



*United States Environmental Protection Agency
Office of Water
Office of Environmental Information
Washington, DC
EPA-841-B-07-009*

National Rivers and Streams Assessment Field Operations Manual



April 2009

This document is NOT the full protocol. Wadeable Methods have been extracted from the full protocol, which is available from the EPA. Search for report EPA-841-B-07-009. Or visit, <http://water.epa.gov/type/rs/monitoring/riverssurvey/>

6.0 WADEABLE STREAMS

6.1 Water Quality

This section describes the procedures and methods for the field collection and analysis of the water quality indicators (in-situ measurements, water chemistry, and sediment enzymes) from wadeable streams and rivers.

6.1.1 In Situ Measurements of Dissolved Oxygen, pH, Temperature, and Conductivity

6.1.1.1 Summary of Method

You will measure dissolved oxygen (DO), pH, temperature, and conductivity by using a multi-parameter water quality meter (or sonde). Take all measurements at the X site at 0.5 m depth, or mid-depth if depth is <1 m. The site depth must be accurately measured before taking the measurements, and care should be taken to avoid the probe contacting bottom sediments.

6.1.1.2 Equipment and Supplies

Table 6.1-1 provides the equipment and supplies needed to measure dissolved oxygen, pH, temperature, and conductivity. Record the measurements on the Field Measurement Form, as seen in Figure 6.1-1.

Table 6.1-1. Equipment and supplies—DO, pH, temperature, and conductivity

For taking measurements and calibrating the water quality meter	<ul style="list-style-type: none"> ▪ Multi-parameter water quality meter with DO, pH, temperature, and conductivity probes. ▪ Extra batteries ▪ De-ionized and tap water ▪ Calibration cups and standards ▪ QC calibration standard ▪ Barometer or elevation chart to use for calibration
For recording measurements	<ul style="list-style-type: none"> ▪ Field Measurement Form ▪ Pencils (for data forms)

FIELD MEASUREMENT FORM - WADEABLE						Reviewed by (initial): <u>JD</u>	
SITE ID: <u>FW08 XX000</u>		DATE: <u>07/01/2008</u>					
CALIBRATION INFORMATION							
Instrument manufacturer and model: <u>YSI MODEL 85</u>							
Instrument ID number: <u>EPA 654321</u>			Operator: <u>J. DOLF</u>				
TEMPERATURE	Thermometer Reading (°C)	Sensor Reading (°C)	Flag	Comments			
	<u>15.2</u>	<u>15.0</u>					
DO	Elevation	OR	Barometric Pressure (mm Hg)	Calibration Value	Displayed Value	Flag	
	<u>200</u> <input type="radio"/> ft <input type="radio"/> m			<u>100.0</u> <input type="radio"/> mg/L <input type="radio"/> %	<u>99.9</u> <input type="radio"/> mg/L <input type="radio"/> %		
pH	Cal. STD 1 Description		Cal. STD 1 Value	Cal. STD 2 Description		Cal. STD 2 Value	
	<u>pH 7 BUFFER</u>		<u>7.00</u>	<u>pH 4 BUFFER</u>		<u>4.00</u>	
	Calibration Verified with Quality Control Sample (QCS)						
	QCS Description		QCS True	QCS Measured	Flag		
<u>DILUTE NIST PHOSPHATE BUFFER</u>		<u>6.98</u>	<u>6.95</u>	<u>F1</u>			
CONDUCTIVITY	Cal. STD 1 Description		Cal. STD 1 Value	Cal. STD 2 Description		Cal. STD 2 Value	
	<u>KCl STANDARD</u>		<u>147</u>				
	Calibration Verified with Quality Control Sample (QCS)						
	QCS Description		QCS True (µS/cm @25°C)	QCS Measured (µS/cm @25°C)	Flag		
<u>DILUTE NIST PHOSPHATE BUFFER</u>		<u>75.3</u>	<u>83.2</u>				
Flag	Comments						
Field Measurements <input checked="" type="radio"/> MID CHANNEL <input type="radio"/> OTHER							
TRANSECT:	Time of Day (hh:mm)	<u>09:15</u>					
<input checked="" type="checkbox"/> F	DO(mg/L) XX.X	<u>8.9</u>					
	Temp. (°C) XX.X	<u>19.3</u>					
	pH XX.XX	<u>6.75</u>					
	Cond. (µS/cm@25°C) XX.X	<u>320.4</u>					
	Corrected to 25°C ?	<input checked="" type="radio"/> Y <input type="radio"/> N					
	Secchi Depth (cm) XX.X	<u>30.2</u>					
	Visible on bottom?	<input checked="" type="radio"/> YES					
	Flag						
Flag	Comments						
Draft							
<small>Flag codes: K = No measurement or observation made; U = Suspect measurement or observation; F1, F2, etc. = misc. flags assigned by field crew. Explain all flags in comment sections. 03/26/2008 NRSA Fld Measrmt Wadeable</small>							

Figure 6.1-1. Field Measurement Form.

6.1.1.3 Multi-Probe Sonde

Dissolved Oxygen Meter

Calibrate the DO meter prior to each sampling event. We recommend that the probe be calibrated in the field against an atmospheric standard (ambient air saturated with water) prior to sampling. In addition, manufacturers typically recommend periodic comparisons with a DO chemical analysis procedure (e.g., Winkler titration) to check accuracy and linearity.

pH Meter

Calibrate the pH meter prior to each sampling event. Calibrate the meter in accordance with the manufacturer's instructions and with the team agency's existing SOP. You must also conduct a quality control check with the provided standard to verify the calibration and periodically evaluate instrument precision (see Section 3.1.2). Crews must check their probe once a week against the provided Quality Control Standard (QCS) and record the information on the data forms.

Temperature Meter

You must check the accuracy of the sensor against a thermometer that is traceable to the National Institute of Standards (NIST) at least once per sampling season. The entire temperature range encountered in the NRSA should be incorporated in the testing procedure and a record of test results kept on file.

Conductivity Meter

Calibrate the conductivity meter prior to each sampling event. Calibrate the meter in accordance with the manufacturer's instructions. The entire conductivity range encountered in the NRSA should be incorporated in the testing procedure and a record of test results kept on file. You must also conduct a quality control check with the provided standard to verify the calibration and periodically evaluate instrument precision (see Section 3.1.2). Crews must check their probe once a week against the provided QCS and record the information on the data forms.

6.1.1.4 Sampling Procedure

Table 6.1-2 presents step-by-step procedures for measuring dissolved oxygen, pH, temperature, and conductivity.

Table 6.1-2. Sampling procedure—temperature, pH, conductivity and dissolved oxygen

1. Check meter and probes and calibrate according to manufacturer’s specifications.
2. **Wadeable Sites:** Measurements are taken at the X site at a depth of 0.5 meters or at mid-depth if less than 1 meter deep.
3. Lower the sonde in the water and measure DO, pH, temperature, and conductivity at 0.5 m depth.
4. Record the measurements on the Field Measurement Form.
5. If sampling at the X-site is not possible, move to another part of the reach to collect the sample (as close to the X-site as possible), record the letter of the nearest transect in the “TRANSECT” box and more detailed reasons and/or information in the Comments section.
6. Flag any measurements that need further comment (or when a measurement cannot be made).

6.1.2 Water Chemistry Sample Collection and Preservation

6.1.2.1 Summary of Method

The water chemistry samples will be analyzed for total phosphorus (TP), total nitrogen (TN), total ammonia-nitrogen (NH₄), nitrate (NO₃), basic anions, cations, total suspended solids (TSS), turbidity, acid neutralizing capacity (ANC, alkalinity), dissolved organic carbon (DOC), and total organic carbon (TOC). You will collect a grab sample in one 4-L cube container and in one 2-L amber Nalgene bottle from the X site at the center of the reach. Store all samples on ice in a closed cooler.

6.1.2.2 Equipment and Supplies

Table 6.1-3 provides the equipment and supplies needed to collect water samples at the index site. Record the Water Sample Collection and Preservation data on the Sample Collection Form, as seen in Figure 6.1-2.

Table 6.1-3. Equipment and supplies—water chemistry sample collection and preservation

For collecting samples	<ul style="list-style-type: none"> ▪ Nitrile gloves ▪ 4-L cube container for wadeable sites ▪ 2-L amber Nalgene bottle ▪ 3 L Nalgene beaker ▪ Cooler with ice ▪ DI water (for cleaning beaker and carboy between sites) ▪ Field Operations Manual and/or laminated Quick Reference Guide
For recording measurements	<ul style="list-style-type: none"> ▪ Sample Collection Form ▪ Field Measurement Form ▪ Pencils (for data forms) ▪ Fine tipped indelible markers

6.1.2.3 Sampling Procedure

Table 6.1-4 presents step-by-step procedures for collecting water chemistry samples at wadeable sites.

Table 6.1-4. Sampling procedure for wadeable sites—water chemistry sample collection

1. Collect the water samples from the X-site in a flowing portion near the middle of the stream.
2. Put on nitrile gloves. Make sure not to handle sunscreen or other chemical contaminants until after the sample is collected.
3. Rinse the 3-L Nalgene beaker three times with water, and discard the rinse downstream.
4. Remove the cube container lid and expand the cube container by pulling out the sides. **NOTE: DO NOT BLOW into the cube container to expand them, this will cause contamination.**
5. Fill the 3-liter beaker with water and slowly pour 30 - 50 mL into the cube container. Cap the cube container and rotate so that the water contacts all the surfaces. Discard the water downstream. Repeat this rinsing procedure 2 more times.
6. Fill the beaker with water and pour into the cube container. Repeat as necessary to fill the cube container. Let the weight of the water expand the cube container. Pour the water slowly as the cube container expands. Fill the cube container to at least three-fourths of its maximum volume. Rinse the cube container lid with water. Eliminate any air space from the cube container, and cap it tightly. Make sure the cap is tightly sealed and not on at an angle.
7. Fill the 3-liter beaker with water and slowly pour 30 - 50 mL into the 2 L amber Nalgene bottle. Cap the bottle and rotate so that the water contacts all the surfaces. Discard the water downstream. Repeat this rinsing procedure 2 more times.
8. Fill the beaker with water and pour into the 2 L amber Nalgene bottle. Cap the bottle tightly.
9. Place the cube container and bottle in a cooler (on ice or water) and shut the lid. If a cooler is not available, place the cube container in an opaque garbage bag and immerse it in the stream.
10. Record the Sample ID on the Sample Collection Form along with the pertinent stream information (stream name, ID, date, etc.). Note anything that could influence sample chemistry (heavy rain, potential contaminants) in the Comments section. If sampling at the X-site is not possible, move to another part of the reach to collect the sample (as close to the X-site as possible), record the letter of the nearest transect and more detailed reasons and/or information in the Comments section.

6.1.3 Sediment Enzymes

6.1.3.1 Summary of Method

Collect sediment samples at the 11 sampling stations along each reach and combine for all stations at a site, resulting in a single 500 mL sample per site. Collect fine surface sediments (top 5 cm) using a scoop, spoon or dredge. Store samples on ice until shipment to the laboratory. Samples will be analyzed for available DIN, NH₄, DIP, TP, TN, total carbon (TC) and enzyme activity.

6.1.3.2 Equipment and Supplies

Table 6.1-5 lists the equipment and supplies needed to collect sediment enzyme samples. Record collection data on the Sample Collection Form, as seen in Figure 6.1-2.

Table 6.1-5. Equipment and supplies—sediment enzymes

For collecting samples	<ul style="list-style-type: none">▪ 4 L graduated plastic bucket▪ Large stainless steel spoon for mixing sediment composite▪ 500 mL plastic jar for storing sediment sample
For recording measurements	<ul style="list-style-type: none">▪ Sample Collection Form▪ Sample labels▪ Pencils▪ Fine tipped indelible markers▪ Clear tape strips

Reviewed by (initials): _____

SAMPLE COLLECTION FORM - WADEABLE (Front)

46387 **SITE ID: FW08** **DATE: 1 / 12 / 0**

Sample ID	Sample Category *	Chilled	Comments
999001	<input checked="" type="radio"/> P <input type="radio"/> D	<input checked="" type="radio"/>	
	<input type="radio"/> P <input type="radio"/> D	<input type="radio"/>	

Sample ID	Sample Category *	Volume Filtered (mL)	Frozen	Comments
999002	<input checked="" type="radio"/> P <input type="radio"/> D	1200	<input checked="" type="radio"/>	
	<input type="radio"/> P <input type="radio"/> D		<input type="radio"/>	

Sample ID	Sample Category *	Chilled	Comments
999004	<input checked="" type="radio"/> P <input type="radio"/> D	<input checked="" type="radio"/>	
	<input type="radio"/> P <input type="radio"/> D	<input type="radio"/>	

		A		B		C		D		E		F		G		H		I		J		K	
SUBSTRATE	CHAN.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.
Fine/Sand	Pool	<input checked="" type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P	<input type="radio"/> F	<input type="radio"/> P
Gravel	Glide	<input type="radio"/> G	<input checked="" type="radio"/> GL	<input type="radio"/> G	<input checked="" type="radio"/> GL	<input type="radio"/> G	<input type="radio"/> GL																
Coarse	Riffle	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI	<input type="radio"/> C	<input type="radio"/> RI
Other:	Rapid	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA	<input type="radio"/> O	<input type="radio"/> RA

999007	<input type="radio"/> P <input type="radio"/> D	01	<input checked="" type="radio"/>	
	<input type="radio"/> P <input type="radio"/> D		<input type="radio"/>	

Dominant Substrate: (ONE PER TRANSECT)	<input checked="" type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT	<input type="radio"/> F <input type="radio"/> C <input type="radio"/> G <input type="radio"/> OT
Channel: (ONE PER TRANSECT)	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT	<input type="radio"/> P <input type="radio"/> RA <input type="radio"/> RI <input type="radio"/> GL <input type="radio"/> OT
Dominant Edge: (L and R) (ONE PER TRANSECT)	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT	<input type="radio"/> U <input type="radio"/> S <input type="radio"/> R <input type="radio"/> M <input type="radio"/> L <input type="radio"/> OG <input type="radio"/> OT

Edge: U = Undercut S = Snag R = Rootwad M = Macrophyte bed L = Leaf Litter OG = Organic deposits OT = Other or Co-Dominant (Explain in comment section below)

Substrate: F = Fine/Sand C = Coarse substrate G = Gravel OT = Other (Explain in comment section below)

Channel: P = Pool RI = Riffle GL = Glide RA = Rapid OT = Other (Explain in comment section below)

999008	<input checked="" type="radio"/> P <input type="radio"/> D		<input checked="" type="radio"/>	
	<input type="radio"/> P <input type="radio"/> D		<input type="radio"/>	

Flag codes: K = No measurement or observation made; U = Suspect measurement or observation; F1, F2, etc. = misc. flags assigned by field crew. Explain all flags in comment sections. *Sample Categories: P = Primary, D = Field Duplicate

04/07/2009 NRSA Sample Collection Wadeable 2009
Figure 6.1-2. Sample Collection Form, Side 1.



Draft

SAMPLE COLLECTION FORM - WADEABLE (Back)

Reviewed by (initial): _____

SITE ID: FW08
DATE: / / 20

COMPOSITE PERIPHYTON SAMPLE - Primary												No Sample Collected <input type="radio"/>
Sample ID		Sample Category *	Composite Volume (mL)			Number of transects sampled (0-11):						
		<input type="radio"/> P <input type="radio"/> D										
Assemblage ID (.1) (50-mL tube)			Chlorophyll (.2) (GF/F filter)			Biomass (.3) (GF/F Filter)			APA (.4) (50-mL tube)			
Sample Vol. (mL)	Flag	Preserved	Sample Vol. (mL)	Flag	Frozen	Sample Vol. (mL)	Flag	Frozen	Sample Vol. (mL)	Flag	Frozen	
		<input type="radio"/>			<input type="radio"/>			<input type="radio"/>			<input type="radio"/>	

COMPOSITE PERIPHYTON SAMPLE - Duplicate												No Sample Collected <input type="radio"/>
Sample ID		Sample Category *	Composite Volume (mL)			Number of transects sampled (0-11):						
		<input type="radio"/> P <input type="radio"/> D										
Assemblage ID (.1) (50-mL tube)			Chlorophyll (.2) (GF/F filter)			Biomass (.3) (GF/F Filter)			APA (.4) (50-mL tube)			
Sample Vol. (mL)	Flag	Preserved	Sample Vol. (mL)	Flag	Frozen	Sample Vol. (mL)	Flag	Frozen	Sample Vol. (mL)	Flag	Frozen	
		<input type="radio"/>			<input type="radio"/>			<input type="radio"/>			<input type="radio"/>	

Flag	Comments

Flag codes: K = No measurement or observation made; U = Suspect measurement or observation; F1, F2, etc. = flags assigned by field crew. Explain all flags in comment sections.

SEDIMENT CHEMISTRY / ENZYMES						No Sample Collected <input type="radio"/>
Sample ID	Sample Category *	Composite Volume	No. of Transects	Chilled	Comments	
	<input type="radio"/> P <input type="radio"/> D			<input type="radio"/>		
	<input type="radio"/> P <input type="radio"/> D			<input type="radio"/>		

ENTEROCOCCI (Target Volume = 250 mL)										No Sample Collected <input type="radio"/>		
Sample ID One unique ID per line	Sample Category *	Time Collected (hhmm)	Depth Collected (m)	Sample Volume (mL)	Filt. Start Time (hhmm)	Volume Filtered (Target = 50 mL) **				Filt. End Time (hhmm)	Time Frozen (hhmm)	Flag
						Filt. 1	Filt. 2	Filt. 3	Filt. 4			
	<input type="radio"/> P <input type="radio"/> D											
	<input type="radio"/> P <input type="radio"/> D											
	<input type="radio"/> P <input type="radio"/> D											
	<input type="radio"/> F											

Flag	Comment

* Sample Categories: P = Primary, D = Duplicate; F = Filter Blank (Enterococci sample only) Filter blank is collected at visit where field duplicate sample is NOT taken.
** If <25 ml of buffer solution was used to rinse filter, indicate with an F flag and note in comment section which filter(s) were affected along with the approximate volume(s) of buffer solution used.

Figure 6.1-3. Sample Collection Form, Side 2.

6.1.3.3 Sampling Procedure

Near each of the macroinvertebrate and periphyton sampling locations, collect a fine-grained sediment sample using either a hand scoop or spoon sampler. The objective is to collect a 500-mL composite sample that is representative of depositional areas at the site. The composite sample will be subsampled in the lab for multiple analyses. Table 6.1-6 presents step-by-step procedures for collecting sediment enzyme samples.

Table 6.1-6. Sampling procedure—sediment enzymes

1. Collect a sediment sample at each of the macroinvertebrate and periphyton sample locations. Make sure each of the subsamples comprises an approximately equal portion of the total composite. It is permissible to collect sediment between stations to insure a composite volume of at least 500 mL. (Note any deviations from standard procedure in a comment.)
2. Locate sediment samples in areas or patches of fine-grained substrate (silty sand, silt, clay, muck) in a zone bounded on the shore side by the apparent low-water mark from daily flow fluctuations and bounded on the river side by the 0.3-m (usually about mid-biceps) depth contour (recommended maximum sample depth; deeper sampling may be possible). The low-water mark at a site can often be detected by the presence of periphyton or attached filamentous algae just below the low-water mark. If samples cannot be safely collected by wading at a station due to vertical banks or other reason go to step 5.
3. Be sure to avoid the area that has just been kick sampled for macroinvertebrates. Sampling upstream from the kick sample location is recommended. If fine substrates are not present within 5 m up- or downstream from the station, flag the station on the form.
4. If fine substrate is present, use a stainless steel spoon to collect a sample of about 50ml or one spoonful from the top 5 cm of substrate. Place the sample in a clean bucket. Use gloves for handling sediment. Do not assume rip rapped shorelines lack fine-grained sediment. Look for fines between the large rocks.
5. Repeat steps 2-4 at each of the 11 littoral stations. Record the total number of replicates (stations) included in the composite. Note in a comment the stations at which sediment was collected using a non-wading method.
6. It is important that a sufficient sediment (not less than 500 mL) sample for analysis be collected. If multiple stations have no fine sediment, it is permissible to collect extra sample at stations that do have fine sediment or between stations. Be sure to note this in a comment.
7. Using the stainless steel spoon, thoroughly mix the composite sample and transfer 500 mL into the 500 mL plastic bottle. Place in a cooler with ice for final labeling and preservation.
8. Prepare a label for the sample jar. Using a fine-point indelible marker, fill in the site # and sample date. Place the label on the jar and cover it with clear tape. Record the sample ID and other data on sampling form. Place the sample on ice or in a refrigerator. Do not freeze sediment samples. The sediment enzyme samples have a 2 week holding time.

