32	0.95	1.58	2.21	2.84	3.47	4.10	4.73	5.36	5.99
6.4	0.32	0.96	1.60	2.24	2.88	3.52	4.16	4.80	5.44	6.08
6.5	0.33	0.98	1.63	2.28	2.93	3.58	4.23	4.88	5.53	6.18
6.6	0.33	0.99	1.65	2.31	2.97	3.63	4.29	4.95	5.61	6.27
6.7	0.34	1.01	1.68	2.35	3.02	3.69	4.36	5.03	5.70	6.37
6.8	0.34	1.02	1.70	2.38	3.06	3.74	4.42	5.10	5.78	6.46
6.9	0.35	1.04	1.73	2.42	3.11	3.80	4.49	5.18	5.87	6.56
7.0	0.35	1.05	1.75	2.45	3.15	3.85	4.55	5.25	5.95	6.65
7.1	0.36	1.07	1.78	2.49	3.20	3.91	4.62	5.33	6.04	6.75
7.2	0.36	1.08	1.80	2.52	3.24	3.96	4.68	5.40	6.12	6.84
7.3	0.37	1.10	1.83	2.56	3.29	4.02	4.75	5.48	6.21	6.94
7.4	0.37	1.11	1.85	2.59	3.33	4.07	4.81	5.55	6.29	7.03
7.5	0.38	1.13	1.88	2.63	3.38	4.13	4.88	5.63	6.38	7.13
7.6	0.38	1.14	1.90	2.66	3.42	4.18	4.94	5.70	6.46	7.22
7.7	0.39	1.16	1.93	2.70	3.47	4.24	5.01	5.78	6.55	7.32
7.8	0.39	1.17	1.95	2.73	3.51	4.29	5.07	5.85	6.63	7.41
7.9	0.40	1.19	1.98	2.77	3.56	4.35	5.14	5.93	6.72	7.51
8.0	0.40	1.20	2.00	2.80	3.60	4.40	5.20	6.00	6.80	7.60
8.1	0.41	1.22	2.03	2.84	3.65	4.46	5.27	6.08	6.89	7.70
8.2	0.41	1.23	2.05	2.87	3.69	4.51	5.33	6.15	6.97	7.79
8.3	0.42	1.25	2.08	2.91	3.74	4.57	5.40	6.23	7.06	7.89
8.4	0.42	1.26	2.10	2.94	3.78	4.62	5.46	6.30	7.14	7.98
8.5	0.43	1.28	2.13	2.98	3.83	4.68	5.53	6.38	7.23	8.08
8.6	0.43	1.29	2.15	3.01	3.87	4.73	5.59	6.45	7.31	8.17
8.7	0.44	1.31	2.18	3.05	3.92	4.79	5.66	6.53	7.39	8.26
8.8	0.44	1.32	2.20	3.08	3.96	4.84	5.72	6.60	7.48	8.36
8.9	0.45	1.34	2.23	3.12	4.01	4.90	5.79	6.68	7.57	8.45
9.0	0.45	1.35	2.25	3.15	4.05	4.95	5.85	6.75	7.65	8.55
9.1	0.46	1.37	2.28	3.19	4.10	5.01	5.92	6.82	7.73	8.64
9.2	0.46	1.38	2.30	3.22	4.14	5.06	5.98	6.90	7.82	8.74
9.3	0.47	1.40	2.33	3.26	4.19	5.12	6.05	6.98	7.91	8.84
9.4	0.47	1.41	2.35	3.29	4.23	5.17	6.11	7.05	7.99	8.93
9.5	0.48	1.43	2.38	3.33	4.28	5.23	6.17	7.12	8.07	9.02
9.6	0.48	1.44	2.40	3.36	4.32	5.28	6.24	7.20	8.16	9.12
9.7	0.49	1.46	2.43	3.40	4.37	5.33	6.30	7.27	8.24	9.21
9.8	0.49	1.47	2.45	3.43	4.41	5.39	6.37	7.35	8.33	9.31
9.9	0.49	1.49	2.48	3.47	4.46	5.44	6.43	7.42	8.41	9.40

Bankfull Depth Tape Station Matrix (METRIC)

BFW	Cell/Tape Station 1	2	3	4	5	6	7	8	9	10
10.0	0.50	1.50	2.50	3.50	4.50	5.50	6.50	7.50	8.50	9.50
10.1	0.51	1.52	2.53	3.54	4.55	5.56	6.57	7.58	8.59	9.60
10.2	0.51	1.53	2.55	3.57	4.59	5.61	6.63	7.65	8.67	9.69
10.3	0.52	1.55	2.58	3.61	4.64	5.67	6.70	7.73	8.76	9.79
10.4	0.52	1.56	2.60	3.64	4.68	5.72	6.76	7.80	8.84	9.88
10.5	0.53	1.58	2.63	3.68	4.73	5.78	6.83	7.88	8.93	9.98
10.6	0.53	1.59	2.65	3.71	4.77	5.83	6.89	7.95	9.01	10.07
10.7	0.54	1.61	2.68	3.75	4.82	5.89	6.96	8.03	9.10	10.17
10.8	0.54	1.62	2.70	3.78	4.86	5.94	7.02	8.10	9.18	10.26
10.9	0.55	1.64	2.73	3.82	4.91	6.00	7.09	8.18	9.27	10.36
11.0	0.55	1.65	2.75	3.85	4.95	6.05	7.15	8.25	9.35	10.45
11.1	0.56	1.67	2.78	3.89	5.00	6.11	7.22	8.33	9.44	10.55
11.2	0.56	1.68	2.80	3.92	5.04	6.16	7.28	8.40	9.52	10.64
11.3	0.57	1.70	2.83	3.96	5.09	6.22	7.35	8.48	9.61	10.74
11.4	0.57	1.71	2.85	3.99	5.13	6.27	7.41	8.55	9.69	10.83
11.5	0.58	1.73	2.88	4.03	5.18	6.33	7.48	8.63	9.78	10.93
11.6	0.58	1.74	2.90	4.06	5.22	6.38	7.54	8.70	9.86	11.02
11.7	0.59	1.76	2.93	4.10	5.27	6.44	7.61	8.78	9.95	11.12
11.8	0.59	1.77	2.95	4.13	5.31	6.49	7.67	8.85	10.03	11.21
11.9	0.60	1.79	2.98	4.17	5.36	6.55	7.74	8.93	10.12	11.31
12.0	0.60	1.80	3.00	4.20	5.40	6.60	7.80	9.00	10.20	11.40
12.1	0.61	1.82	3.03	4.24	5.45	6.66	7.87	9.08	10.29	11.50
12.2	0.61	1.83	3.05	4.27	5.49	6.71	7.93	9.15	10.37	11.59
12.3	0.62	1.85	3.08	4.31	5.54	6.77	8.00	9.23	10.46	11.69
12.4	0.62	1.86	3.10	4.34	5.58	6.82	8.06	9.30	10.54	11.78
12.5	0.63	1.88	3.13	4.38	5.63	6.88	8.13	9.38	10.63	11.88
12.6	0.63	1.89	3.15	4.41	5.67	6.93	8.19	9.45	10.71	11.97
12.7	0.64	1.91	3.18	4.45	5.72	6.99	8.26	9.53	10.80	12.07
12.8	0.64	1.92	3.20	4.48	5.76	7.04	8.32	9.60	10.88	12.16
12.9	0.65	1.94	3.23	4.52	5.81	7.10	8.39	9.68	10.97	12.26
13.0	0.65	1.95	3.25	4.55	5.85	7.15	8.45	9.75	11.05	12.35
13.1	0.66	1.97	3.28	4.59	5.90	7.21	8.52	9.83	11.14	12.45
13.2	0.66	1.98	3.30	4.62	5.94	7.26	8.58	9.90	11.22	12.54
13.3	0.67	2.00	3.33	4.66	5.99	7.32	8.65	9.98	11.31	12.64
13.4	0.67	2.01	3.35	4.69	6.03	7.37	8.71	10.05	11.39	12.73
13.5	0.68	2.03	3.38	4.73	6.08	7.43	8.78	10.13	11.48	12.83
13.6	0.68	2.04	3.40	4.76	6.12	7.48	8.84	10.20	11.56	12.92
13.7	0.69	2.06	3.43	4.80	6.17	7.54	8.91	10.28	11.65	13.02
13.8	0.69	2.07	3.45	4.83	6.21	7.59	8.97	10.35	11.73	13.11
13.9	0.70	2.09	3.48	4.87	6.26	7.65	9.04	10.43	11.82	13.21
14.0	0.70	2.10	3.50	4.90	6.30	7.70	9.10	10.50	11.90	13.30
14.1	0.71	2.12	3.53	4.94	6.35	7.76	9.17	10.58	11.99	13.40
14.2	0.71	2.13	3.55	4.97	6.39	7.81	9.23	10.65	12.07	13.49
14.3	0.72	2.15	3.58	5.01	6.44	7.87	9.30	10.73	12.16	13.59
14.4	0.72	2.16	3.60	5.04	6.48	7.92	9.36	10.80	12.24	13.68
14.5	0.73	2.18	3.63	5.08	6.53	7.98	9.43	10.88	12.33	13.78
14.6	0.73	2.19	3.65	5.11	6.57	8.03	9.49	10.95	12.41	13.87
14.7	0.74	2.21	3.68	5.15	6.62	8.09	9.56	11.03	12.50	13.97
14.8	0.74	2.22	3.70	5.18	6.66	8.14	9.62	11.10	12.58	14.06
14.9	0.75	2.24	3.73	5.22	6.71	8.20	9.69	11.18	12.67	14.16