6.2 Physical Habitat Characterization—Wadeable Streams

Physical habitat in streams includes all those physical attributes that influence or provide sustenance to organisms within the stream. The physical habitat of a stream varies naturally, thus expectations differ even in the absence of anthropogenic disturbance. Within a given physiographic-climatic region, stream drainage area and overall stream gradient are likely to be strong natural determinants of many aspects of stream habitat. This is because of their influence on discharge, flood stage, and stream power (the product of discharge times gradient). Kaufmann (1993) identified seven general physical habitat attributes important in influencing stream ecology:

- Channel Dimensions
- Channel Gradient
- Channel Substrate Size and Type
- Habitat Complexity and Cover
- Riparian Vegetation Cover and Structure
- Anthropogenic Alterations
- Channel-Riparian Interaction

The procedures are employed on a support reach length 40 times its baseflow wetted width, as described in Section 4. Measurement points are systematically placed to statistically represent the entire reach. Stream depth and wetted width are measured at very tightly spaced intervals, whereas channel cross-section profiles, substrate, bank characteristics and riparian vegetation structure are measured at larger intervals. Woody debris is tallied along the full length of the sampling reach, and discharge is measured at one location. The tightly spaced depth and width measures allow calculation of indices of channel structural complexity, objective classification of channel units such as pools, and quantification of residual pool depth, pool volume, and total stream volume.

6.2.1 Components of the Habitat Characterization

There are five components of the physical habitat characterization (Table 6.2-1). Measurements are recorded on 11 copies of a two-sided field form, and separate forms for recording slope and bearing measurements, recording observations concerning riparian *legacy* (large) trees and alien invasive riparian plants, assessing the degree of channel constraint, and recording evidence of debris torrents or recent major flooding. The *thalweg profile* is a longitudinal survey of depth, habitat class, presence of deposits of soft/small sediments, and presence of off-channel habitats at 100 equally spaced stations (150 in streams less than 2.5 m wide) along the centerline between the two ends of the sampling reach. *Thalweg* refers to the flow path of the deepest water in a stream channel. Wetted width is measured and substrate size is evaluated at 21 equally spaced cross-sections (at 11 regular transects [A through K], and 10 supplemental cross-sections spaced midway between each of these). Data for the second component, the *woody debris tally*, are recorded for each of 10 segments of stream located between the 11 regular transects. The third component, the *channel and riparian characterization*, includes measures and/or visual estimates of channel dimensions, substrate, fish cover, bank characteristics, riparian vegetation structure, presence of large (legacy) riparian trees, nonnative (alien) riparian plants, and evidence of human disturbances. These data are obtained at each of the 11 equally-spaced transects established within the sampling reach. In addition, measurements of the stream slope and compass bearing between stations are obtained, providing information necessary for calculating reach gradient, residual pool volume, and channel sinuosity. The fourth component, *assessment of channel constraint, debris*

torrents, and major floods, is an overall assessment of these characteristics for the whole reach, and is undertaken after the other components are completed.

Table 6.2-1. Components of physical habitat characterization

Component	Description
Thalweg Profile (Section 6.2.4.1)	<ul style="list-style-type: none"> ▪ Measure maximum depth, classify habitat and pool-forming features, and check presence of backwaters, side channels and loose, soft deposits of sediment particles at 10-15 equally spaced intervals between each of 11 transects (100 or 150 individual measurements along entire reach). ▪ Measure wetted width and evaluate substrate particle size classes at 11 cross-section transects and midway between them (21 width measurements and substrate cross-sections).
Woody Debris Tally (Section 6.2.4.2)	<ul style="list-style-type: none"> ▪ Between each of the channel cross-sections, tally large woody debris numbers within and above the bankfull channel according to specified length and diameter classes (10 separate tallies).
Channel and Riparian Characterization (Section 6.2.5)	<ul style="list-style-type: none"> ▪ At 11 transects (21 for substrate size) placed at equal intervals along reach: ▪ Measure: channel cross-section dimensions, bank height, bank undercut distance, bank angle, slope and compass bearing (backsight), and riparian canopy density (densiometer). ▪ Visually Estimate^a: substrate size class and embeddedness; areal cover class and type (e.g., woody trees) of riparian vegetation in Canopy, Mid-Layer and Ground Cover; areal cover class of fish concealment features, aquatic macrophytes and filamentous algae. ▪ Observe & Record^a: Presence and proximity of human disturbances, presence of large trees, and presence of invasive riparian plants.
Assessment of Channel Constraint, Debris Torrents, and Major Floods (Section 6.2.6)	<ul style="list-style-type: none"> ▪ After completing thalweg and transect measurements and observations, identify features causing channel constraint, estimate the percentage of the channel margin that is constrained for the whole reach, and estimate the ratio of bankfull/valley width. Check evidence of recent major floods and debris torrent scour or deposition.
Discharge (Section 6.2.6.3)	<ul style="list-style-type: none"> ▪ Measure water depth and velocity at 0.6 depth at 15 to 20 equally spaced intervals across one carefully chosen channel cross-section. ▪ In very small streams, measure discharge by timing the passage of a neutrally buoyant object through a segment whose cross-sectional area has been estimated or by timing the filling of a bucket.

^a Substrate size class is estimated for a total of 105 particles taken at 5 equally-spaced points along each of 21 cross-sections. Depth is measured and embeddedness estimated for the 55 particles located along the 11 regular transects A through K. Cross-sections are defined by laying the surveyor's rod or tape to span the wetted channel. Woody debris is tallied over the distance between each cross-section and the next cross-section upstream. Riparian vegetation and human disturbances are observed 5m upstream and 5m downstream from the cross-section transect. They extend shoreward 10m from left and right banks. Fish cover types, aquatic macrophytes, and algae are observed within the channel 5m upstream and 5m downstream from the cross-section stations. These boundaries for visual observations are estimated by eye.

6.2.2 Habitat Sampling Locations within the Reach

Measurements are made at two scales of resolution along the length of the reach; the results are later aggregated and expressed for the entire reach, a third level of resolution. Figure 6.2-1 illustrates the locations within the reach where data for the different components of the physical habitat characterization are obtained. Many channel and riparian features are characterized on 11 cross-sections and pairs of riparian plots spaced at 4 channel-width intervals (i.e., transect spacing = 1/10th the total reach length). The thalweg profile measurements must be spaced evenly over the entire support reach. In addition, they must be sufficiently close together that they do not miss deep areas and major habitat units. Follow these guidelines for choosing the increment between thalweg profile measurements:

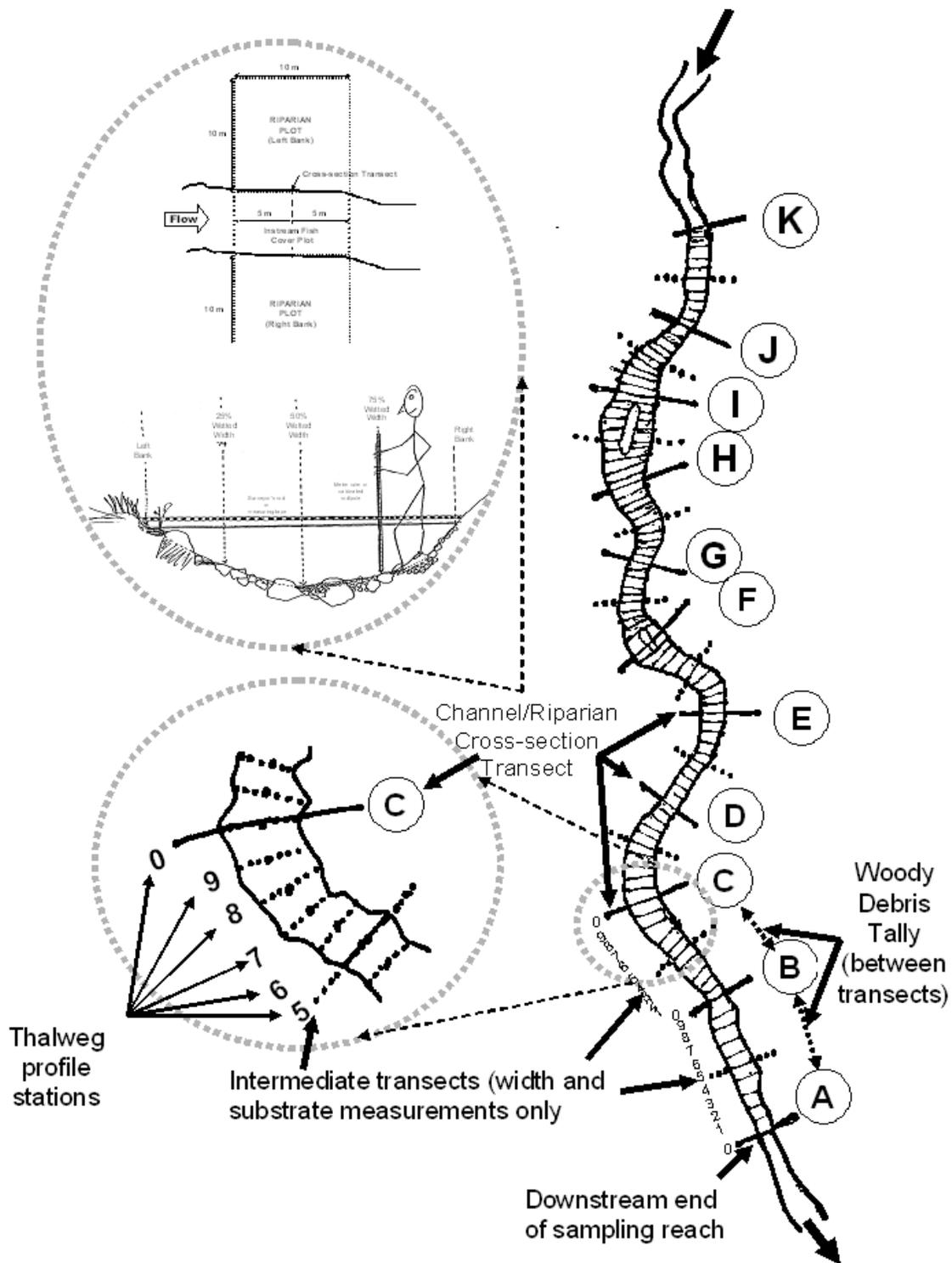
- Channel Width < 2.5 m — increment = 1.0 m
- Channel Width 2.5 to 3.5 m — increment = 1.5 m
- Channel Width > 3.5 m — increment = $0.01 \times (\text{reach length})$

Following these guidelines, make 150 evenly spaced thalweg profile measurements in the smallest category of streams, 15 between each detailed channel cross-section. In all of the larger stream sizes, you will make 100 measurements, 10 between each cross-section.

6.2.3 Logistics and Work Flow

The five components (Table 6.2-1) of the habitat characterization are organized into four grouped activities:

1. *Thalweg Profile and Large Woody Debris Tally (Section 6.2.4)*. Two people proceed upstream from the downstream end of the sampling reach (see Figure 6.2-1) making observations and measurements at the chosen increment spacing. One person is in the channel making width and depth measurements, and determining whether soft/small sediment deposits are present under his/her staff. The other person records these measurements, classifies the channel habitat, records presence/absence of side channels and off-channel habitats (e.g., backwater pools, sloughs, alcoves), and tallies large woody debris. Each time this team reaches a flag marking a new cross-section transect, they start filling out a new copy of the Thalweg Profile and Woody Debris Form. They interrupt the thalweg profile and woody debris tallying activities to complete data collection at each cross-section transect as it comes. When the crew member in the water makes a width measurement at channel locations midway between regular transects (i.e., A, B, K), she or he also locates and estimates the size class of the substrate particles on the left channel margin and at positions 25%, 50%, 75%, and 100% of the distance across the wetted channel. Procedures for this substrate tally are the same as for those at regular cross-sections, but data are recorded on the thalweg profile side of the field form.



PRK/DVP 8/06

Figure 6.2-1. Reach layout for physical habitat measurements (plan view).

2. *Channel/Riparian Cross-Sections (Section 6.2.5)*. One person proceeds with the channel cross-section dimension, substrate, bank, and canopy cover measurements. The second person records those measurements on the Channel/ Riparian Cross-section Form while making visual estimates of riparian vegetation structure, instream fish cover, and human disturbance specified on that form. They also make observations to complete the riparian “legacy” tree field form. Slope is measured by measuring the difference in elevation between each transect and bearing is determined by backsighting to the previous transect. Supplementary points may need to be located and flagged (using a different color) if the stream is extremely brushy, sinuous, or steep to the point that you cannot sight for slope and bearing measures between two adjacent transects.

The work flow for the thalweg profile and channel cross described above can be modified by delaying the measurements for slope and bearing and the woody debris tally until after reaching the upstream end of the reach. Backsighting and wood tallies can be done on the way back down (Note that in this case, the slope and bearing data form would have to be completed in reverse order).

3. *Channel Constraint and Torrent Evidence (Section 6.2.6)*. After completing observations and measurements along the thalweg and at all 11 transects, the field crew completes the overall reach assessments of channel constraint and evidence of debris torrents and major floods.
4. *Stream Discharge*. Discharge measurements are made after collecting the water chemistry sample. They are done at a chosen optimal cross-section (but not necessarily at a transect) near the X-site. However, do not use the electromagnetic current meter close to where electrofishing is taking place. Furthermore, if a lot of channel disruption is necessary and sediment must be stirred up, wait on this activity until all chemical and biological sampling has been completed.

6.2.4 Thalweg Profile and Large Woody Debris Measurements

6.2.4.1 Thalweg Profile

Thalweg refers to the flow path of the deepest water in a stream channel. The thalweg profile is a longitudinal survey of maximum flow path depth and several other selected characteristics at 100 or 150 equally spaced points (termed *stations*) along the length of the reach measured along the centerline of the channel. Data from the thalweg profile allows calculation of indices of residual pool volume, stream size, channel complexity, and the relative proportions of habitat types such as riffles and pools. One person walks upstream carrying a fiberglass telescoping (1.5 to 7.5 m) surveyor's rod and a 1-m metric ruler (or a calibrated rod or pole, such as a ski pole, shovel handle, wooden dowel, or old billiard cue). A second person on the bank or in the stream carries a clipboard with 11 copies of the field data form.

The procedure for obtaining thalweg profile measurements is presented in Table 6.2-2. Record data on the Thalweg Profile and Woody Debris Data Form as shown in Figure 6.2-2. Use the surveyor's rod and a metric ruler or calibrated rod or pole to make the required depth and width measurements at each station, and to measure off the distance between stations as you proceed upstream. You may need to make minor adjustments to align each 10th measurement to be one increment short of the next transect. In streams with average widths less than 2.5 m, make thalweg measurements at 1-meter increments. Because the minimum reach length is set

at 150 meters, there will be 15 measurements on a field data form: Station 0 at the transect plus 14 additional stations between it and the next transect upstream. Use the five extra lines on the thalweg profile portion of the data form (Figure 6.2-2) to record these measurements.

Table 6.2-2. Thalweg profile procedure

1. Determine the increment distance between measurement stations based on the wetted width used to determine the length of the reach. Using a laser rangefinder or surveyor's rod:
 - For widths ≤ 2.5 m, establish stations every 1 m (150 total).
 - For widths > 2.5 and ≤ 3.5 m, establish stations every 1.5 m (100 total).
 - For widths > 3.5 m, establish stations at increments equal to 0.01 times the reach length (100 total).
2. Complete the header information on the Thalweg Profile and Woody Debris Form, noting the transect pair (downstream to upstream). Record the increment distance determined in Step 1 in the *INCREMENT* field on the field data form.
3. Begin at the downstream end (*station 0*) of the first transect (transect A).
4. Measure the wetted width at station 0, and at either station 5 (if the stream width defining the reach length is ≥ 2.5 m), or station 7 (if the stream width defining the reach length is < 2.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the width on the field data form to the nearest 0.1 m. For streams with interrupted flow, where no water is in the channel at the station or transect, record zeros for wetted width.

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

5. At station 5 or 7 (see above) classify the size of the bed surface particle at the tip of your depth measuring rod at the left wetted margin and at positions 25%, 50%, 75%, and 100% of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections (transects A - K), except that for these midway supplemental cross-sections, substrate size is entered on the thalweg profile side of the field form.
6. At each thalweg profile station, use a calibrated pole or rod to locate the deepest point within the deepest flow path (*the thalweg*), which may not always be found at mid-channel (and may not always be the absolute deepest point in every channel cross-section). Measure the thalweg depth to the nearest cm from the substrate surface to the water surface, and record it on the thalweg profile form. Read the depth on the **side** of the rod to avoid inaccuracies due to the wave formed by the rod in moving water.

NOTE: For streams with interrupted flow - if there is no water at a transect, record zeros for depth.

*NOTE: Obtain thalweg depths at all stations. If the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor's rod or pole at an angle to reach the thalweg. Determine the angle by resting the clinometer on the upper surface of the rod and reading the angle on the external scale of the clinometer. Leave the depth reading for the station blank, and record a U flag to indicate a non-standard procedure was used. Record the water level on the rod and the rod angle in the comments section of the field data form. For deeper depths, use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line, and toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the clinometer exactly as done for the surveyor's rod. If a direct measurement cannot be obtained, make the **best estimate** you can of the thalweg depth, and use a U flag to identify it as an estimated measurement.*

7. At the point where the thalweg depth is determined, observe if unconsolidated, loose (*soft*) deposits of small diameter (≤ 16 mm) sediments are present directly beneath your ruler, rod, or pole.

Soft/ small sediments are defined here as fine gravel, sand, silt, clay or muck readily apparent by “feeling” the bottom with the rod. Record presence or absence in the *SOFT/SMALL SEDIMENT* field on the field data form. *Note: A thin coating of fine sediment or silty algae coating the surface of cobbles should not be considered soft/small sediment. However, fine sediment coatings should be identified in the comments section of the field form when determining substrate size and type.*

8. Determine the channel unit code and pool forming element codes for the station. Record these on the field data form using the standard codes provided. For dry and intermittent streams, where no water is in the channel, record habitat type as dry channel (*DR*).
9. If the station cross-section intersects a mid-channel bar, indicate the presence of the bar in the *BAR WIDTH* field on the field data form.
10. Record the presence or absence of a side channel at the station’s cross-section in the *SIDE CHANNEL* field on the field data form.
Record the presence or absence of quiescent off-channel aquatic habitats, including sloughs, alcoves and backwater pools in the *BACKWATER* column of the field form.
11. Proceed upstream to the next station, and repeat Steps 2 through 11.
12. Repeat Steps 2 through 12 until you reach the next transect. At this point complete Channel/ Riparian measurements at the new transect (Section 6.2.5). Then prepare a new Thalweg Profile and Woody Debris Form and repeat Steps 2 through 12 for each of the reach segments, until you reach the upstream end of the sampling reach (transect *K*). At transect *K*, you will have completed 10 copies of the Thalweg Profile and Woody Debris Form, one for each segment (*A to B, B to C, etc.*).

Measure thalweg depths at **all** stations. Missing depths at the end of the reach (e.g., due to the stream flowing into or out of a culvert or under a large pile of debris) can be tolerated, but those in the middle of the reach are more difficult to deal with. Flag any missing measurements using a *K* code and explain the reason in the comments section of the field data form. At points where a direct depth measurement cannot be made, make your best estimate of the depth, record it on the field form, and flag the value using a *U* code (nonstandard measurement), explaining that it is an estimated value in the comments section of the field data form. *Where the thalweg points are too deep for wading*, measure the depth by extending the surveyor’s rod at an angle to reach the thalweg point. Record the water level on the rod, and the rod angle, as determined using the external scale on the clinometer (vertical = 90°). In analyzing these data we calculate the thalweg depth as the length of the rod (or string) under water multiplied by the trigonometric *sine* of the rod angle. (For example, if 3 meters of the rod are under water when the rod held at 30 degrees (*sine*=0.5), the actual thalweg depth is 1.5 meters.) These calculations are done after field forms are returned for data analysis. On the field form, crews are required only to record the wetted length of the rod under the water, a *U* code in the flag field (to indicate a nonstandard technique), and a comment to the right saying “*depth taken at an angle of xx degrees.*” If a direct measurement of the thalweg depth is not possible, make the best estimate you can of the depth, record it, and use a *U* flag and a comment to note it is an estimated value.