BFW	Cell/Tape Station 1	2	3	4	5	6	7	8	9	10
15.0	0.75	2.25	3.75	5.25	6.75	8.25	9.75	11.25	12.75	14.25
15.1	0.76	2.27	3.78	5.29	6.80	8.31	9.82	11.33	12.84	14.35
15.2	0.76	2.28	3.80	5.32	6.84	8.36	9.88	11.40	12.92	14.44
15.3	0.77	2.30	3.83	5.36	6.89	8.42	9.95	11.48	13.01	14.54
15.4	0.77	2.31	3.85	5.39	6.93	8.47	10.01	11.55	13.09	14.63
15.5	0.78	2.33	3.88	5.43	6.98	8.53	10.08	11.63	13.18	14.73
15.6	0.78	2.34	3.90	5.46	7.02	8.58	10.14	11.70	13.26	14.82
15.7	0.79	2.36	3.93	5.50	7.07	8.64	10.21	11.78	13.35	14.92
15.8	0.79	2.37	3.95	5.53	7.11	8.69	10.27	11.85	13.43	15.01
15.9	0.80	2.39	3.98	5.57	7.16	8.75	10.34	11.93	13.52	15.11
16.0	0.80	2.40	4.00	5.60	7.20	8.80	10.40	12.00	13.60	15.20
16.1	0.81	2.42	4.03	5.64	7.25	8.86	10.47	12.08	13.69	15.30
16.2	0.81	2.43	4.05	5.67	7.29	8.91	10.53	12.15	13.77	15.39
16.3	0.82	2.45	4.08	5.71	7.34	8.97	10.60	12.23	13.86	15.49
16.4	0.82	2.46	4.10	5.74	7.38	9.02	10.66	12.30	13.94	15.58
16.5	0.83	2.48	4.13	5.78	7.43	9.08	10.73	12.38	14.03	15.68
16.6	0.83	2.49	4.15	5.81	7.47	9.13	10.79	12.45	14.11	15.77
16.7	0.84	2.51	4.18	5.85	7.52	9.19	10.86	12.53	14.20	15.87
16.8	0.84	2.52	4.20	5.88	7.56	9.24	10.92	12.60	14.28	15.96
16.9	0.85	2.54	4.23	5.92	7.61	9.30	10.99	12.68	14.37	16.06
17.0	0.85	2.55	4.25	5.95	7.65	9.35	11.05	12.75	14.45	16.15
17.1	0.86	2.57	4.28	5.99	7.70	9.41	11.12	12.83	14.54	16.25
17.2	0.86	2.58	4.30	6.02	7.74	9.46	11.18	12.90	14.62	16.34
17.3	0.87	2.60	4.33	6.06	7.79	9.52	11.25	12.98	14.71	16.44
17.4	0.87	2.61	4.35	6.09	7.83	9.57	11.31	13.05	14.79	16.53
17.5	0.88	2.63	4.38	6.13	7.88	9.63	11.38	13.13	14.88	16.63
17.6	0.88	2.64	4.40	6.16	7.92	9.68	11.44	13.20	14.96	16.72
17.7	0.89	2.66	4.43	6.20	7.97	9.74	11.51	13.28	15.05	16.82
17.8	0.89	2.67	4.45	6.23	8.01	9.79	11.57	13.35	15.13	16.91
17.9	0.90	2.69	4.48	6.27	8.06	9.85	11.64	13.43	15.22	17.01
18.0	0.90	2.70	4.50	6.30	8.10	9.90	11.70	13.50	15.30	17.10
18.1	0.91	2.72	4.53	6.34	8.15	9.96	11.77	13.58	15.39	17.20
18.2	0.91	2.73	4.55	6.37	8.19	10.01	11.83	13.65	15.47	17.29
18.3	0.92	2.75	4.58	6.41	8.24	10.07	11.90	13.73	15.56	17.39
18.4	0.92	2.76	4.60	6.44	8.28	10.12	11.96	13.80	15.64	17.48
18.5	0.93	2.78	4.63	6.48	8.33	10.18	12.03	13.88	15.73	17.58
18.6	0.93	2.79	4.65	6.51	8.37	10.23	12.09	13.95	15.81	17.67
18.7	0.94	2.81	4.68	6.55	8.42	10.29	12.16	14.03	15.90	17.77
18.8	0.94	2.82	4.70	6.58	8.46	10.34	12.22	14.10	15.98	17.86
18.9	0.95	2.84	4.73	6.62	8.51	10.40	12.29	14.18	16.07	17.96
19.0	0.95	2.85	4.75	6.65	8.55	10.45	12.35	14.25	16.15	18.05
19.1	0.96	2.87	4.78	6.69	8.60	10.51	12.42	14.33	16.24	18.15
19.2	0.96	2.88	4.80	6.72	8.64	10.56	12.48	14.40	16.32	18.24
19.3	0.97	2.90	4.83	6.76	8.69	10.62	12.55	14.48	16.41	18.34
19.4	0.97	2.91	4.85	6.79	8.73	10.67	12.61	14.55	16.49	18.43
19.5	0.98	2.93	4.88	6.83	8.78	10.73	12.68	14.63	16.58	18.53
19.6	0.98	2.94	4.90	6.86	8.82	10.78	12.74	14.70	16.66	18.62
19.7	0.99	2.96	4.93	6.90	8.87	10.84	12.81	14.78	16.75	18.72
19.8	0.99	2.97	4.95	6.93	8.91	10.89	12.87	14.85	16.83	18.81
19.9	1.00	2.99	4.98	6.97	8.96	10.95	12.94	14.93	16.92	18.91
20.0	1.00	3.00	5.00	7.00	9.00	11.00	13.00	15.00	17.00	19.00

Bankfull Depth Tape Station Matrix
(METRIC)

Cell/Tape Station

BFW	1	2	3	4	5	6	7	8	9	10
20.0	1.00	3.00	5.00	7.00	9.00	11.00	13.00	15.00	17.00	19.00
20.1	1.01	3.02	5.03	7.04	9.05	11.06	13.07	15.08	17.09	19.10
20.2	1.01	3.03	5.05	7.07	9.09	11.11	13.13	15.15	17.17	19.19
20.3	1.02	3.05	5.08	7.11	9.14	11.17	13.20	15.23	17.26	19.29
20.4	1.02	3.06	5.10	7.14	9.18	11.22	13.26	15.30	17.34	19.38
20.5	1.03	3.08	5.13	7.18	9.23	11.28	13.33	15.38	17.43	19.48
20.6	1.03	3.09	5.15	7.21	9.27	11.33	13.39	15.45	17.51	19.57
20.7	1.04	3.11	5.18	7.25	9.32	11.39	13.46	15.53	17.60	19.67
20.8	1.04	3.12	5.20	7.28	9.36	11.44	13.52	15.60	17.68	19.76
20.9	1.05	3.14	5.23	7.32	9.41	11.50	13.59	15.68	17.77	19.86
21.0	1.05	3.15	5.25	7.35	9.45	11.55	13.65	15.75	17.85	19.95
21.1	1.06	3.17	5.28	7.39	9.50	11.61	13.72	15.83	17.94	20.05
21.2	1.06	3.18	5.30	7.42	9.54	11.66	13.78	15.90	18.02	20.14
21.3	1.07	3.20	5.33	7.46	9.59	11.72	13.85	15.98	18.11	20.24
21.4	1.07	3.21	5.35	7.49	9.63	11.77	13.91	16.05	18.19	20.33
21.5	1.08	3.23	5.38	7.53	9.68	11.83	13.98	16.13	18.28	20.43
21.6	1.08	3.24	5.40	7.56	9.72	11.88	14.04	16.20	18.36	20.52
21.7	1.09	3.26	5.43	7.60	9.77	11.94	14.11	16.28	18.45	20.62
21.8	1.09	3.27	5.45	7.63	9.81	11.99	14.17	16.35	18.53	20.71
21.9	1.10	3.29	5.48	7.67	9.86	12.05	14.24	16.43	18.62	20.81
22.0	1.10	3.30	5.50	7.70	9.90	12.10	14.30	16.50	18.70	20.90
22.1	1.11	3.32	5.53	7.74	9.95	12.16	14.37	16.58	18.79	21.00
22.2	1.11	3.33	5.55	7.77	9.99	12.21	14.43	16.65	18.87	21.09
22.3	1.12	3.35	5.58	7.81	10.04	12.27	14.50	16.73	18.96	21.19
22.4	1.12	3.36	5.60	7.84	10.08	12.32	14.56	16.80	19.04	21.28