PHAB: THALWEG PROFILE & WOODY DEBRIS FORM - WADEABLE Reviewed by (initial): **JD**

SITE ID: **FW08 XX000** DATE: **07/01/2008** TRANSECT: **0** A-B B-C C-D D-E E-F
 F-G G-H H-I I-J J-K

Total Reach Length (m): **230**

STA-TION	THALWEG PROFILE		For Transect A-B ONLY:				SOFT SMALL SEDIMENT	CHANNEL UNIT CODE	POOL FORM CODE	SIDE CHANNEL	BLACK WATER	THALWEG PROFILE COMMENTS
	THALWEG DEPTH (cm) (XXX)	WETTED WIDTH (m) (XXX.X)	BAR WIDTH Present	XX.X	BAR WIDTH1	Increment (m) X.X						
0	14	3.6	<input checked="" type="radio"/> N	0.8			R1	N	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
1	13		<input checked="" type="radio"/> N				R1	N	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
2	27		<input checked="" type="radio"/> N				R1	N	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
3	46		<input checked="" type="radio"/> N				R1	N	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
4	40		<input checked="" type="radio"/> N				PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
*5	35	3.2	<input checked="" type="radio"/> N	0.2			PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y	BAR IS A BOULDER	
6	34		<input checked="" type="radio"/> N				PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
*7	47		<input checked="" type="radio"/> N				PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
8	53		<input checked="" type="radio"/> N				PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y		
9	57		<input checked="" type="radio"/> N				PT	F	<input checked="" type="radio"/> N	<input checked="" type="radio"/> Y	SIDE CHANNEL CONFLUENCE	
10			<input checked="" type="radio"/> N						<input checked="" type="radio"/> Y	<input checked="" type="radio"/> Y		
11			<input checked="" type="radio"/> N						<input checked="" type="radio"/> Y	<input checked="" type="radio"/> Y		
12			<input checked="" type="radio"/> N						<input checked="" type="radio"/> Y	<input checked="" type="radio"/> Y		
13			<input checked="" type="radio"/> N						<input checked="" type="radio"/> Y	<input checked="" type="radio"/> Y		
14			<input checked="" type="radio"/> N						<input checked="" type="radio"/> Y	<input checked="" type="radio"/> Y		

SUBSTRATE	Station (5 or 7)							LARGE WOODY DEBRIS (x 10 cm small and diameter > 1.5 m length)	CHECK IF UNMARKED BOXES ARE ZERO	FLAG
	LFT	LCTR	CTR	RCR	RGT	RCR	RGT			
	5	SA	SA	GF	SA	FN				
FLAG	COMMENTS (for SUBSTRATE and LWD)							PIECES ALLPART IN BANKFULL CHANNEL	PIECES BRIDGE ABOVE BANKFULL CHANNEL	
							0.1-<0.3 m	Length 1.5-5m	Length 1.5-5m	>15m
							0.3-0.6 m	Length 1.5-5m	Length 1.5-5m	5-15m
							0.6-0.8 m	Length 1.5-5m	Length 1.5-5m	5-15m
							>0.8 m	Length 1.5-5m	Length 1.5-5m	>15m

SUBSTRATE SIZE CLASS CODES	POOL FORM CODES	CHANNEL UNIT CODES

Flag Codes: K = no measurement made; U = suspect measurement; F1, F2, etc. = flags assigned by each field crew; G1, G2, etc. for flags not specific to one station. Explain all flags in comments. 1 = Measure Bar Width at Station 0 and Mid-Station (5 or 7).

03/05/2008 Phab Thalweg NRSA

Figure 6.2-2. Thalweg Profile and Woody Debris Form.

At every thalweg station, determine by sight or feel whether deposits of *soft/small sediments* are present on the channel bottom. These particles are defined as substrate equal to or smaller than fine gravel (≤ 16 mm diameter). These soft/small sediments are **different** from *Fines* described when determining the substrate particle sizes at the cross-section transects (Section 6.2.5.2). If the channel bottom is not visible, determine if soft/small sediment deposits are readily obvious by feeling the bottom with your boot, the surveyor's rod, or a calibrated rod or pole.

Measure wetted width at each transect (station 0), and midway between transects (station 5 for larger streams having 100 measurement points, or station 7 for smaller streams having 150 measurement points). The wetted width boundary is the point at which substrate particles are no longer surrounded by free water. Estimate substrate size for five particles evenly spaced across each midway cross-section using procedures described for substrate at regular cross-sections (Section 6.2.5.2), but at the supplemental cross-sections, only the size class (not distance and depth) data are recorded.

While recording the width and depth measurements and the presence of soft/small sediments, the second person evaluates and records the habitat class and the pool forming element (Table 6.2-3) applicable to each of the 100 (or 150) measurement points along the length of the reach. Make channel unit scale habitat classifications at the thalweg of the cross-section. The habitat unit itself must meet a minimum size criteria in addition to the qualitative criteria listed in Table 6.2-3. Before being considered large enough to be identified as a channel-unit scale habitat feature, the unit should be at least as long as the channel is wide. For instance, if there is a small deep (pool-like) area at the thalweg within a large riffle area, do not record it as a pool unless it occupies an area about as wide or long as the channel is wide. If a backwater pool **dominates the channel**, record *PB* as the dominant habitat unit class. If the backwater is a pool that **does not dominate** the main channel, or if it is an **off-channel** alcove or slough (large enough to offer refuge to small fishes), circle *Y* to indicate presence of a backwater in the *BACKWATER* column of the field form, but classify the main channel habitat unit type according to characteristics of the main channel. *Sloughs* are backwater areas having marsh-like characteristics such as vegetation, and *alcoves* (or *side pools*) are deeper areas off the main channel that are typically wide and shallow (Helm 1985, Bain and Stevenson 1999). When trying to identify the pool forming element for a particular pool, remember that most pools are formed at high flows, so you may need to look for elements that are dry at baseflow, but still within the bankfull channel (e.g., boulders or large woody debris).

Table 6.2-3. Channel unit and pool forming element categories

Channel Unit Habitat Classes ^a	
Class (Code)	Description
Pools: Still water, low velocity, a smooth, glassy surface, usually deep compared to other parts of the channel:	
Plunge Pool (<i>PP</i>)	Pool at base of plunging cascade or falls
Trench Pool (<i>PT</i>)	Pool-like trench in the center of the stream
Lateral Scour Pool (<i>PL</i>)	Pool scoured along a bank
Backwater Pool (<i>PB</i>)	Pool separated from main flow off the side of the channel (large enough to offer refuge to small fishes). Includes sloughs (backwater with marsh characteristics such as vegetation), and alcoves (a deeper area off a wide and shallow main channel)
Impoundment Pool(<i>PD</i>)	Pool formed by impoundment above dam or constriction.
Pool (<i>P</i>)	Pool (unspecified type)
Glide (<i>GL</i>)	Water moving slowly, with a <i>smooth, unbroken surface</i> . Low turbulence.
Riffle (<i>RI</i>)	Water moving, with <i>small ripples, waves and eddies</i> -- waves not breaking, <i>surface tension not broken</i> . Sound: babbling, gurgling.
Rapid (<i>RA</i>)	Water movement rapid and turbulent, surface with <i>intermittent whitewater</i> with breaking waves. Sound: continuous rushing, but not as loud as cascade.
Cascade (<i>CA</i>)	Water movement rapid and very turbulent over steep channel bottom. Much of the water surface is broken in <i>short, irregular plunges, mostly whitewater</i> . Sound: roaring.
Falls (<i>FA</i>)	<i>Free falling water</i> over a vertical or near vertical drop into plunge, water turbulent and white over high falls. Sound: from splash to roar.
Dry Channel (<i>DR</i>)	No water in the channel, or flow is submerged under the substrate (<i>hyporheic flow</i>).
^a Note that in order for a channel habitat unit to be distinguished, it must be at least as wide or long as the channel is wide (except for off channel backwater pools, which are noted as present regardless of size).	
Categories of Pool-forming Elements ^b	
Code	Category
N	Not Applicable, Habitat Unit is not a pool
W	Large Woody Debris.
R	Rootwad
B	Boulder or Bedrock
F	Unknown cause (unseen fluvial processes)
WR, RW, RBW	Combinations
OT	Other (describe in the comments section of field form)

^b In determining the pool forming element, remember that most pools are formed at high flows, so you may need to look at features, such as large woody debris, that are dry at baseflow, but still within the bankfull channel.

6.2.4.2 Large Woody Debris Tally

Large Woody Debris is defined here as woody material with a small end diameter of at least 10 cm (4 in.) **and** a length of at least 1.5 m (5 ft.). The procedure for tallying LWD is presented in Table 6.2-4. The tally includes all pieces of LWD that are at least partially in the baseflow channel (Zone 1), in the *bankfull channel* (Zone 2, flood channel up to bankfull stage), or spanning above the bankfull channel (Zone 3), as shown in Figure 6.2-3. The *bankfull channel* is defined as the channel that is filled by moderate sized flood events that typically recur every one to two years. LWD in or above the bankfull channel is tallied over the entire length of the reach, including the area between the channel cross-section transects. Pieces of LWD that are not at least partially within Zones 1, 2, or 3 are not tallied.

Table 6.2-4. Procedure for tallying large woody debris

Note: Tally pieces of large woody debris (LWD) within each segment of stream while the thalweg profile is being determined. Include all pieces in the tally whose large end is found within the segment.

1. Scan the stream segment between the two cross-section transects where thalweg profile measurements are being made.
2. Tally all LWD pieces within the segment that are at least partially within the bankfull channel. Determine if a piece is LWD (*small end diameter* ≥ 10 cm [4 in.], **and** *length* ≥ 1.5 m [5 ft.])
3. For each piece of LWD, determine the class based on the *diameter of the large end* (0.1 m to < 0.3 m, 0.3 m to < 0.6 m, 0.6 m to < 0.8 m, or > 0.8 m), **and** the class based on the *length of the piece* (1.5 m to < 5.0 m, 5 m to < 15 m, or > 15 m).
 - If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with circular cross-section that would have the same volume.
 - When estimating length, include only the part of the LWD piece that has a diameter > 10 cm (4 in)
4. Place a tally mark in the appropriate diameter \times length class tally box in the *PIECES ALL/PART IN BANKFULL CHANNEL* section of the Thalweg Profile and Woody Debris Form.
5. Tally all LWD pieces within the segment that are not actually within the bankfull channel, but are at least partially spanning (bridging) the bankfull channel. For each piece, determine the class based on the diameter of the **large end** (0.1 m to < 0.3 m, 0.3 m to < 0.6 m, 0.6 m to < 0.8 m, or > 0.8 m), **and** the class based on the **length** of the piece (1.5 m to < 5.0 m, 5 m to < 15 m, or > 15 m).
6. Place a tally mark for each piece in the appropriate diameter \times length class tally box in the *PIECES BRIDGE ABOVE BANKFULL CHANNEL* section of the Thalweg Profile and Woody Debris Form.
7. After all pieces within the segment have been tallied, write the total number of pieces for each diameter \times length class in the small box at the lower right-hand corner of each tally box.
8. Repeat Steps 1 through 7 for the next stream segment, using a new Thalweg Profile and Woody Debris Form.

6.2.5 Channel and Riparian Measurements at Cross-Section Transects

6.2.5.1 Slope and Bearing

Measure bearing by *sighting* between transects (e.g., transect *B* and *A*, *C* and *B*, etc.) as shown in Figure 6.2-4. To measure the bearing between adjacent transects, follow the procedure presented in Table 6.2-5. Record bearing data on the Slope and Bearing Form as shown in Figure 6.2-5.

Slope is typically measured by two people, one holding a surveyor's rod and the second sighting through the surveyor's level. Be sure that the person is standing (or holding the marked pole) at the water's edge holding the rod at the surface of the water. The intent is to get a measure of the *water surface* slope, which may not necessarily be the same as the bottom slope. The surveyor's level is leveled according to the manufacturer's recommendations which is generally to adjust the three screw leveling feet until the bubble is centered. Level is checked in all planes to be measured. If the level does not "self level" in all measured planes the user should check the instruction manual for suggested options. Elevation readings are made at each transect and the difference between each elevation reading is recorded as the change in elevation. NOTE: Multiple transect elevations can often be made for each setup of the level, but every time the transit is moved requires re-measuring the last transect elevation from the last setup. You cannot use elevations from previous setups because the relative height of the transit has changed.

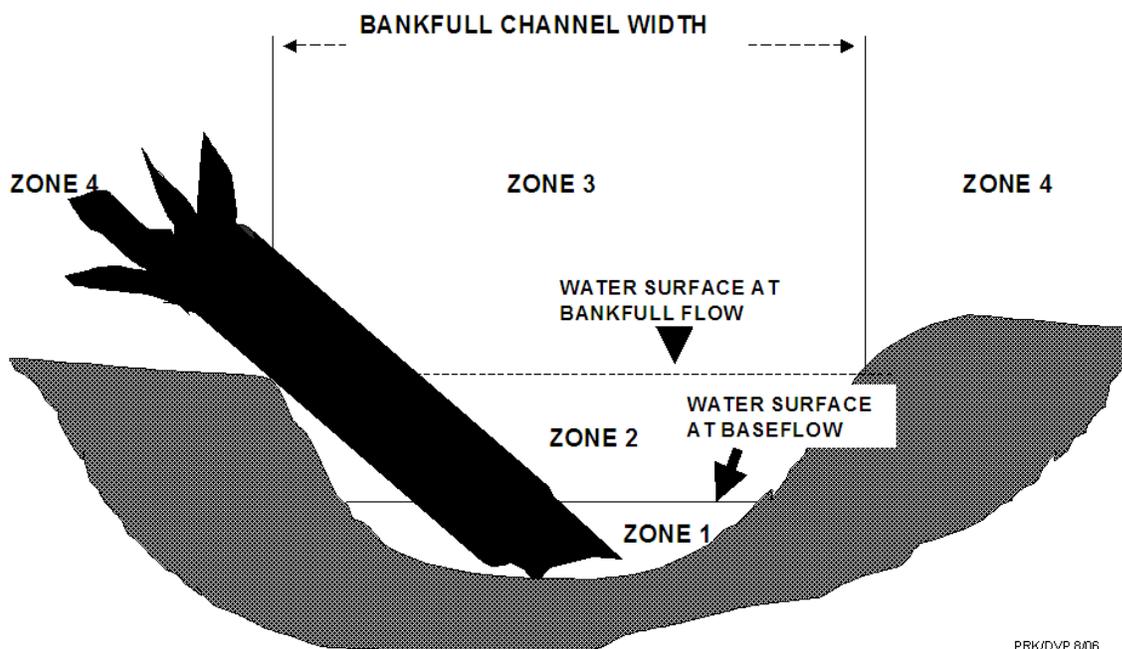
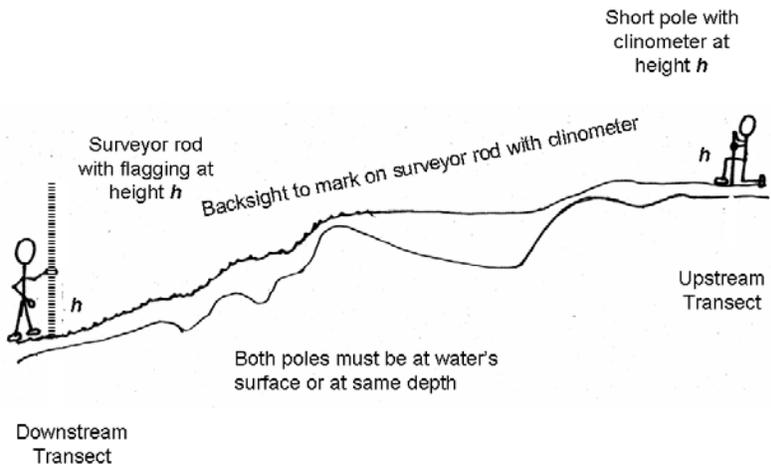


Figure 6.2-3. Large woody debris influence zones (modified from Robison and Beschta, 1990).

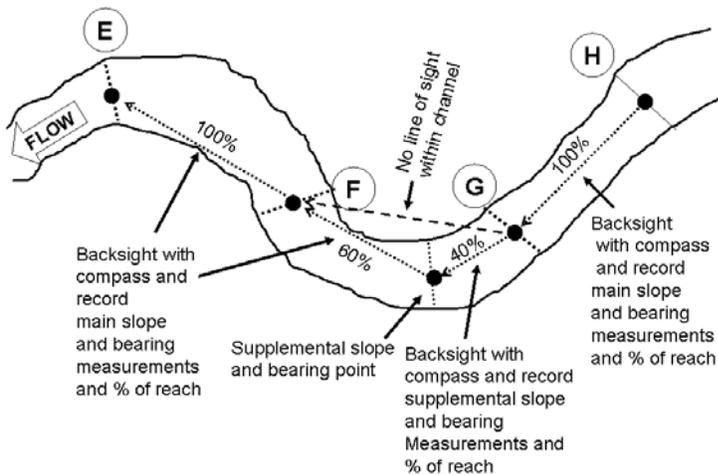
To calculate sinuosity from bearing measurements, it does not matter whether or not you adjust your compass bearings for magnetic declination, but it is important that you are **consistent** in the use of magnetic or true bearings throughout all the measurements you make on a given reach. Note in the comments section of the Slope and Bearing Form which type of bearings you are taking, so the measurements can be used to describe reach aspect. Also, guard against recording *reciprocal bearings* (erroneous bearings 180 degrees from what they should be). The best way to do this is to know where the primary (cardinal) directions are in the field: (north [0 degrees], east [90 degrees], south [180 degrees], and west [270 degrees]), and insure that your bearings “make sense.”

As stated earlier, it may be necessary to set up intermediate (supplemental) slope and bearing points between a pair of cross-section transects if you do not have direct line-of-sight along (and within) the channel between stations (see Figure 6.2-4). This can happen if brush is too heavy, or if there are sharp slope breaks or tight meander bends. *If you would have to sight across land to measure slope or bearing between two transects, then you need to make one or more supplemental measurements* (i.e., do not “short-circuit” a meander bend). Mark these supplemental locations with a different color of plastic flagging than used for the cross-section transects to avoid confusion. Record these supplemental slope and bearing measurements, along with the proportion of the stream segment between transects included in each supplemental measurement, in the appropriate sections of the Slope and Bearing Form (Figure 6-5). Note that the main slope and bearing observations are always downstream of supplemental observations (i.e., from or to the downstream transect). Similarly, first supplemental observations are always downstream of second supplemental observations.



PRR/DVP 606

Bearing Measurements Between Transects



PRR/DVP 606

Figure 6.2-4. Channel slope and bearing measurements.

Because of ease of use, portability, and cost, hand-held clinometers were previously used to determine slope. In this instance, the field crews will have access to more sophisticated instrumentation (e.g., surveyor's level), and have field personnel who are experienced in the use of these instruments. The Slope and Bearing Form (Figure 6-5) is designed to allow for different methods and/or different units of measuring slope. Mark the appropriate method circle (instead of *CL*; method codes are identified in Tables 6.2-5 and 6.2-6), and mark the *CM* circle (instead of the % circle) if the method or instrument measures the change in elevation rather than the percent slope.