22.5	1.13	3.38	5.63	7.88	10.13	12.38	14.63	16.88	19.13	21.38
22.6	1.13	3.39	5.65	7.91	10.17	12.43	14.69	16.95	19.21	21.47
22.7	1.14	3.41	5.68	7.95	10.22	12.49	14.76	17.03	19.30	21.57
22.8	1.14	3.42	5.70	7.98	10.26	12.54	14.82	17.10	19.38	21.66
22.9	1.15	3.44	5.73	8.02	10.31	12.60	14.89	17.18	19.47	21.76
23.0	1.15	3.45	5.75	8.05	10.35	12.65	14.95	17.25	19.55	21.85
23.1	1.16	3.47	5.78	8.09	10.40	12.71	15.02	17.33	19.64	21.95
23.2	1.16	3.48	5.80	8.12	10.44	12.76	15.08	17.40	19.72	22.04
23.3	1.17	3.50	5.83	8.16	10.49	12.82	15.15	17.48	19.81	22.14
23.4	1.17	3.51	5.85	8.19	10.53	12.87	15.21	17.55	19.89	22.23
23.5	1.18	3.53	5.88	8.23	10.58	12.93	15.28	17.63	19.98	22.33
23.6	1.18	3.54	5.90	8.26	10.62	12.98	15.34	17.70	20.06	22.42
23.7	1.19	3.56	5.93	8.30	10.67	13.04	15.41	17.78	20.15	22.52
23.8	1.19	3.57	5.95	8.33	10.71	13.09	15.47	17.85	20.23	22.61
23.9	1.20	3.59	5.98	8.37	10.76	13.15	15.54	17.93	20.32	22.71
24.0	1.20	3.60	6.00	8.40	10.80	13.20	15.60	18.00	20.40	22.80
24.1	1.21	3.62	6.03	8.44	10.85	13.26	15.67	18.08	20.49	22.90
24.2	1.21	3.63	6.05	8.47	10.89	13.31	15.73	18.15	20.57	22.99
24.3	1.22	3.65	6.08	8.51	10.94	13.37	15.80	18.23	20.66	23.09
24.4	1.22	3.66	6.10	8.54	10.98	13.42	15.86	18.30	20.74	23.18
24.5	1.23	3.68	6.13	8.58	11.03	13.48	15.93	18.38	20.83	23.28
24.6	1.23	3.69	6.15	8.61	11.07	13.53	15.99	18.45	20.91	23.37
24.7	1.24	3.71	6.18	8.65	11.12	13.59	16.06	18.53	21.00	23.47
24.8	1.24	3.72	6.20	8.68	11.16	13.64	16.12	18.60	21.08	23.56
24.9	1.25	3.74	6.23	8.72	11.21	13.70	16.19	18.68	21.17	23.66
25.0	1.25	3.75	6.25	8.75	11.25	13.75	16.25	18.75	21.25	23.75