Table 6.2-5. Procedure for obtaining slope and bearing data

1. Determine a location at transect K to hold a surveyor's rod that will be visible from a point between transect J and transect K:
 - a) Set up the instrument at a point approximately halfway between points J and K and where a clear line of sight is possible.
 - b) Position the staff at point K, holding the bottom of the staff at the water level and the staff as vertical as possible and the numbers facing the instrument.
 - c) Site the staff and record the reading to the nearest centimeter.
 - d) Move the staff to point J and gently swivel the instrument to face the next reading. Hold the staff as before, vertically, with the bottom at the water level and the numbers facing the instrument.
 - e) Site the staff and record the reading to the nearest centimeter.
 - f) Repeat measurements between each transect.
 - g) The difference in the readings is the height difference or gradient.
- Note: In small streams with a clear line of site it may be possible to set the instrument up once and make readings to several transects from a single set up. Simply record the readings for each transect and do not skip transects.*
- If you are backsighting from a supplemental point, record the bearing in the appropriate *SUPPLEMENTAL* section of the Slope and Bearing Form.
2. Proceed to the next cross-section transect (or supplementary point), and repeat Steps a - g above.
Instrument Setup:
 - a) Extend the tripod legs to approximately eye level and set the legs firmly into the ground; adjust the legs so that they form a regular triangle and are firmly set with no wobble. Adjust the legs so that the base plate is approximately level.
 - b) Hold the instrument on the tripod and start the centering screw. Ensure the adjustable feet are roughly evenly adjusted. While the centering screw is still loose slide the instrument on the base plate until the bubble is approximately centered in the circular level. Tighten the centering screw.
 - c) Adjust the leveling foot screws until the bubble is exactly level in the center circle.
 - d) Self Leveling instruments can now be swiveled gently on the base plate and maintain level as long as the tripod remains steady.
 - e) Adjust focus, brightness and parallax according to manufactures specifications.
 - f) The instrument is ready to make measurements.

^a Method codes are: *CL*=clinometer, *TR*=transit, *HL*=hand level, *WT*=Water tube, *LA*=laser level, *OTHER*=method not listed (describe in comments section of form).

PHab: SLOPE AND BEARING FORM - WADEABLE

Reviewed by (initials): JD

SITE ID: FW08 XX000 DATE: 07/01/2008

TRANSECT & METHOD <small>Mark method for every transect</small>	MAIN (always used)			FIRST SUPPLEMENTAL			SECOND SUPPLEMENTAL			FLAG
	Slope(%) or Elev. Diff. (cm) <small>Mark units for every transect</small>	BEARING 0 - 359	PROPOR-TION %	Slope(%) or Elev. Diff. (cm)	BEARING 0 - 359	PROPOR-TION %	Slope(%) or Elev. Diff. (cm)	BEARING 0 - 359	PROPOR-TION %	
A < B <input checked="" type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	3.5 %	203	50	4.5	226	50	1.0	230	30	
B < C <input type="radio"/> CL <input type="radio"/> TR <input checked="" type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	2.0 %	218	40	2.0	203	30	1.0	230	30	
C < D <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	1.0 %	184	100							
D < E <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	3.0 %	179	100							
E < F <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	1.0 %	193	100							
F < G <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	2.0 %	211	100							
G < H <input type="radio"/> CL <input type="radio"/> TR <input checked="" type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	4.5 %	177	25	3.0	163	75				F.1
H < I <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	3.0 %	176	100							
I < J <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	0.1 %	189	100							
J < K <input type="radio"/> CL <input type="radio"/> TR <input type="radio"/> HL <input type="radio"/> WT <input type="radio"/> LA <input type="radio"/> Other	0.0 %	189	100							F.2

COMMENT

F1 CLINOMETER READING = 0, BUT THERE IS PERCEPTABLE FLOW

F2 CLINOMETER READING = 0, WITH NO PERCEPTABLE FLOW

Flow direction: \downarrow

Points: B (First Supplemental), Main, A

Flag codes: K = Sample not collected; U = Suspect sample; F1, F2, M (M = Method - used for method comment only) = flag assigned by field crew. Explain all flags in comment sections
 03/04/2008 2008 Phab Slope - NRSA CL=Clinometer; HL=Hand Level; LA=Laser rangefinder with electronic clinometer; TR=Transit, surveyors level or total station; WT=Water Tubing.

Figure 6.2-5. Slope and Bearing Form.

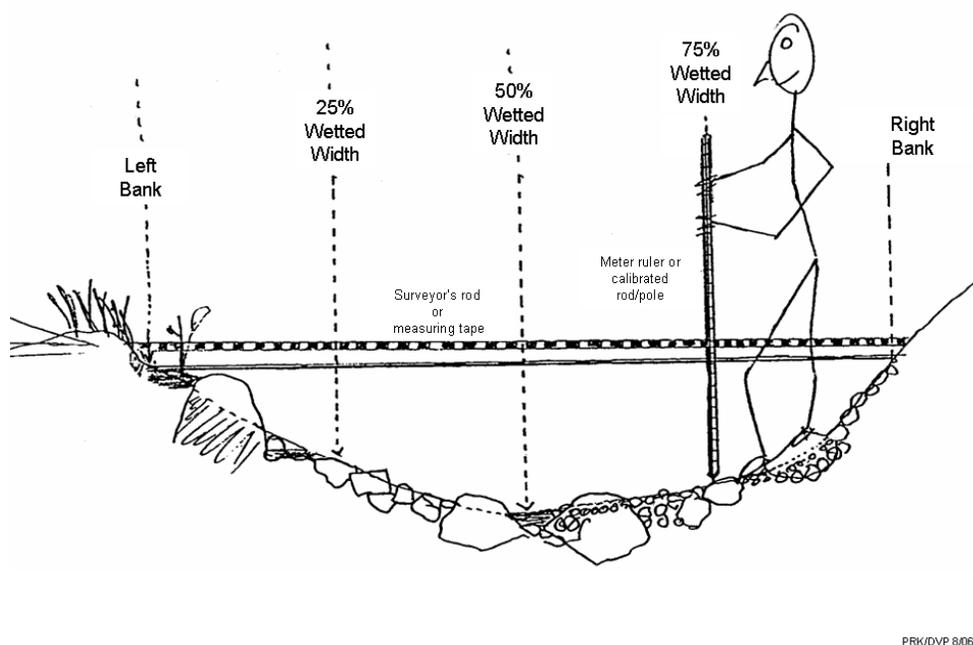
Table 6.2-6. Modified procedure for obtaining slope and bearing data

Use this procedure if you are starting at the **upstream transect (K)**, after completing the thalweg profile and other cross-section measurements at transects A through K.

1. Stand in the center of the channel at the upstream cross-section transect. Determine if you can see the center of the channel at the next cross-section transect downstream without sighting across land (i.e., do not “short-circuit” a meander bend). If not, you will have to take supplementary slope and bearing measurements.
Mark a surveyor’s rod and a calibrated rod (or meter ruler) at the same height. If a shorter pole or ruler is used, measure the height from the ground to the opening of the clinometer when it is resting on top.
2. Have one person take the marked surveyor’s rod to the downstream transect. Hold the rod vertical with the bottom at the same level as the water surface. If no suitable location is available at the stream margin, position the rod in the water and note the depth.
 - If you have determined in Step 1 that supplemental measurements are required for this segment, walk downstream to the furthest point where you can stand in the center of the channel and still see the center of the channel at the upstream cross-section transect . Remember that your line of sight cannot “cross land.” Mark this location with a different color flagging than that marking the cross-section transects.
3. Place the base of the calibrated rod at the level as the surveyor’s rod (either at the water surface or at the same depth in the water).
4. Place the clinometer on the calibrated rod at the height determined in Step 2. With the clinometer, sight back downstream to the flagged height on the surveyor’s rod at the downstream transect (or at the supplementary point).
 - If you are sighting to the next downstream transect, read and record the **percent** slope in the *MAIN* section on the Slope and Bearing Form for the **downstream transect** (e.g., $J < K$), which is at the **bottom** of the form (i.e., you are completing the form in reverse order). Record the *PROPORTION* as 100%.
 - If you are backsighting from a supplemental point, record the slope (%) and proportion (%) of the stream segment that is included in the measurement in the appropriate *SUPPLEMENTAL* section of the Slope and Bearing Form. The last sighting to a downstream transect (from either the upstream transect or the nearest upstream supplemental point) is always recorded as the *MAIN* reading.
5. Stand in the middle of the channel at upstream transect (or at a supplemental point), and sight with your compass to the middle of the channel at the downstream transect (or at a supplemental point). Record the bearing (degrees) in the same section of the Slope and Bearing form (Supplemental or Main) as you recorded the slope in Step 6.
6. Proceed to the next cross-section transect (or to a supplementary point), and repeat Steps 3 through 7 above.

6.2.5.2 Substrate Size and Channel Dimensions

Substrate size and embeddedness are evaluated at 5 points at each of the 11 transects (refer to Figure 6.2-6). Substrate size is also evaluated at 10 additional cross-sections located midway between each of the 11 regular transects (A-K). In the process of measuring substrate particle sizes at each channel cross-section, the wetted width of the channel and the water depth at each substrate sample point are measured (at the 10 midway cross-sections, only substrate size and wetted width are recorded). If the wetted channel is split by a mid-channel bar (see Section 6.2.4.1), the five substrate points are centered between the wetted width boundaries regardless of the mid-channel bar in between. Consequently, substrate particles selected in some cross-sections may be “high and dry”. *For cross-sections that are entirely dry, make measurements across the **unvegetated portion** of the channel.*



PRK/DVP 8/06

Figure 6.2-6. Substrate sampling cross-section.

The substrate sampling points along the cross-section are located at 0, 25, 50, 75, and 100 percent of the measured wetted width, with the first and last points located at the water's edge just within the left and right banks. The procedure for obtaining substrate measurements is described in Table 6.2-7 (including all particle size classifications). Record these measurements on the Channel/Riparian Cross-section side of the field form, as shown in Figure 6.2-7. For the supplemental cross-sections midway between regular transects,

Table 6.2-7. Substrate measurement procedure

1. Fill in the header information on page 1 of a Channel/Riparian Cross-section Form. Indicate the cross-section transect. At the transect, extend the surveyor's rod or metric tape across the channel perpendicular to the flow, with the "zero" end at the left bank (facing downstream).

NOTE: If a side channel is present, and contains 16 - 49% of the total flow, establish a secondary cross-section transect. Use a separate field data form to record data for the side channel, designating it as a secondary transect by marking both the X-TRA SIDE CHANNEL circle and the associated primary transect letter (e.g., XA, XB, etc.). Collect all channel and riparian cross-section measurements from the side channel.

2. Divide the wetted channel width channel by 4 to locate substrate measurement points on the cross-section. In the *DISTLB* fields of the form, record the distances corresponding to 0% (*LFT*), 25% (*LCTR*), 50% (*CTR*), 75% (*RCTR*), and 100% (*RGT*) of the measured wetted width. Record these distances at Transects A-K, but just the wetted width at midway cross-sections.

3. Place your sharp-ended meter stick or calibrated pole at the *LFT* location (0 m). Measure the depth and record it on the field data form. (Cross-section depths are measured only at regular transects A-K, not at the 10 midway cross-sections).

- Depth entries at the left and right banks may be 0 (zero) if the banks are gradual.
- If the bank is nearly vertical, let the base of the measuring stick fall to the bottom (i.e., the depth at the bank will be > 0 cm), rather than holding it suspended at the water surface.

4. Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder), and visually *estimate its particle size*, according to the following table. Classify the particle according to its **median diameter** (the middle dimension of its length, width, and depth). Record the size class code on the field data form. (Cross-section side of form for transects A-K; special entry boxes on Thalweg Profile side of form for midway cross-sections.)

Code	Size Class	Size Range (mm)	Description
RS	Bedrock (Smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (Rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan	>4000	Firm, consolidated fine substrate
LB	Boulders (large)	>1000 to 4000	Yard/meter stick to car size
SB	Boulders (small)	>250 to 1000	Basketball to yard/meter stick size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (Coarse)	>16 to 64	Marble to tennis ball size
GF	Gravel (Fine)	> 2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size - gritty between fingers
FN	Fines	≤0.06	Silt Clay Muck (not gritty between fingers)
WD	Wood	Regardless of Size	Wood & other organic particles
RC	Concrete	Regardless of size	Record size class in comment field
OT	Other	Regardless of Size	Metal, tires, car bodies etc. (describe in comments)

5. Evaluate substrate embeddedness as follows at each transects. For particles larger than sand, examine the surface for stains, markings, and algae. Estimate the average % embeddedness of particles in the

10 cm circle around the measuring rod. Record this value on the field data form. For sand and smaller particles, you will not be able to pick up an individual particle, but a “pinch” of fine particles between your fingers. Determine and record the dominant size of particles in the “pinch.” By definition, sand and fines are embedded 100%; bedrock and hardpan are embedded 0%.

6. Move to the next location on the transect, and repeat Steps 4 - 6 at each location. Repeat Steps 1 - 6 at each transect, including any additional side channel transects established if islands are present.

record substrate size and wetted width data on the thalweg profile side of the field form. To minimize bias in selecting a substrate particle for size classification, it is important to concentrate on correct placement of the measuring stick along the cross-section, and to select the particle right at the bottom of the stick (not, for example, a more noticeable large particle that is just to the side of the stick). Classify the particle into one of the size classes listed on the field data form (Figure 6.2-7) based on the middle dimension of its length, width, and depth. This *median dimension* determines the sieve size through which the particle can pass. When you record the size class as *Other*, assign an *Fn* flag on the field data form and describe the substrate type in the comments section of the field form, as shown in Figure 6.2-7.

At substrate sampling locations on the 11 regular transects (A-K), examine particles larger than sand for surface stains, markings, and algal coatings to estimate embeddedness of all particles in the 10 cm diameter circle around the substrate sampling point. Embeddedness is the fraction of a particle’s volume that is surrounded by (embedded in) sand or finer sediments on the stream bottom. By definition, record the embeddedness of sand and fines (silt, clay, and muck) as 100 percent, and record the embeddedness of hardpan and bedrock as 0 percent.

6.2.5.3 Bank Characteristics

The procedure for obtaining bank and channel dimension measurements is presented in Table 6.2-8. Data are recorded in the *BANK MEASUREMENTS* section of the Channel/Riparian Cross-section Form as shown in Figure 6.2-7. Bank angle and bank undercut distance are determined on the left and right banks at each cross-section transect. Figure 6.2-8 illustrates how bank angle is determined for several different situations. The scale at which bank angle is characterized is approximately 0.5 m. A short (approx. 1-m long) pole is used to determine bank angle. The angle is determined based on the pole resting on the ground for about 0.5 m. Other features include the wetted width of the channel (as determined in Section 6.2.5.2), the width of exposed mid-channel bars of gravel or sand, estimated incision height, and the estimated height and width of the channel at bankfull stage as described in Table 6-8. *Bankfull height* and *incised height* are both measured relative to the present water surface (i.e. the level of the wetted edge of the stream). This is done by placing the base of the small measuring rod at the bankfull elevation and sighting back to the survey rod placed at the water’s edge using the clinometer as a level (i.e., positioned so the slope reading is 0%). The height of the clinometer above the base of the smaller rod is subtracted from the elevation sighted on the surveyor’s rod.

Table 6.2-8. Procedure for measuring bank characteristics

1. To measure *bank angle*, lay a meter ruler or a short (approx. 1-m long) rod down against the left bank (determined as you face downstream), with one end at the water's edge. At least 0.5 m of the ruler or rod should be *resting comfortably* on the ground to determine bank angle. Lay the clinometer on the rod, and read the bank angle in degrees from the external scale on the clinometer. Record the angle in the field for the left bank in the *BANK MEASUREMENT* section of the Channel/Riparian Cross-section Form.
 - A *vertical bank* is 90°, *overhanging banks* have angles >90° approaching 180°, and more gradually sloped banks have angles <90°. To measure bank angles >90°, turn the clinometer (which only reads 0 to 90°) over and subtract the angle reading from 180°.
 - If there is a large boulder or log present at the transect, measure bank angle at a nearby point where conditions are more representative.
2. If the bank is *undercut*, measure the horizontal distance of the undercutting to the nearest 0.01 m. The undercut distance is the distance from the water's edge out to the point where a vertical plumb line from the bank would hit the water's surface. Record the distance on the field data form. Measure submerged undercuts by thrusting the rod into the undercut and reading the length of the rod that is hidden by the undercutting.
3. Repeat Steps 1 and 2 on the right bank.
4. Hold the surveyor's rod vertical, with its base planted at the water's edge. Examine both banks, then determine the channel *incision* as the *height up from the water surface to elevation of the first terrace of the valley floodplain* (Note this is at or above the bankfull channel height). Whenever possible, use the clinometer as a level (positioned so it reads 0% slope) to measure this height by transferring (backsighting) it onto the surveyor's rod. Record this value in the *INCISED HEIGHT* field of the bank measurement section on the field data form.
5. While still holding the surveyor's rod as a guide, and sighting with the clinometer as a level, examine both banks to measure and record the *height of bankfull flow above the present water level*. Look for evidence on one or both banks such as:
 - An obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel.
 - A transition from exposed stream sediments to terrestrial vegetation.
 - Moss growth on rocks along the banks.
 - Presence of drift material caught on overhanging vegetation.
 - A transition from flood- and scour-tolerant vegetation to that which is relatively intolerant of these conditions.
6. Record the *wetted width* value determined when locating substrate sampling points in the *WETTED WIDTH* field in the bank measurement section of the field data form. Also determine the *bankfull channel width* and the *width of exposed mid-channel bars* (if present). Record these values in the *BANK MEASUREMENT* section of the field data form.
7. Repeat Steps 1 through 6 at each cross-section transect, (including any additional side channel transects established when islands are present). Record data for each transect on a separate field data form.

Bankfull flows are large enough to erode the stream bottom and banks, but frequent enough (every 1 to 2 years) to not allow substantial growth of upland terrestrial vegetation. Consequently, in many regions, it is these flows that have determined the width and depth of the

channel. Estimates of the bankfull dimensions of stream channels are extremely important in EMAP surveys. They are used to calculate shear stress and bed stability (see Kaufmann et al., 1999). Unfortunately, we have to depend upon evidence visible during the low-flow sampling season. If available, consult published rating curves relating expected bankfull channel dimensions to stream drainage area within the region of interest. Graphs of these rating curves can help you get a rough idea of where to look for field evidence to determine the level of bankfull flows. Curves such as these are available from the USGS for streams in most regions of the U.S. (e.g., Dunne and Leopold 1978; Harrelson et al. 1994, Leopold 1994). To use them, you need to know the contributing drainage area to your sample site. Interpret the expected bankfull levels from these curves as a height above the streambed in a riffle, but remember that your field measurement will be a height above the present water surface of the stream. Useful resources to aid your determination of bankfull flow levels in streams in the United States are video presentations produced by the USDA Forest Service for western streams (USDA Forest Service 1995) and eastern streams (USDA Forest Service 2002).

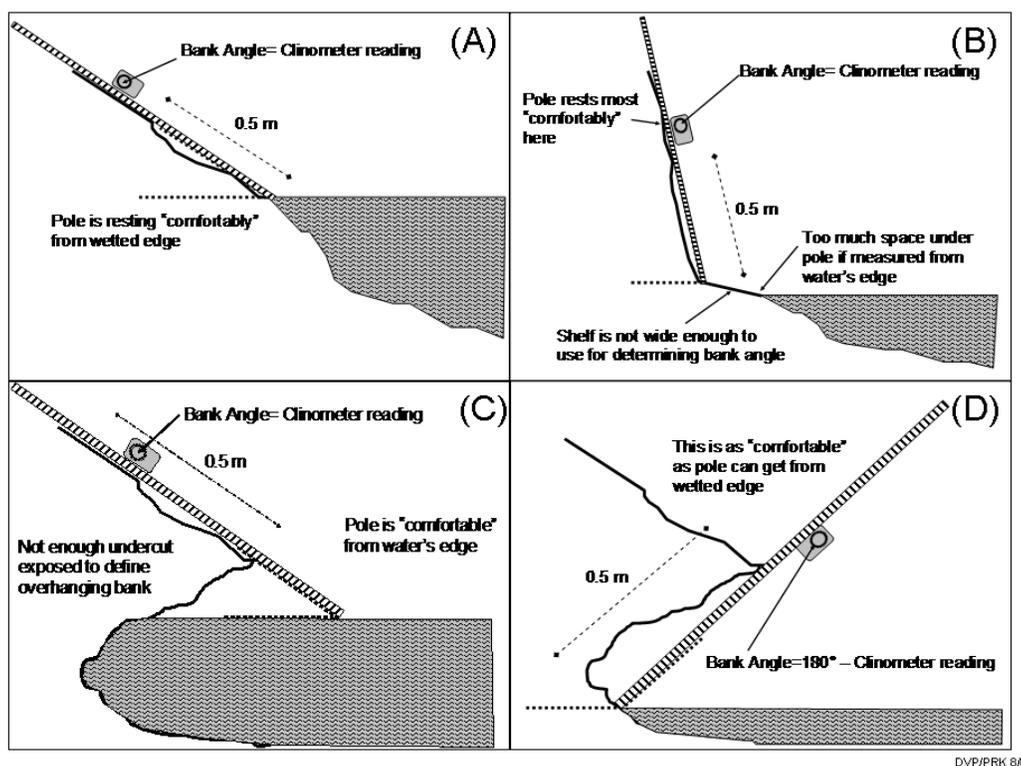


Figure 6.2-8. Determining bank angle under different types of bank conditions. (A) typical, (B) incised channel, (C) undercut bank, and (D) overhanging bank.