Appendix G

Data Management Examples

APPENDIX G

Reference Point Header Excel Entry Sheet

TFW Monitoring																	
Reference Point Survey Header																	
wria basin	wria stream	trib	segm	sub segm	beginning survey date	end survey date	leader first name	leader last name	leader affiliation	recorder first name	recorder last name	recorder affiliation	beginning river mile (mi)	ending river mile (mi)	survey length (m)	survey coverage	survey percentage (%)	field notes

APPENDIX G

Reference Point Detail Excel Entry Sheet

TFW Monitoring																				
Reference Point Survey Data																				
wria basin	wria stream	trib	segm	sub segm	beginning survey date	refpt survey date	refpt num	refpt bank	cum dist (m)	roll num	upstr frame	dwnstr frame	bank width (m)	bank depth (m)	upstr canopy	left bank canopy	dwnstr canopy	right bank canopy	prcnt canopy	multi-chan canopy	field notes	entry date

Reference Point Survey Report

Stream Name:	KENNEDY CREEK	WRIA:	14 .0012 .000
Survey Date:	9/1/94 to 9/1/94	Segment:	1 sub: 0
Reference Points:	0 to 4	Survey Length:	400
River Miles:	0 to 0.2	Survey Coverage:	
Survey Leader:	IAN CHILD	Affiliation:	SQUAXIN ISLAND TRIBE

Number of Reference Points: 5

Cumulative Distance (meters): 400

Bankful Width (meters)

Mean:	6.12
Minimum:	5.10
Maximum:	7.70

Bankful Depth (meters)

Mean:	0.420
Minimum:	0.330
Maximum:	0.610

Width to Depth Ratio: 14.57

Canopy Closure

Mean:	18.20 %
Minimum:	2.00 %
Maximum:	45.00 %

Appendix H

Glossary of Terms

GLOSSARY OF TERMS

Bankfull Channel - The drainage system through which water, sediment and LWD inputs are actively transported and deposited and that are capable of containing most flows. The channel is self-formed in that the water in the channel and the debris it carries result in the channel. The water carves and maintains the conduit containing it (Dunne and Leopold, 1978). Because of the range of discharge to which most natural channels are subject, it is logical to assume that the channel shape is affected by a range of flows rather than by a single discharge (Wolman and Miller, 1960).