After consulting rating curves that show where to expect bankfull levels in a given size of stream, estimate the bankfull flow level by looking at the following indicators:

- First look at the stream and its valley to determine the active floodplain. This is a depositional surface that frequently is flooded and experiences sediment deposition under the current climate and hydrological regime.
- Then look specifically for:
 - An obvious break in the slope of the banks.
 - A change from water-loving and scour-tolerant vegetation to more drought-tolerant vegetation.
 - A change from well-sorted stream sediments to unsorted soil materials.

In the absence of clear bankfull indications, consider the previous season's flooding as the best evidence available (note: you could be wrong if very large floods or prolonged droughts have occurred in recent years.). Look for:

- Drift debris ("sticky wickets" left by the previous seasons flooding).
- The level where deciduous leaf-fall is absent on the ground (carried away by previous winter flooding).
- Unvegetated sand, gravel or mud deposits from previous year's flooding.

In years that have experienced large floods, drift material and other recent high flow markers may be much higher than other bankfull indicators. In such cases, base your determination on less-transient indicators such as channel form, perennial vegetation, and depositional features. In these cases, flag your data entry and also record the height of drift material in the comments section of the field data form.

We use the vertical distance (height) from the observed water surface up to the level of the first major valley depositional surface (Figure 6.2-9) as a measure of the degree of *incision* or *downcutting* of the stream below the general level of its valley. This value is recorded in the *INCISED HEIGHT* field. It may not be evident at the time of sampling whether the channel is downcutting, stable, or aggrading (raising its bed by depositing sediment). However, by recording incision heights measured in this way and monitoring them over time, we will be able to tell if streams are incising or aggrading.

If the channel is not greatly incised, bankfull channel height and incision height will be the same (i.e., the first valley depositional surface is the active floodplain). However, if the channel is incised greatly, the bankfull level will be below the level of the first terrace of the valley floodplain, making bankfull channel height less than incision height (Figure 6.2-10). **Bankfull height is never greater than incision height.** You may need to look for evidence of recent flows (within about one year) to distinguish bankfull and incision heights. In cases where the channel is cutting a valley sideslope and has oversteepened and destabilized that slope, the bare "cutbank" against the steep hillside at the edge of the valley is not necessarily an indication of recent incision. In such a case, the opposite bank may be lower, with a more obvious terrace above bankfull height; choose that bank for your measurement of incised height. Examine both banks to more accurately determine incision height and bankfull height. Remember that incision height is measured as *the vertical distance to the first major depositional surface above bankfull* (whether or not it is an active floodplain or a terrace. If terrace heights differ on left and right

banks (both are above bankfull), choose the lower of the two terraces. In many cases your sample reach may be in a “V” shaped valley or gorge formed over eons, and the slope of the channel banks simply extends uphill indefinitely, not reaching a terrace before reaching the top of a ridge (Figure 6.2-10). In such cases, record incision height values equal to bankfull values and make appropriate comment that no terrace is evident. Similarly, when the stream has extremely incised into an ancient terrace, (e.g., the Colorado River in the Grand Canyon), you may crudely estimate the terrace height if it is the first one above bankfull level. If you cannot estimate the terrace height, make appropriate comments describing the situation.

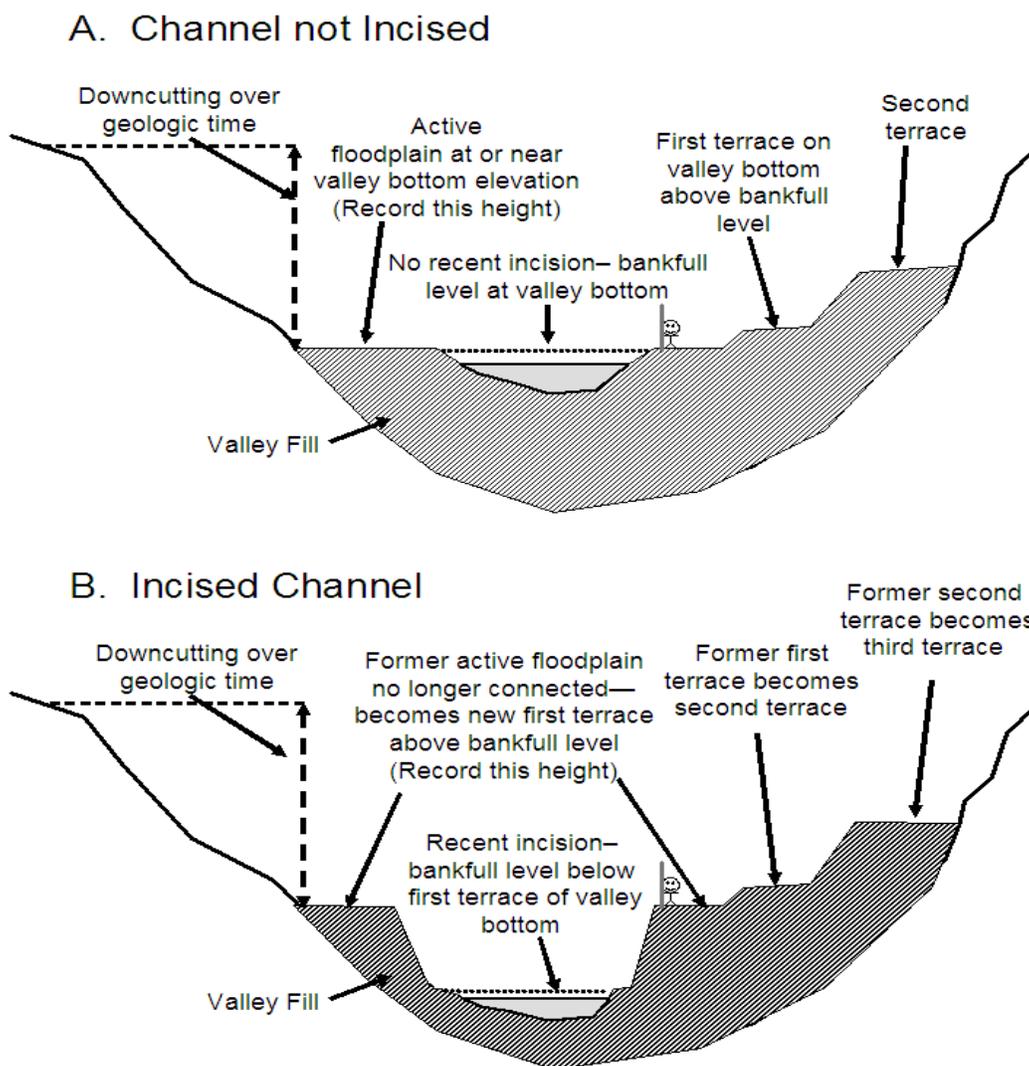
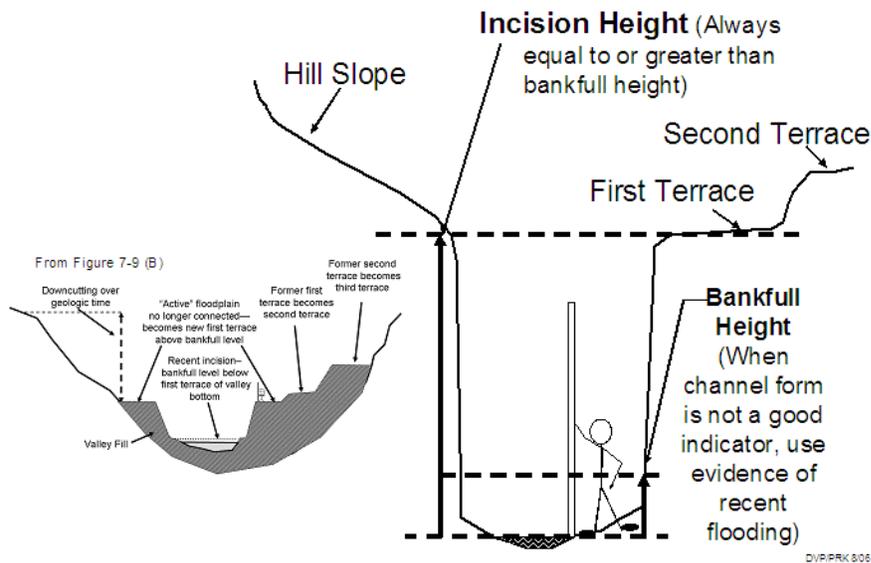


Figure 6.2-9. Schematic showing relationship between bankfull channel and incision. (A) not recently incised, and (B) recently incised into valley bottom. Note level of bankfull stage relative to elevation of first terrace (abandoned floodplain) on valley bottom. (Stick figure included for scale).

A) Deeply Incised Channel



B) Small stream constrained in V-shaped valley

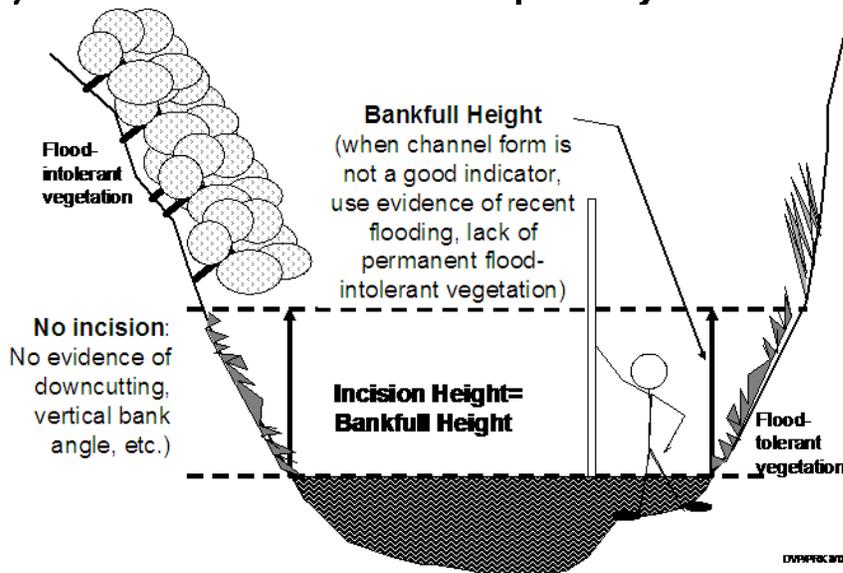


Figure 6.2-10. Determining bankfull and incision heights for (A) deeply incised channels, and (B) streams in deep V-shaped valleys. (Stick figure included for scale).

6.2.5.4 Canopy Cover Measurements

Canopy cover over the stream is determined at each of the 11 cross-section transects. A spherical densiometer (model A- **convex type**) is used (Lemmon 1957). Mark the densiometer with a permanent marker or tape exactly as shown in Figure 6.2-11 to limit the number of square grid intersections read to 17. Densiometer readings can range from 0 (no canopy cover) to 17 (maximum canopy cover). Six measurements are obtained at each cross-section transect (four measurements in each of four directions at mid-channel and one at each bank).

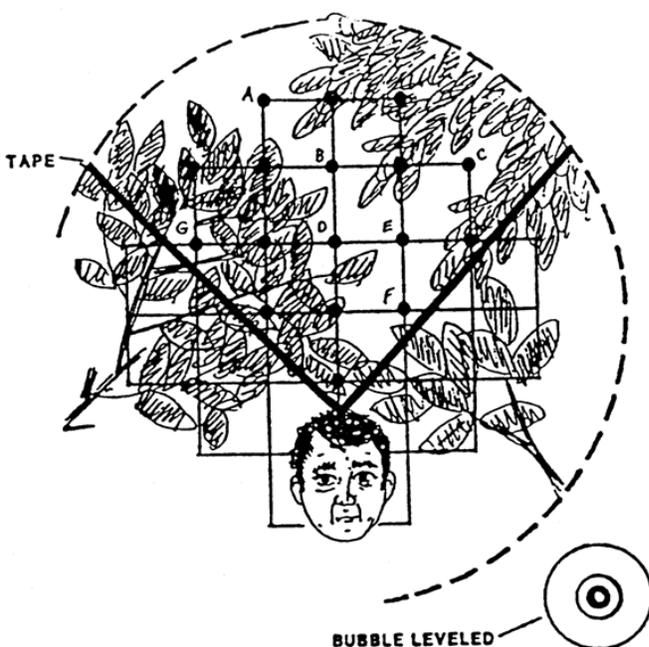


Figure 6.2-11. Schematic of modified convex spherical canopy densiometer. From Mulvey et al. (1992). Note proper positioning with the bubble leveled and face reflected at the apex of the “V”. In this example, 10 of the 17 intersections show canopy cover, giving a densiometer reading of 10.

The procedure for obtaining canopy cover data is presented in Table 6.2-9. Hold the densiometer level (using the bubble level) 0.3 m above the water surface with your face reflected just below the apex of the taped “V”, as shown in Figure 6.2-11. Concentrate on the 17 points of grid intersection on the densiometer that lie within the taped “V”. If the reflection of a tree or high branch or leaf overlies any of the intersection points, that particular intersection is counted as having cover. For each of the six measurement points, record the number of intersection points (maximum=17) that have vegetation covering them in the *CANOPY COVER MEASUREMENT* section of the Channel/Riparian Cross-section Form as shown in Figure 6.2-7.

Table 6.2-9. Procedure for canopy cover measurements

1. At each cross-section transect, stand in the stream at mid-channel and face upstream.
2. Hold the densiometer 0.3 m (1 ft) above the surface of the stream. Level the densiometer using the bubble level. Move the densiometer in front of you so your face is just below the apex of the taped "V".
3. Count the number of grid intersection points within the "V" that are covered by either a tree, a leaf, or a high branch. Record the value (0 to 17) in the *CENUP* field of the canopy cover measurement section of the Channel/Riparian Cross-section and Thalweg Profile Form.
4. Face toward the left bank (left as you face downstream). Repeat Steps 2 and 3, recording the value in the *CENL* field of the field data form.
5. Repeat Steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the *CENDWN* and *CENR* fields of the field data form.
6. Move to the water's edge (either the left or right bank). Repeat Steps 2 and 3 again, this time facing the bank. Record the value in the *LFT* or *RGT* fields of the field data form. Move to the opposite bank and repeat.
7. Repeat Steps 1 through 6 at each cross-section transect (including any additional side channel transects established when islands are present). Record data for each transect on a separate field data form.

6.2.5.5 Riparian Vegetation Structure

The previous section (6.2.5.4) described methods for quantifying the cover of canopy over the stream channel. The following visual estimation procedures supplement those measurements with a semi-quantitative evaluation of the type and amount of various types of riparian vegetation. Additional measures within the riparian zone (legacy trees and invasive riparian plants) are described in Section 6.2.5.9.

Riparian vegetation observations apply to the riparian area upstream 5 meters and downstream 5 meters from each of the 11 cross-section transects (refer to Figure 6.2-1). They include the visible area from the stream back a distance of 10m (~30 ft) shoreward from both the left and right banks, creating a 10 m × 10 m riparian plot on each side of the stream (Figure 6.2-12). The riparian plot dimensions are estimated, not measured. On steeply sloping channel margins, the 10 m × 10 m plot boundaries are defined as if they were projected down from an aerial view.

Table 6.2-10 presents the procedure for characterizing riparian vegetation structure and composition. Figure 6.2-7 illustrates how measurement data are recorded on the Channel/Riparian Cross-section Form. Conceptually divide the riparian vegetation into 3 layers: the *Canopy* layer (> 5 m high), the *Understory* layer (0.5 to 5 m high), and the *Ground cover* layer (< 0.5 m high). Note that several vegetation types (e.g., grasses or woody shrubs) can potentially occur in more than one layer. Similarly note that some things other than vegetation are possible entries for the *Ground cover* layer (e.g., barren ground).

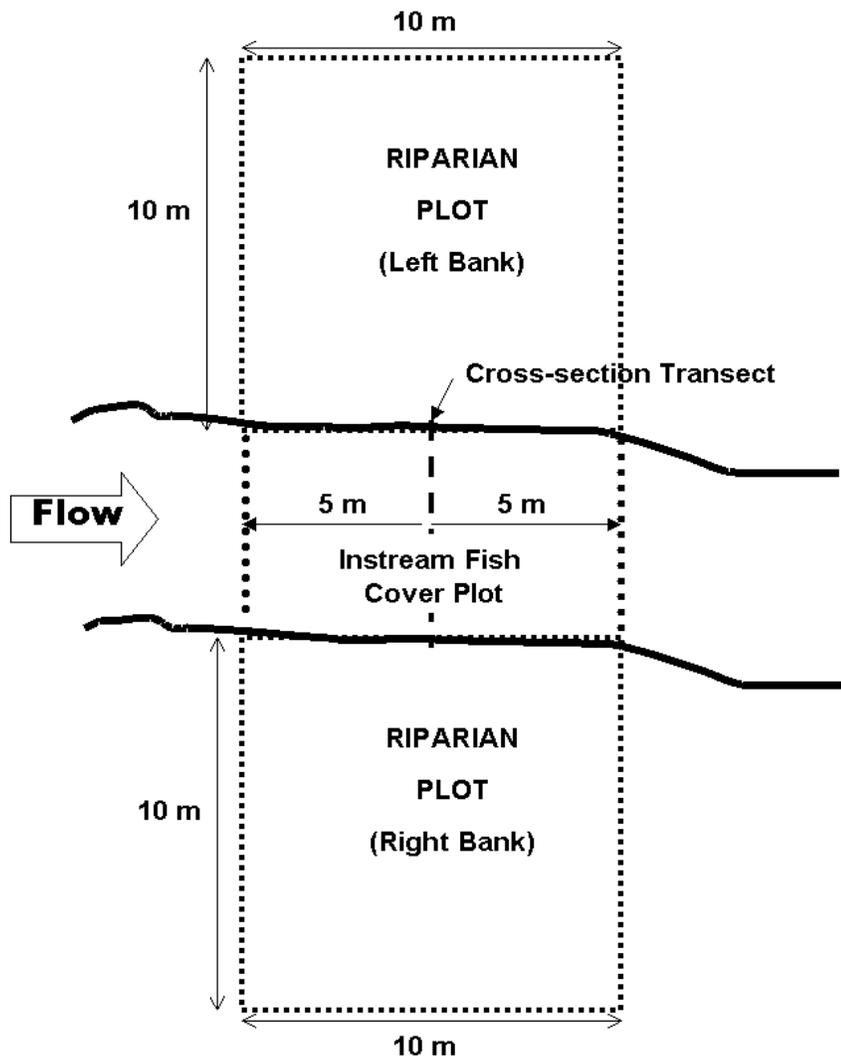


Figure 6.2-12. Riparian zone and instream fish cover plots for a stream cross-section transect.

Table 6.2-10. Procedure for characterizing riparian vegetation structure

1. Standing in mid-channel at a cross-section transect, estimate a 5 m distance upstream and downstream (10 m total length).
2. Facing the left bank (left as you face downstream), estimate a distance of 10 m back into the riparian vegetation.
On steeply-sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.
3. Within this 10 m × 10 m area, conceptually divide the riparian vegetation into 3 layers: a *Canopy Layer* (>5 m high), an *Understory* (0.5 to 5 m high), and a *Ground Cover* layer (<0.5 m high).
4. Within this 10 m × 10 m area, determine the dominant vegetation type for the *CANOPY LAYER* (vegetation >5 m high) as either *Deciduous*, *Coniferous*, *broadleaf Evergreen*, *Mixed*, or *None*. Consider the layer *Mixed* if more than 10% of the areal coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the *VISUAL RIPARIAN ESTIMATES* section of the Channel/Riparian Cross-section Form.
5. Determine separately the areal cover class of large trees (≥0.3 m [1 ft] diameter at breast height [dbh]) and small trees (<0.3 m dbh) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (0=*absent*: zero cover, 1=*sparse*: <10%, 2=*moderate*: 10-40%, 3=*heavy*: 40-75%, or 4=*very heavy*: >75%).
6. Look at the *UNDERSTORY* layer (vegetation between 0.5 and 5 m high). Determine the dominant **woody** vegetation type for the understory layer as described in Step 4 for the canopy layer. If there is no woody vegetation in the understory layer, record the type as *None*.
7. Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in Step 5 for the canopy layer.
8. Look at the *GROUND COVER* layer (vegetation <0.5 m high). Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in Step 5 for large canopy trees.
9. Repeat Steps 1 through 8 for the right bank.
10. Repeat Steps 1 through 9 for all cross-section transects (including any additional side channel transects established when islands are present). Use a separate field data form for each transect.

Before estimating the areal coverage of the vegetation layers, record the type of *woody* vegetation (*broadleaf Deciduous*, *Coniferous*, *broadleaf Evergreen*, *Mixed*, or *None*) in each of the two taller layers (Canopy and Understory). Consider the layer *Mixed* if more than 10% of the areal coverage is made up of the alternate vegetation type. If there is no woody vegetation in the understory layer, record the type as *None*.

Estimate the areal cover separately in each of the three vegetation layers. Note that the areal cover can be thought of as the amount of shadow cast by a particular layer alone when the sun is directly overhead. *The maximum cover in each layer is 100%, so the sum of the areal covers for the combined three layers could add up to 300%.* The four areal cover classes are *Absent*, *Sparse* (<10%), *Moderate* (10 to 40%), *Heavy* (40 to 75%), and *Very Heavy* (>75%). These cover classes and their corresponding codes are shown on the field data form (Figure 6.2-7). When rating vegetation cover types for a single vegetation layer, mixtures of two or more subdominant classes might all be given *Sparse* (1), *Moderate* (2), or *Heavy* (3) ratings. One *Very Heavy* cover class with no clear subdominant class might be rated 4 with all the remaining classes rated as either *Moderate* (2), *Sparse* (1) or *Absent* (0). Note that within a

given vegetation layer, two cover types with 40-75% cover can both be rated 3, but no more than one cover type could receive a rating of 4.

6.2.5.6 Instream Fish Cover, Algae, and Aquatic Macrophytes

The procedure to estimate the types and amounts of instream fish cover is outlined in Table 6.2-11. Data are recorded on the Channel/Riparian Cross-section Form as shown in Figure 6.2-7. Estimate the areal cover of all of the fish cover and other listed features that are in the water and on the banks 5 m upstream and downstream of the cross-section (see Figure 6.2-12). The areal cover classes of fish concealment and other features are the same as those described for riparian vegetation (Section 6.2.5.5).

The entry *FILAMENTOUS ALGAE* refers to long streaming algae that often occur in slow moving waters. *AQUATIC MACROPHYTES* are water-loving plants, including mosses, in the stream that could provide cover for fish or macroinvertebrates. If the stream channel contains live wetland grasses, include these as aquatic macrophytes. *WOODY DEBRIS* are the larger pieces of wood that can influence cover and stream morphology (i.e., those pieces that would be included in the large woody debris tally [Section 6.2.4]). *BRUSH/WOODY DEBRIS* refers to smaller wood pieces that primarily affect cover but not morphology. *LIVE TREES OR ROOTS* are living trees that are within the channel – estimate the areal cover provided by the parts of these trees or roots that are inundated. *OVERHANGING VEGETATION* includes tree branches, brush, twigs, or other small debris that is not in the water but is close to the stream (within 1 m of the surface) and provides potential cover. *BOULDERS* are typically basketball- to car-sized particles. *ARTIFICIAL STRUCTURES* include those designed for fish habitat enhancement, as well as in-channel structures that have been discarded (e.g., concrete, asphalt, cars, or tires) or deliberately placed for diversion, impoundment, channel stabilization, or other purposes.

Table 6.2-11. Procedure for estimating instream fish cover

1. Standing mid-channel at a cross-section transect, estimate a 5m distance upstream and downstream (10 m total length).
2. Examine the water and both banks within the 10-m segment of stream for the following features and types of fish cover: *filamentous algae, aquatic macrophytes, large woody debris, brush and small woody debris, in-channel live trees or roots, overhanging vegetation, undercut banks, boulders, and artificial structures*.
3. For each cover type, estimate the areal cover. Record the appropriate cover class in the *FISH COVER/OTHER* section of the Channel/Riparian Cross-section Form:
 - 0=absent*: zero cover,
 - 1=sparse*: <10%,
 - 2=moderate*: 10-40%,
 - 3=heavy*: >40-75%, or
 - 4=very heavy*: >75%).
4. Repeat Steps 1 through 3 at each cross-section transect (including any additional side channel transects established when islands are present). Record data from each transect on a separate field data form.

6.2.5.7 Human Influence

For the left and right banks at each of the 11 detailed Channel and Riparian Cross-sections, evaluate the presence/absence and the proximity of 11 categories of human influences with the procedure outlined in Table 6.2-12. Relate your observations and proximity evaluations to the stream and riparian area within 5 m upstream and 5 m downstream from the station (Figure 6.2-12). Four proximity classes are used: In the stream or on the bank within 5 m upstream or downstream of the cross-section transect, present within the 10 m × 10 m riparian plot but not in the stream or on the bank, present outside of the riparian plot, and absent. Record data on the Channel/Riparian Cross-section Form as shown in Figure 6.2-7. If a disturbance is within more than one proximity class, record the one that is closest to the stream (e.g., *C* takes precedence over *P*).

A particular influence may be observed outside of more than one riparian observation plot (e.g., at both transects *D* and *E*). Record it as present at every transect where you can see it without having to sight through another transect or its 10 m × 10 m riparian plot.

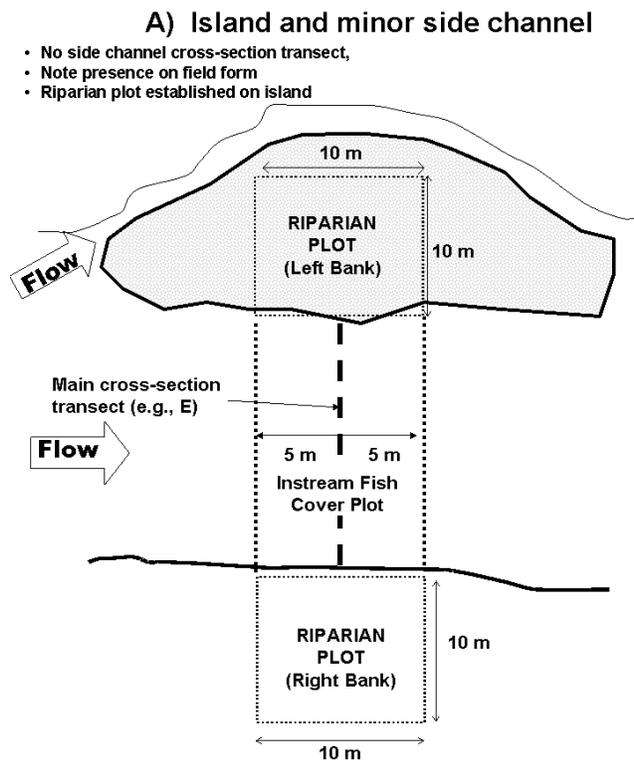
Table 6.2-12. Procedure for estimating human influence

1. Standing mid-channel at a cross-section transect, look toward the left bank (left when facing downstream), and estimate a 5 m distance upstream and downstream (10 m total length). Also, estimate a distance of 10 m back into the riparian zone to define a riparian plot area.
2. Examine the channel, bank and riparian plot area adjacent to the defined stream segment for the following human influences: (1) *walls, dikes, revetments, riprap, and dams*; (2) *buildings*; (3) *pavement/cleared lots* (e.g., paved, gravelled, dirt parking lot, foundation); (4) *roads or railroads*, (5) *inlet or outlet pipes*; (6) *landfills or trash* (e.g., cans, bottles, trash heaps); (7) *parks or maintained lawns*; (8) *row crops*; (9) *pastures, rangeland, hay fields, or evidence of livestock*; (10) *logging*; and (11) *mining* (including gravel mining).
3. For each type of influence, determine if it is present and what its proximity is to the stream and riparian plot area. Consider human disturbance items as present if you can see them from the cross-section transect. Do not include them if you have to sight through another transect or its 10 m × 10 m riparian plot.
4. For each type of influence, record the appropriate proximity class in the *HUMAN INFLUENCE* part of the *VISUAL RIPARIAN ESTIMATES* section of the Channel/Riparian Cross-section Form. Proximity classes are:

<i>B (Bank)</i>	Present within the defined 10 m stream segment and located in the stream or on the stream bank.
<i>C (Close)</i>	Present within the 10 × 10 m riparian plot area, but away from the bank.
<i>P (Present)</i>	Present, but outside the riparian plot area.
<i>0 (Absent)</i>	Not present within or adjacent to the 10 m stream segment or the riparian plot area at the transect
5. Repeat Steps 1 through 4 for the right bank.
6. Repeat Steps 1 through 5 for each cross-section transect, (including any additional side channel transects established when islands are present). Record data for each transect on a separate field form.

6.2.5.8 Cross-section Transects on Side Channels

If the wetted channel is split by an island, and the estimated flow in the side channel is less than or equal to 15% of the total flow, the bank and riparian measurements are made at each side of the main channel (the minor side channel is ignored other than to note its presence on the thalweg profile form), so one riparian plot is established on the island as shown in Figure 6.2-13. If an island is present that creates a major side channel containing **more than 15%** of the total flow (Section 6.2.4.1), an additional cross-section transect is established for the side channel as shown in Figure 6.2-13. Separate substrate, bank and riparian measurements are made for side channel transects. Data from the additional side channel transect are recorded on a separate Channel/Riparian Cross-section Form as shown in Figure 6.2-14. Riparian plots established on the island for each transect may overlap (and be < 10 m shoreward) if the island is less than 10 m wide at the transect.



PRN/DVP 8/06

Figure 6.2-13. Riparian and instream fish cover plots for a stream with minor and major side channels.

6.2.5.9 Riparian “Legacy” Trees and Invasive Alien Species

Follow the procedures in Table 6.2-13 to locate the **largest** tree associated with each transect. The tree you choose may not truly be an old *legacy* tree – just choose the largest you see. We use these data to determine if there are true legacy trees somewhere within the support reach. Note that only one tree is identified for each transect between that transect and the next one upstream; at transect *K*, look upstream a distance of 4 channel widths. Record the type of tree, and, if possible, the taxonomic group (using the list provided in Table 6.2-13) on the left-hand column of the Riparian “Legacy” Trees and Invasive Alien Plants form (Figure 6.2-15). Estimate the height of the tree and the diameter at breast height (dbh), and mark the appropriate height and dbh classes on the form. Estimate and record the distance of the legacy tree from the wetted margin of the stream.

Search in the 10 m x 10 m riparian and littoral plots on both banks for the presence of any invasive alien species listed in the NRSA Invasive Species Guide provided to each field crew. Document the species observed on the Riparian “Legacy” Trees and Invasive Alien Plants form (Figure 5.2-8), answering the question of whether each of the target species is present in the plot. If you have a camera, document the species with a photograph. If you observe no alien taxa within the riparian and littoral plots, but can confidently identify them outside of the plots, include your observations in the comments portion of the form. If the river is too wide to effectively observe the far bank at a transect, record what you observe for the plot on the near bank, record a “U” flag, and explain in the comments section of the form.

Table 6.2-13. Procedure for identifying riparian legacy trees

Legacy Trees:

- Beginning at Transect A, look upstream and downstream as far as you can see confidently. Search both sides of the stream downstream to the next transect. Locate the largest tree visible within 100m (or as far as you can see, if less) from the wetted bank.
- Classify this tree as broadleaf deciduous, coniferous, or broadleaf evergreen (classify western larch as coniferous). Identify, if possible, the species or the taxonomic group of this tree from the list below.

1. Acacia/Mesquite	10. Poplar/Cottonwood
2. Alder/Birch	11. Snag (Dead Tree of Any Species)
3. Ash	12. Spruce
4. Cedar/Cypress/Sequoia	13. Sycamore
5. Fir (including Douglas Fir, Hemlock)	14. Willow
6. Juniper	15. Unknown, other Broadleaf Evergreen
7. Maple/Boxelder	16. Unknown or Other Conifer
8. Oak	17. Unknown or Other Deciduous
9. Pine	

NOTE: If the largest tree is a dead “snag”, enter “Snag” as the taxonomic group.

Estimate the height of the potential legacy tree, its diameter at breast height (dbh) and its distance from the wetted margin of the stream. Enter this information on the left hand column of the Riparian “Legacy” Trees and Invasive Alien Plants field form.

Alien Invasive Plants:

Examine the 10m x 10m riparian and littoral plots on both banks for the presence of alien species. (Species lists will be provided)

Record the presence of any species listed within the plots on either the left or right bank on the Riparian “Legacy” Trees and Invasive Alien Species field form. If none of the species listed is present in the plots at a given transect, fill in the circle indicating “None” for this transect.

Repeat for each remaining transect (B through K). At transect “K”, look upstream a distance of 4 channel widths when locating the legacy tree.

6.2.6 Channel Constraint, Debris Torrents, Recent Floods, and Discharge

6.2.6.1 Channel Constraint

After completing the thalweg profile and riparian/channel cross-section measurements and observations, envision the stream at bankfull flow and evaluate the degree, extent and type of channel constraint, using the procedures presented in Table 6.2-14. Record data on the Channel Constraint Assessment Form (Figure 6.2-16). First, classify the stream reach channel pattern as predominantly a *single channel*, an *anastomosing channel*, or a *braided channel* (Figure 6.2-17):

1. *Single channels* may have occasional in-channel bars or islands with side channels, but feature a *predominant single channel*, or a *dominant main channel with a subordinate side channel*.
2. *Anastomosing channels* have relatively long *major and minor channels* (but no predominant channel) in a complex network, diverging and converging around many *vegetated islands*. Complex channel pattern remains even during major floods.
3. *Braided channels* also have multiple branching and rejoining channels, (but no predominant channel) *separated by unvegetated bars*. Channels are generally smaller, shorter, and more numerous, often with no obvious dominant channel. During major floods, a single continuous channel may develop

After classifying the channel pattern, determine whether the channel is constrained within a narrow valley, constrained by local features within a broad valley, unconstrained and free to move about within a broad floodplain, or free to move about, but within a relatively narrow valley floor. Then examine the channel to ascertain the bank and valley features that constrain the stream. Entry choices for the type of constraining features are bedrock, hillslopes, terraces/alluvial fans, and human land use (e.g., a road, a dike, landfill, rip-rap, etc.). Estimate the percent of the channel margin in contact with constraining features (for unconstrained channels, this is 0%). To aid in this estimate, you may wish to refer to the individual transect assessments of incision and constraint. Finally, estimate the “typical” bankfull channel width and estimate the average width of the valley floor either with a topographic map or visually. If you cannot directly estimate the valley width (e.g., it is further than you can see, or if your view is blocked by vegetation), record the distance you can see and mark the appropriate circle on the field form.

Draft

Reviewed by (initial):

DATE: 07/01/2008

RIPARIAN "LEGACY" TREES AND INVASIVE ALIEN PLANTS

SITE ID: FW08XX000

Tran	LARGEST POTENTIAL LEGACY TREE VISIBLE FROM THIS STATION					ALIEN PLANT SPECIES PRESENT IN LEFT AND RIGHT RIPARIAN PLOTS, AND INSTREAM FISH COVER PLOT	
	Trees not Visible	DBH (m)	Height (m)	Dist. from wetted margin (m)	Type	Taxonomic Category	Check all that are present
A	<input type="radio"/>	<input type="radio"/> 0-0.1 <input type="radio"/> .75-2 <input checked="" type="radio"/> >2	<input type="radio"/> <5 <input type="radio"/> 5-15 <input type="radio"/> 15-30 <input type="radio"/> >30	<u>10</u>	Deciduous <input checked="" type="radio"/> Coniferous <input type="radio"/> Broadleaf <input type="radio"/> Evergreen <input type="radio"/>	<u>POPULAR / COTTONWOOD</u>	<input checked="" type="radio"/> NONE <input type="radio"/> E Wtrmilf <input type="radio"/> W Hyacinth <input type="radio"/> G Reed <input type="radio"/> MF Rose <input type="radio"/> Hydrilla <input type="radio"/> Ylw Filtheart <input type="radio"/> Flwr Rush <input type="radio"/> Spurge <input type="radio"/> E Wtrchest <input type="radio"/> P Lstrife <input type="radio"/> Salt Ced
B	<input type="radio"/>	<input type="radio"/> 0-0.1 <input type="radio"/> .75-2 <input type="radio"/> >2	<input type="radio"/> <5 <input type="radio"/> 5-15 <input type="radio"/> 15-30 <input type="radio"/> >30	<u>15</u>	Deciduous <input type="radio"/> Coniferous <input type="radio"/> Broadleaf <input type="radio"/> Evergreen <input type="radio"/>	<u>SNAG</u>	<input type="radio"/> NONE <input type="radio"/> E Wtrmilf <input type="radio"/> W Hyacinth <input type="radio"/> G Reed <input type="radio"/> MF Rose <input type="radio"/> Hydrilla <input type="radio"/> Ylw Filtheart <input type="radio"/> Flwr Rush <input type="radio"/> Spurge <input type="radio"/> E Wtrchest <input checked="" type="radio"/> P Lstrife <input type="radio"/> Salt Ced
C	<input type="radio"/>	<input type="radio"/> 0-0.1 <input checked="" type="radio"/> .75-2 <input type="radio"/> >2	<input type="radio"/> <5 <input type="radio"/> 5-15 <input type="radio"/> 15-30 <input type="radio"/> >30	<u>5</u>	Deciduous <input checked="" type="radio"/> Coniferous <input type="radio"/> Broadleaf <input type="radio"/> Evergreen <input type="radio"/>	<u>OTHER (ELM)</u>	<input type="radio"/> NONE <input type="radio"/> E Wtrmilf <input type="radio"/> W Hyacinth <input type="radio"/> G Reed <input type="radio"/> MF Rose <input type="radio"/> Hydrilla <input type="radio"/> Ylw Filtheart <input type="radio"/> Flwr Rush <input checked="" type="radio"/> Spurge <input type="radio"/> E Wtrchest <input checked="" type="radio"/> P Lstrife <input type="radio"/> Salt Ced

INSTRUCTIONS

Potential Legacy trees are defined as the largest tree within your search area, which is as far as you can see, but within maximum limits as follows:
 Wadeable Streams: Confine search to no more than 50 m from left and right bank and extending upstream to next transect (for 'K' look upstream 4 channel widths)
 Non-wadeable Rivers: Confine search to no more than 100 m from left and right bank and extending both upstream and downstream as far as you can see

Alien Plants: Confine search to riparian plots on left and right bank
 Wadeable Streams: 10 m x 10 m
 Non-wadeable Rivers: 10 m x 20 m

Not all aliens are to be identified in all states. See Field Manual and Plant Identification Guide.

TAXONOMIC CATEGORIES

Acacia/Mesquite
Alder/Birch
Ash
Maple/Boxelder
Oak
Poplar/Cottonwood
Sycamore
Willow
Unknown or Other Deciduous
Cedar/Cypress/Sequoia
Fir (including Douglas fir and hemlock)
Juniper
Pine
Spruce
Unknown or Other Conifer
Unknown or Other Broadleaf Evergreen
Snag (Dead tree of any species)

ALIEN SPECIES

E Wtrmilf Eurasian water milfoil
Hydrilla Hydrilla verticillata
W Wtrchest European water chestnut
Ylw Hyacinth Water Hyacinth
P Lstrife Purple loosestrife
G Reed Lythrum salicaria
Flwr Rush Giant Reed
Salt Ced Flowering Rush
MF Rose Multi-flora rose
Spurge Leafy Spurge

COMMENTS

Transects D to K continued on other side

03/26/2001 2001 Riparian Legacy Trees

Figure 6.2-15. Riparian "Legacy" Tree and Invasive Alien Plants Form (Page 1)

Table 6.2-14. Procedures for assessing channel constraint

NOTE: These activities are conducted after completing the thalweg profile and littoral-riparian measurements and observations, and represent an evaluation of the entire stream reach.