Bankfull Channel Edge (BFCE)- the point along the perimeter of the channel where shear stress caused by flow is just balanced by the resisting stress of the bed or banks (Leopold et al., 1964). The shape of the cross section of a river channel at any location is a function of flow, the quantity and character of the sediment in movement through the section, and the character or composition of the materials making up the bed and banks of the channel. In nature the last will usually include vegetation .

Bankfull Event - the storm system or other event that produces the water input required to bring the stream level up to or past the bankfull channel edge.

Bankfull Flow - the quantity of water measured in cubic feet or meters per minute required to bring the water level up to the bankfull channel edge.

Bankfull Stage - the height of the water surface when it intersects the bankfull channel edges. This parameter is typically measured with a staff gauge. Stage corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Bankfull Width (BFW) - the distance between bankfull channel edges (BFCE) and measured at cross-sections perpendicular to the center of the channel. The location of the wetted channel, direction of flow, or the absence of water at the time of the survey does not affect this measurement.

Channel Confinement - the degree to which stream channel migration is limited in its lateral movement by terraces or hillslope. It is expressed as the ratio of the width of the floodplain to the channel's bankfull width.

Channel Gradient - Rise in water surface elevation between two points along the length of the bankfull channel divided by the run (distance) between them. Recorded as a percentage for each measurement sight or used to calculate the segment mean.

Channelization - The human modification of a channel which typically includes straightening and deepening to permit the water to move faster, protect against flooding and channel migration, or to drain marshy acreage for farming (Bates and Jackson, 1984).

Floodplain - (Watershed Analysis calls this the 'valley width') The relatively flat area adjoining a channel constructed by the river through lateral migration in the present climate and flooded (all or partially) at a relatively consistent recurrence interval of 1.5 years in the annual flood series; this area provides temporary storage for sediment and flood waters (Dunne and Leopold, 1978).

Fluvial - anything that is produced by the action of a stream or river (Bates and Jackson, 1984). Channels are formed and maintained through fluvial processes.

Hillslope - (also called 'valley wall') Natural boundaries that have never been occupied by the channel. Supply sediment to stream channels (Dunne and Leopold, 1978).

Island - an area of terrestrial land that is isolated from the floodplain or valley flat by the bankfull channel of a divided stream and meets the following criteria: 1) the length of the island above the bankfull channel is equal to or greater than twice the estimated bankfull channel width; and 2) it is vegetated by two or more perennial plants that are greater than 2 meters in height.

Side Channel - A small channel divided from the primary low flow channel by an island and currently contains or would contain flowing water fed primarily by the main channel during a bankfull event. The side channel's bankfull channel edges must be definable.

Sinuosity - the extent of channel meandering typically expressed as a ratio of lengths related to: a) the bankfull channel within the floodplain; and b) the summer low flow channel within the bankfull channel. The greater the length of the first parameter, the greater the value of sinuosity.

Splitting - the process of dividing or separating out sections of stream with similar parameters and/or other characteristics. Splitting tends to make more and smaller similar stream segments.

Terrace - The inactive floodplain, or active only during severe storm events on some rivers. These are raised areas on the valley flat that were historically part of the floodplain but were abandoned when the channel cut down (e.g., due to a new relation between discharge and sediment production)(Dunne and Leopold, 1978).

Tributary - Any stream that contributes water either continuously or periodically to another stream (Bates and Jackson, 1984).

Valley flat - (also called the 'valley floor' or 'valley width') The area that at some time in the past the channel has occupied each and every position across its width. Includes terraces and floodplain (Dunne and Leopold, 1978).