CHANNEL CONSTRAINT: Determine the degree, extent, and type of channel constraint based on envisioning the stream at **bankfull flow**.

Classify the stream reach channel pattern as predominantly a **single** channel, an **anastomosing** channel, or a **braided** channel.

Single channels may have occasional in-channel bars or islands with side channels, but feature a predominant single channel, or a dominant main channel with a subordinate side channel.

Anastomosing channels have relatively long major and minor channels branching and rejoining in a complex network separated by vegetated islands, with no obvious dominant channel.

Braided channels also have multiple branching and rejoining channels, separated by unvegetated bars. Subchannels are generally small, short, and numerous, often with no obvious dominant channel.

After classifying the channel pattern, determine whether the channel is constrained within a narrow valley, constrained by local features within a broad valley, unconstrained and free to move about within a broad floodplain, or free to move about, but within a relatively narrow valley floor.

Then examine the channel to ascertain the bank and valley features that constrain the stream. Entry choices for the type of constraining features are bedrock, hillslopes, terraces/alluvial fans, and human land use (e.g., a road, a dike, landfill, rip-rap, etc.).

Based on your determinations from Steps 1 through 3, select and record one of the constraint classes shown on the Channel Constraint Form.

Estimate the percent of the channel margin in contact with constraining features (for unconstrained channels, this is 0%). Record this value on the Channel Constraint Form.

Finally, estimate the "typical" bankfull channel width, and visually estimate the average width of the valley floor. Record these values on the Channel Constraint Form.

NOTE: To aid in this estimate, you may wish to refer to the individual transect assessments of incision and constraint that were recorded on the Channel/Riparian Cross-Section Forms.

NOTE: If the valley is wider than you can directly estimate, record the distance you can see and mark the circle on the field form.

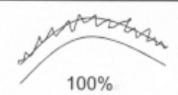
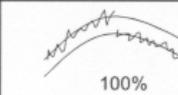
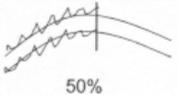
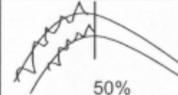
CHANNEL CONSTRAINT FORM - WADEABLE/BOATABLE		Reviewed by (initial): JD
SITE <u>FW08 XX000</u>	DATE: <u>07/01/2008</u>	
CHANNEL CONSTRAINT		
CHANNEL PATTERN (Fill in one) <input checked="" type="radio"/> One channel <input type="radio"/> Anastomosing (complex) channel - (Relatively long major and minor channels branching and rejoining.) <input type="radio"/> Braided channel - (Multiple short channels branching and rejoining - mainly one channel broken up by numerous mid-channel bars.)		
CHANNEL CONSTRAINT (Fill in one) <input type="radio"/> Channel very constrained in V-shaped valley (i.e. it is very unlikely to spread out over valley or erode a new channel during flood) <input checked="" type="radio"/> Channel is in Broad Valley but channel movement by erosion during floods is constrained by Incision (Flood flows do not commonly spread over valley floor or into multiple channels.) <input type="radio"/> Channel is in Narrow Valley but is not very constrained , but limited in movement by relatively narrow valley floor (< ~10 x bankfull width) <input type="radio"/> Channel is Unconstrained in Broad Valley (i.e. during flood it can fill off-channel areas and side channels, spread out over flood plain, or easily cut new channels by erosion)		
CONSTRAINING FEATURES (Fill in one) <input type="radio"/> Bedrock (i.e. channel is a bedrock-dominated gorge) <input type="radio"/> Hillslope (i.e. channel constrained in narrow V-shaped valley) <input checked="" type="radio"/> Terrace (i.e. channel is constrained by its own incision into river/stream gravel/soil deposits) <input type="radio"/> Human Bank Alterations (i.e. constrained by rip-rap, landfill, dike, road, etc.) <input type="radio"/> No constraining features		
Percent of channel length with margin in contact with constraining feature:	<u>100</u> % ---> (0-100%)	Percent of Channel Margin Examples  100%  100%
Bankfull width:	<u>4.5</u> (m)	 50%  50%
Valley width (Visual Estimated Average): <small>Note: Be sure to include distances between both sides of valley border for valley width. If you cannot see the valley borders, record the distance you can see and mark this box.</small>	<u>50.0</u> (m) <input type="radio"/>	
Comments		

Figure 6.2-16. Channel Constraint Form, showing data for channel constraint.

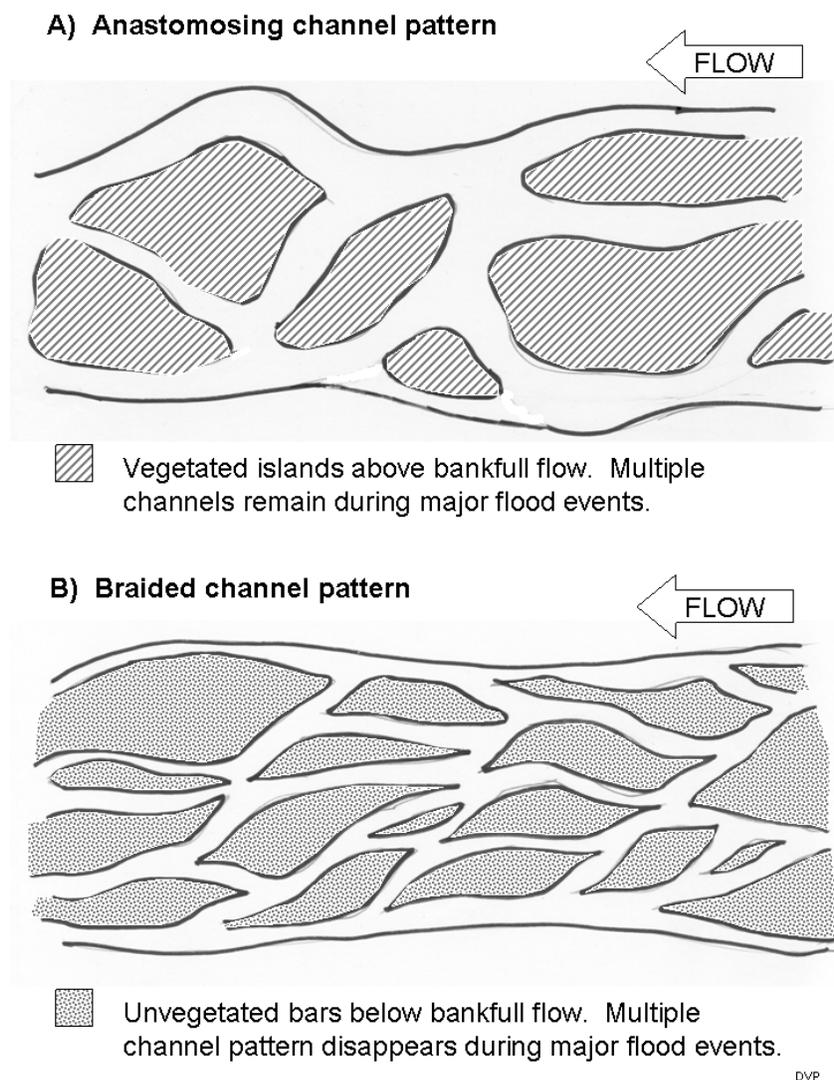


Figure 6.2-17. Types of multiple channel patterns.

6.2.6.2 Debris Torrents and Recent Major Floods

Debris torrents, or *lahars*, differ from conventional floods in that they are flood waves of higher magnitude and shorter duration, and their flow consists of a dense mixture of water and debris. Their high flows of dense material exert tremendous scouring forces on streambeds. For example, in the Pacific Northwest, flood waves from debris torrents can exceed 5 meters deep in small streams normally 3 m wide and 15 cm deep. These torrents move boulders in excess of 1 m diameter and logs >1 m diameter and >10 m long. In temperate regions, debris torrents occur primarily in steep drainages and are relatively infrequent, occurring typically less than once in several centuries. They are usually set into motion by the sudden release of large volumes of water upon the breaching of a natural or human-constructed impoundment, a process often initiated by mass hillslope failures (landslides) during high intensity rainfall or snowmelt. Debris torrents course downstream until the slope of the stream channel can no longer keep their viscous sediment suspension in motion (typically <3% for small streams); at this point, they “set up”, depositing large amounts of sediment, boulders, logs, and whatever

else they were transporting. Upstream, the *torrent track* is severely scoured, often reduced in channel complexity and devoid of near-bank riparian vegetation. As with floods, the massive disruption of the stream channel and its biota are transient, and these intense, infrequent events will often lead to a high-quality complex habitat within years or decades, as long as natural delivery of large wood and sediment from riparian and upland areas remains intact.

In arid areas with high runoff potential, debris torrents can occur in conjunction with flash flooding from extremely high-intensity rainfall. They may be nearly annual events in some steep ephemeral channels where drainage area is sufficient to guarantee isolated thunderstorms somewhere within their boundaries, but small enough that the effect of such storms is not dampened out by the portion of the watershed not receiving rainfall during a given storm.

Because they may alter habitat and biota substantially, infrequent major floods and torrents can confuse the interpretation of measurements of stream biota and habitat in regional surveys and monitoring programs. Therefore, it is important to determine if a debris torrent or major flood has occurred within the recent past. After completing the thalweg profile and channel/riparian measurements and observations, examine the stream channel along the entire sample reach, including its substrate, banks, and riparian corridor, checking the presence of features described on the Torrent Evidence Assessment Form (Figure 6.2-18). It may be advantageous to look at the channel upstream and downstream of the actual sample reach to look for areas of torrent scour and massive deposition to answer some of the questions on the field form. For example, you may more clearly recognize the sample reach as a torrent deposition area if you find extensive channel scouring upstream. Conversely, you may more clearly recognize the sample reach as a torrent scour reach if you see massive deposits of sediment, logs, and other debris downstream.

6.2.6.3 Stream Discharge

Stream discharge is equal to the product of the mean current velocity and vertical cross-sectional area of flowing water. Discharge measurements are critical for assessing trends in streamwater acidity and other characteristics that are very sensitive to streamflow differences. Discharge should be measured at a suitable location within the sample reach that is as close as possible to the location where chemical samples are collected, so that these data correspond. Discharge is usually determined after collecting water chemistry samples.

No single method for measuring discharge is applicable to all types of stream channels. The preferred procedure for obtaining discharge data is based on “velocity-area” methods (e.g., Rantz and others, 1982; Linsley et al., 1982). For streams that are too small or too shallow to use the equipment required for the velocity-area procedure, two alternative procedures are presented. One procedure is based on timing the filling of a volume of water in a calibrated bucket. The second procedure is based on timing the movement of a neutrally buoyant object (e.g., an orange or a small rubber ball) through a measured length of the channel, after measuring one or more cross-sectional depth profiles within that length.

Reviewed by (Initials): JD

TORRENT EVIDENCE ASSESSMENT FORM

SITE ID: <u>FW08 XX000</u>	DATE: <u>07/01/2008</u>
TORRENT EVIDENCE	
Please fill in any of the following that are evident.	
EVIDENCE OF TORRENT SCOURING:	
<input type="radio"/>	01 - Stream channel has a recently devegetated corridor two or more times the width of the low flow channel. This corridor lacks riparian vegetation with possible exception of fireweed, even-aged alder or cottonwood seedlings, grasses, or other herbaceous plants.
<input type="radio"/>	02 - Stream substrate cobbles or large gravel particles are NOT IMBRICATED. (Imbricated means that they lie with flat sides horizontal and that they are stacked like roof shingles -- imagine the upstream direction as the top of the "roof.") In a torrent scour or deposition channel, the stones are laying in unorganized patterns, lying "every which way." In addition many of the substrate particles are angular (not "water-worn.")
<input type="radio"/>	03 - Channel has little evidence of pool-riffle structure. (For example, could you ride a mountain bike down the channel?)
<input type="radio"/>	04 - The stream channel is scoured down to bedrock for substantial portion of reach.
<input type="radio"/>	05 - There are gravel or cobble berms (little levees) above bankfull level.
<input type="radio"/>	06 - Downstream of the scoured reach (possibly several miles), there are massive deposits of sediment, logs, and other debris.
<input type="radio"/>	07 - Riparian trees have fresh bark scars at many points along the stream at seemingly unbelievable heights above the channel bed.
<input type="radio"/>	08 - Riparian trees have fallen into the channel as a result of scouring near their roots.
EVIDENCE OF TORRENT DEPOSITS:	
<input type="radio"/>	09 - There are massive deposits of sediment, logs, and other debris in the reach. They may contain wood and boulders that, in your judgement, could not have been moved by the stream at even extreme flood stage.
<input type="radio"/>	10 - If the stream has begun to erode newly laid deposits, it is evident that these deposits are "MATRIX SUPPORTED." This means that the large particles, like boulders and cobbles, are often not touching each other, but have silt, sand, and other fine particles between them (their weight is supported by these fine particles -- in contrast to a normal stream deposit, where fines, if present, normally "fill-in" the interstices between coarser particles.)
NO EVIDENCE:	
<input checked="" type="radio"/>	11 - No evidence of torrent scouring or torrent deposits.
COMMENTS	

Figure 6.2-18. Torrent Evidence Assessment Form.

6.2.6.4 Velocity-Area Procedure

Because velocity and depth typically vary greatly across a stream, accuracy in field measurements is achieved by measuring the mean velocity and flow cross-sectional area of many increments across a channel (Figure 6.2-19). Each increment gives a subtotal of the stream discharge, and the whole is calculated as the sum of these parts. Discharge measurements are made **at only one carefully chosen channel cross-section within the sampling reach**. It is important to choose a channel cross-section that is as much like a canal as possible. A glide area with a “U” shaped channel cross-section that is free of obstructions provides the best conditions for measuring discharge by the velocity-area method. You may remove rocks and other obstructions to improve the cross-section before any measurements are made. However, because removing obstacles from one part of a cross-section affects adjacent water velocities, you must not change the cross-section once you commence collecting the set of velocity and depth measurements.

The procedure for obtaining depth and velocity measurements is outlined in Table 6.2-15. Record the data from each measurement on the Stream Discharge Form as shown in Figure 6.2-20. In the field, data will be recorded using only one of the available procedures.

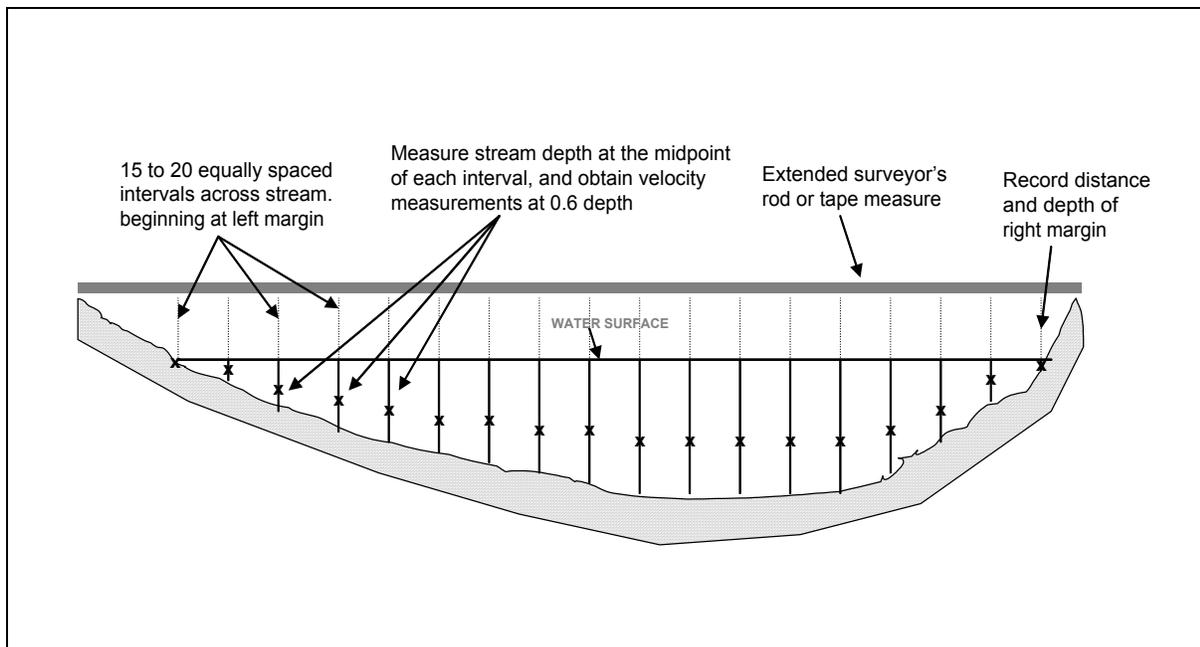


Figure 6.2-19. Layout of channel cross-section for obtaining discharge data by the velocity-area procedure.

Table 6.2-15. Velocity-Area procedure for determining stream discharge

1. Locate a cross-section of the stream channel for discharge determination that has most of the following qualities (based on Rantz and others, 1982):
 - Segment of stream above and below cross-section is straight
 - Depths mostly greater than 15 centimeters, and velocities mostly greater than 0.15 meters/second. Do not measure discharge in a pool.
 - “U” shaped, with a uniform streambed free of large boulders, woody debris or brush, and dense aquatic vegetation.
 - Flow is relatively uniform, with no eddies, backwaters, or excessive turbulence.
2. Lay the surveyor’s rod (or stretch a measuring tape) across the stream perpendicular to its flow, with the “zero” end of the rod or tape on the left bank, as viewed when looking downstream. Leave the tape tightly suspended across the stream, approximately one foot above water level.
3. Attach the velocity meter probe to the calibrated wading rod. Check to ensure the meter is functioning properly and the correct calibration value is displayed. Calibrate (or check the calibration) the velocity meter and probe as directed in the meter’s operating manual. Fill in the “VELOCITY AREA” circle on the Stream Discharge Form.
4. Divide the total wetted stream width into 15 to 20 equal-sized intervals. To determine interval width, divide the width by 20 and round up to a convenient number. Intervals should not be less than 10 cm wide, even if this results in less than 15 intervals. The first interval is located at the left margin of the stream (left when looking downstream), and the last interval is located at the right margin of the stream (right when looking downstream).
5. Stand downstream of the rod or tape and to the side of the first interval point (closest to the left bank if looking downstream).
6. Place the wading rod in the stream at the interval point and adjust the probe or propeller so that it is at the water surface. Fill in the appropriate “Distance Units” and “Depth Units” circles on the Stream Discharge Form. Record the distance from the left bank and the depth indicated on the wading rod on the Stream Discharge Form.

Note for the first interval, distance equals 0 cm, and in many cases depth may also equal 0 cm. For the last interval, distance will equal the wetted width (in cm) and depth may again equal 0 cm.
7. Stand downstream of the probe or propeller to avoid disrupting the stream flow. Adjust the position of the probe on the wading rod so it is at 0.6 of the measured depth below the surface of the water. Face the probe upstream at a right angle to the cross-section, even if local flow eddies hit at oblique angles to the cross-section.
8. Wait 20 seconds to allow the meter to equilibrate, then measure the velocity. Fill in the appropriate “Velocity Units” circle on the Stream Discharge Form. Record the value on the Stream Discharge Form. Note for the first interval, velocity may equal 0 because depth will equal 0.
 - For the electromagnetic current meter (e.g., Marsh-McBirney), use the lowest time constant scale setting on the meter that provides stable readings.
 - For the impeller-type meter (e.g., Swiffer 2100), set the control knob at the mid-position of “DISPLAY AVERAGING”. Press “RESET” then “START” and proceed with the measurements.

9. Move to the next interval point and repeat Steps 6 through 8. Continue until depth and velocity measurements have been recorded for all intervals. Note for the last interval (right margin), depth and velocity values may equal 0.
10. At the last interval (right margin), record a "Z" flag on the field form to denote the last interval sampled.
11. If using a meter that computes discharge directly, check the "Q" circle on the discharge form, and record calculated discharge value. In this case, you do not have to record the depth and velocity data for each interval.

DISCHARGE FORM - WADEABLE Reviewed by (Initials): JD

SITE ID: FW08 XX000 DATE: 07/01/2008

● Velocity Area					● Timed Filling				
Distance Units <input type="radio"/> ft <input checked="" type="radio"/> cm		Depth Units <input type="radio"/> ft <input checked="" type="radio"/> cm		Velocity Units <input type="radio"/> ft/s XX.X <input checked="" type="radio"/> m/s X.XX		Repeat	Volume (L)	Time (s)	Flag
Dist. from Bank	Depth	Velocity		Flag					
1	0	0	0	F1	1	4.0	10.5	F1	
2	20	6	-0.10		2	4.0	11.2		
3	40	6	0.30		3	4.0	10.8		
4	60	12	0.59		4	4.0	11.0		
5	80	15	0.37		5	4.0	10.7		
6	100	15	0.34						
7	120	24	0.43						
8	140	27	0.37						
9	160	40	0.43						
10	180	40	0.37						
11	200	46	0.30						
12	220	37	0.27						
13	240	30	0.25						
14	260	24	0.15						
15	280	15	0.10						
16	300	0	0						
17									
18									
19									
20									

● Neutral Bouyant Object			
	Float 1	Float 2	Float 3
Float Dist. <input type="radio"/> ft <input checked="" type="radio"/> m	5	5	5
Float Time (s)	1.0	1.0	1.2
Flag	F1		

Cross Sections on Float Reach			
	Upper Section	Middle Section	Lower Section
Width <input type="radio"/> ft <input checked="" type="radio"/> m	2.5	1.8	3.0
Depth 1 <input type="radio"/> ft <input checked="" type="radio"/> cm	1.0	5	1.2
Depth 2	9	1.5	2.0
Depth 3	9	2.0	1.5
Depth 4	8	7	6
Depth 5	5	2	5

● Q Value If discharge is determined directly in field, record value here: Q = 0.24 cfs m³/s FLAG F1

Flag	Comments
<u>F1</u>	<u>DATA FOR ALL FOUR METHODS ARE SHOWN.</u>

Flag Codes: K = No measurement or observation made; U = Suspect measurement or observation; Q = Unacceptable QC check associated with measurement; Z = Last station measured (if not Station 20); F1, F2, etc. = Miscellaneous flags assigned by each field crew. Explain all flags in comments section.

03/18/2008 NRSA Stream Discharge Draft

Figure 6.2-20. Discharge Form, showing data recorded for all discharge measurement procedures.

6.2.6.5 Timed Filling Procedure

In channels too “small” for the velocity-area method, discharge can sometimes be measured by filling a container of known volume and timing the duration to fill the container.

“Small” is defined as a channel so shallow that the current velocity probe cannot be placed in the water, or where the channel is broken up and irregular due to rocks and debris, and a suitable cross-section for using the velocity area procedure is not available. This can be an extremely precise and accurate method, but requires a natural or constructed spillway of freefalling water. If obtaining data by this procedure will result in a lot of channel disturbance or stir up a lot of sediment, wait until after all biological and chemical measurements and sampling activities have been completed.

Choose a cross-section of the stream that contains one or more natural spillways or plunges that collectively include the entire stream flow. A temporary spillway can also be constructed using a portable V-notch weir, plastic sheeting, or other materials that are available onsite. Choose a location within the sampling reach that is narrow and easy to block when using a portable weir. Position the weir in the channel so that the entire flow of the stream is completely rerouted through its notch (Figure 6-3). Impound the flow with the weir, making sure that water is not flowing beneath or around the side of the weir. Use mud or stones and plastic sheeting to get a good waterproof seal. The notch must be high enough to create a small spillway as water flows over its sharp crest.

The timed filling procedure is presented in Table 6.2-16. Make sure that the entire flow of the spillway is going into the bucket. Record the time it takes to fill a measured volume on the Discharge Measurement Form as shown in Figure 6-2. Repeat the procedure 5 times. If the cross-section contains multiple spillways, you will need to do separate determinations for each spillway. If so, clearly indicate which time and volume data replicates should be averaged together for each spillway; use additional Stream Discharge Form if necessary.

Table 6.2-16. Timed filling procedure for determining stream discharge

NOTE: If measuring discharge by this procedure will result in significant channel disturbance or will stir up sediment, delay determining discharge until all biological and chemical measurement and sampling activities have been completed.

1. Choose a cross-section that contains one or more natural spillways or plunges, or construct a temporary one using on-site materials, or install a portable weir using a plastic sheet and on-site materials.
2. Fill in the “TIMED FILLING” circle in the stream discharge section of the Stream Discharge Form.
3. Position a calibrated bucket or other container beneath the spillway to capture the entire flow. Use a stopwatch to determine the time required to collect a known volume of water. Record the volume collected (in liters) and the time required (in seconds) on the Stream Discharge Form.
4. Repeat Step 3 a total of 5 times for each spillway that occurs in the cross-section. If there is more than one spillway in a cross-section, you must use the timed-filling approach on all of them. Additional spillways may require additional data forms

6.2.6.6 Neutrally-Buoyant Object Procedure

In very small, shallow streams with no waterfalls, where the standard velocity-area or timed-filling methods cannot be applied, the neutrally buoyant object method may be the only way to obtain an estimate of discharge. The required pieces of information are the mean flow velocity in the channel and the cross-sectional area of the flow. The mean velocity is estimated by measuring the time it takes for a neutrally buoyant object to flow through a measured length of the channel. The channel cross-sectional area is determined from a series of depth measurements along one or more channel cross-sections. Since the discharge is the product of mean velocity and channel cross-sectional area, this method is conceptually very similar to the standard velocity-area method.

The neutrally buoyant object procedure is described in Table 6.2-17. Examples of suitable objects include plastic golf balls (with holes), small sponge rubber balls, or small sticks. The object must float, but very low in the water. It should also be small enough that it does not “run aground” or drag bottom. Choose a stream segment that is roughly uniform in cross-section, and that is long enough to require 10 to 30 seconds for an object to float through it. Select one to three cross-sections to represent the channel dimensions within the segment, depending on the variability of width and/or depth. Determine the stream depth at 5 equally spaced points at each cross-section. Three separate times, measure the time required for the object to pass through the segment that includes all of the selected cross-sections. Record data on the Stream Discharge Form as shown in Figure 6.2-20.

Table 6.2-17. Neutrally buoyant object procedure for determining stream discharge

1. Fill in the “NEUTRALLY BUOYANT OBJECT” circle on the Stream Discharge Form.
2. Select a segment of the sampling reach that is deep enough to float the object freely, and long enough that it will take between 10 and 30 seconds for the object to travel. Mark the units used and record the length of the segment in the “FLOAT DIST.” field of the Stream Discharge Form.
3. If the channel width and/or depth change substantially within the segment, measure widths and depths at three cross-sections, one near the upstream end of the segment, a second near the middle of the segment, and a third near the downstream end of the segment.

If there is little change in channel width and/or depth, obtain depths from a single “typical” cross-section within the segment.
4. At each cross-section, measure the wetted width using a surveyor’s rod or tape measure, and record both the units and the measured width on the Stream Discharge Form. Measure the stream depth using a wading rod or meter stick at points approximately equal to the following proportions of the total width: 0.1, 0.3, 0.5, 0.7, and 0.9. Record the units and the depth values (not the distances) on the Stream Discharge Form.
5. Repeat Step 4 for the remaining cross-sections.
6. Use a stopwatch to determine the time required for the object to travel through the segment. Record the time in the “FLOAT TIME” field of the Stream Discharge Form.
7. Repeat Step 6 two more times. The float time may differ somewhat for the three trials.

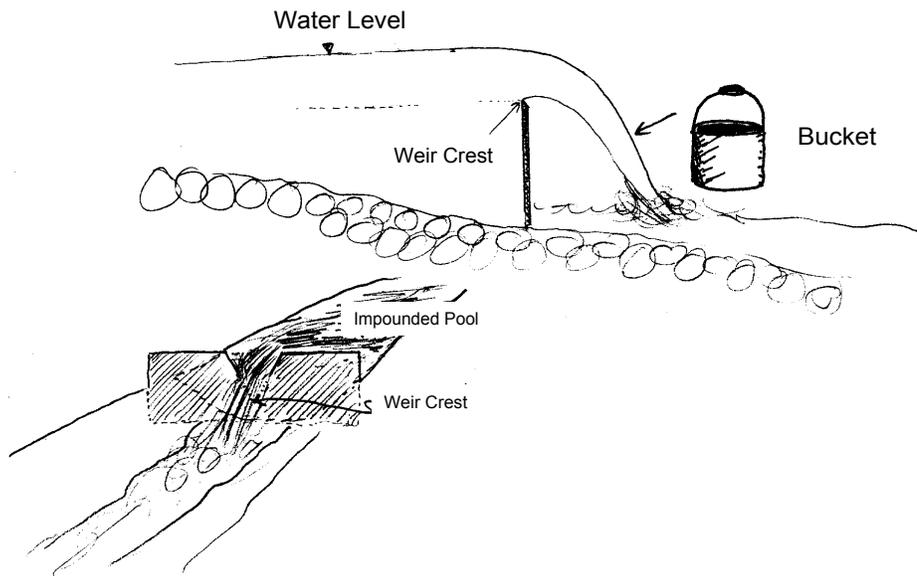


Figure 6.2-21. Use of a portable weir in conjunction with a calibrated bucket to obtain an estimate of stream discharge.

6.2.7 Equipment and Supplies

Table 6.2-18 lists the equipment and supplies required to conduct all the activities described for characterizing physical habitat. This checklist is similar to the checklist presented in Appendix A, which is used at the base location (Section 3) to ensure that all of the required equipment is brought to the stream.

Table 6.2-18. Checklist of equipment and supplies for physical habitat

For taking measurements	<ul style="list-style-type: none"> ▪ Surveyor's telescoping leveling rod (round profile, metric scale, 7.5 m extended) ▪ 50 m or 100 m measuring tape & reel ▪ Laser rangefinder (400 ft. distance range) and clear waterproof bag ▪ Digital camera with extra memory card & battery ▪ Two ½-inch diameter PVC pipe, 2-3 m long: Two of these, each marked at the same height (for use in slope determinations involving two persons) ▪ Meter stick, or a short rod or pole (e.g., a ski pole) with cm markings for thalweg measurements, or the PVC pipe for slope determinations can be marked in cm ▪ 1 roll each colored surveyor's flagging tape (2 colors) ▪ Convex spherical canopy densiometer (Lemmon Model A), modified with taped "V" ▪ Clinometer ▪ Bearing compass (Backpacking type) ▪ Binoculars ▪ 1 or 2 fisherman's vest with lots of pockets and snap fittings. Used to hold the various measurement equipment (densiometer, clinometer, compass, etc.). ▪ 2 pair chest waders (hip waders can be used in shallower streams). ▪ Current velocity meter, probe, and operating manual ▪ Top-set wading rod for use with current velocity meter ▪ Portable Weir with 60° "V" notch (optional) and plastic sheeting to use with weir ▪ Plastic bucket (or similar container) with volume graduations ▪ Stopwatch ▪ Neutrally buoyant object (e.g., plastic golf ball with holes, small rubber ball, stick) ▪ Field Methods Manual and/or laminated quick reference guide
For recording data	<ul style="list-style-type: none"> ▪ Covered clipboards (lightweight, with strap or lanyard) ▪ Soft (#2) lead pencils (mechanical are acceptable) ▪ 11 plus extras Channel/Riparian Cross-section Forms ▪ 11 plus extras Thalweg Profile and Woody Debris Forms ▪ 1+ extras field Form: Stream Verification Form ▪ 1+ extras field Form: Field Measurement Form ▪ 1+ extras field Form: Discharge Form ▪ 1+ extras field Form: Sample Collection Form ▪ 1+ extras field Form: Riparian "Legacy" Trees and Invasive Alien Plants ▪ 1+ extras field Form: Channel Constraint ▪ 1+ extras field Form: Torrent Evidence Form ▪ 1+ extras field Form: Fish Gear and Voucher/Tissue Information Form ▪ 1+ extras field Form: Fish Collection Form ▪ 1+ extras field Form: Slope and Bearing Form ▪ 1+ extras field Form: Visual Assessment Form

6.3 Periphyton

6.3.1 Summary of Method

Collect periphyton from the 11 cross-section transects (“A” through “K”) established within the sampling reach. Collect periphyton samples at the same time as sediment enzyme samples (Section 6.1.3) and benthic macroinvertebrate samples (Sections 6.4.1). Prepare one composite “index” sample of periphyton for each site. At the completion of the day’s sampling activities, but before leaving the site, prepare four types of laboratory samples (an ID/enumeration sample to determine taxonomic composition and relative abundances, a chlorophyll sample, a biomass sample (for ash-free dry mass [AFDM]), and a acid/alkaline phosphatase activity [APA] sample) from the composite periphyton sample.

6.3.2 Equipment and Supplies

Table 6.3-1 is a checklist of equipment and supplies required to conduct periphyton sample collection and processing activities. This checklist is similar to the checklist presented in Appendix A, which is used at the base location (Section 3) to ensure that all of the required equipment is brought to the river.

Table 6.3-1. Equipment and supplies list for periphyton at wadeable sites

For collecting samples	<ul style="list-style-type: none"> ▪ Large Funnel (15-20 cm diameter) ▪ 12-cm² area delimiter (3.8 cm diameter pipe, 3 cm tall) ▪ Stiff-bristle toothbrush with handle bent at 90° angle ▪ 1-L wash bottle for stream water ▪ 500-mL plastic bottle for the composite sample ▪ 60-mL plastic syringe with 3/8” hole bored into the end ▪ Field Operations Manual or laminated Quick Reference Guide
For recording measurements	<ul style="list-style-type: none"> ▪ Sample Collection Form ▪ Soft (#2) lead pencils for recording data on field forms ▪ Fine-tipped indelible markers for filling out sample labels ▪ Sample labels (4 per set) with the same Sample ID Number ▪ Clear tape strips for covering labels

6.3.3 Sampling Procedure

At each of the 11 transects, collect samples from the sampling station assigned during the layout of the reach. Collect the substrate selected for sampling from a depth no deeper than 0.5 m. If a sample cannot be collected because the location is too deep, skip the transect. The procedure for collecting samples and preparing a composite sample is presented in Table 6.3-2. Collect one sample from each of the transects and composite in one bottle to produce one composite sample for each site. Record the volume of the sample on the Sample Collection Form as shown in Figure 6.1-3.

Table 6.3-2. Procedure for collecting composite index samples of periphyton at wadeable sites

1. Starting with Transect "A", collect a single sample from the assigned sampling station using the procedure below.
 - a) Collect a sample of substrate (rock or wood) that is small enough (< 15 cm diameter) and can be easily removed from the river. Place the substrate in a plastic funnel which drains into a 500-mL plastic bottle with volume graduations marked on it.
 - b) Use the area delimiter to define a 12-cm² area on the upper surface of the substrate. Dislodge attached periphyton from the substrate within the delimiter into the funnel by brushing with a stiff-bristled toothbrush for 30 seconds. Take care to ensure that the upper surface of the substrate is the surface that is being scrubbed, and that the entire surface within the delimiter is scrubbed.
 - c) Fill a wash bottle with river water. Using a minimal volume of water from this bottle, wash the dislodged periphyton from the funnel into the 500-mL bottle. If no coarse sediment (cobbles or larger) are present:
 - Use the area delimiter to confine a 12-cm² area of soft sediments.
 - Vacuum the top 1 cm of sediments from within the delimited area into a de-tipped 60-mL syringe.
 - Empty the syringe into the same 500-mL plastic bottle as above.
 - d) **Put the bottle in a cooler on ice while you travel between transects and collect the subsequent samples. (The samples need to be kept cool and dark because a chlorophyll sample will be filtered from the composite.)**
2. Repeat Step 1 for transects "B" through "K". Place the sample collected at each sampling site into the single 500-mL bottle to produce the composite index sample.
3. If all 11 samples are not collected, record the number of transects collected and reason for any missed collection on the field forms.
4. After samples have been collected from all 11 transects, thoroughly mix the 500-mL bottle regardless of substrate type. Record the total estimated volume of the composite sample in the periphyton section of the Sample Collection Form.

6.3.4 Sample Processing in the Field

You will prepare four different types of laboratory samples from the composite index samples: an **ID/enumeration sample** (to determine taxonomic composition and relative abundances), a **chlorophyll sample**, a **biomass sample** (for ash-free dry mass [AFDM]), and an **acid/alkaline phosphatase activity (APA)** sample. All the sample containers required for an individual site should be sealed in plastic bags until use to avoid external sources of contamination (e.g., dust, dirt, or mud) that are present at site shorelines. Please refer to Sections 7.2.5 and 7.2.6 processing the periphyton samples.

6.4 Benthic Macroinvertebrates

6.4.1 Summary of Method

Collect benthic macroinvertebrate composite samples using a D-frame net with 500 µm mesh openings. Take the samples from the sampling stations at the 11 transects equally distributed along the targeted reach. You will proportionally sample multiple habitats at sampling stations randomly assigned on each transect. Multiple habitats will include bottom substrate as well as woody debris, macrophytes, and leaf packs. Composite all sample material and field-preserve with ~95% ethanol.

High gradient streams

- Primary samples are taken at each transect at either 25%, 50%, or 75% transect distance (according to the initial randomized pattern). Primary samples will be collected from a 1 square foot quadrat.

Low gradient streams

- Primary samples are taken at each transect at either 25%, 50%, or 75% transect distance (according to the initial randomized pattern). Primary samples will be collected from a 1 square foot quadrat.
- **additional**, separate samples taken at either 0%, 50%, or 100% transect distance to include edge samples (snags, undercut banks, root wads, macrophyte beds, etc.). Low gradient samples will be collected from a 1 linear meter sweep.

6.4.2 Equipment and Supplies

Table 6.4-1 shows the checklist of equipment and supplies required to complete the collection of benthic macroinvertebrates. This checklist is similar to the checklist presented in Appendix A, which is used at the base location to ensure that all of the required equipment is brought to the site. Record collection data on the Sample Collection Form (Fig. 6.1-2).

Table 6.4-1. Equipment and supplies list for benthic macroinvertebrate collection at wadeable sites

For collecting samples	<ul style="list-style-type: none"> ▪ Modified kick net (D-frame with 500 µm mesh) and 4-ft handle ▪ Watch with timer or stopwatch ▪ Buckets, plastic, 8- to 10-qt ▪ Sieve bucket with 500 µm mesh openings (U.S. std No. 35) ▪ Watchmakers' forceps ▪ Wash bottle, 1-L capacity labeled "STREAM WATER" ▪ Funnel, with large bore spout 	<ul style="list-style-type: none"> ▪ Small spatula, spoon, or scoop to transfer sample ▪ Sample jars, 1-L HDPE plastic suitable for use with ethanol ▪ 95% ethanol, in a proper container ▪ Cooler (with absorbent material) for transporting ethanol & samples ▪ Plastic electrical tape ▪ Scissors ▪ Field Operations Manual or laminated Quick Reference Guide
For recording measurements	<ul style="list-style-type: none"> ▪ Composite benthic sample labels with & without preprinted ID numbers 	<ul style="list-style-type: none"> ▪ Soft (#2) lead pencils ▪ Fine-tip indelible markers

	<ul style="list-style-type: none"> ▪ Blank labels on waterproof paper for inside of jars ▪ Clear tape strips ▪ Sample Collection Form
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6.4.3 Sampling Procedure

Figure 6.4-1 summarizes how samples will be collected from wadeable sites. The transect sample design for collecting benthic macroinvertebrates is shown in Figure 6.4-2. This design was used in the EPA's Wadeable Streams Assessment, which provides continuity for a nationwide assessment. Collect a sample from **1-m downstream** of each of the 11 cross-section transects at the assigned sampling station. The process for selecting the sample stations is described in the Initial Site Procedures Section (Section 4). At transects assigned a "Center" sampling point where the stream width is between one and two net widths wide, pick either the "Left" or "Right" sampling point instead. If the stream is only one net wide at a transect, place the net across the entire stream width and consider the sampling point to be "Center". If a sampling point is located in water that is too deep or unsafe to wade, select an alternate sampling point on the transect at random.

The procedure for collecting a sample at each transect is described in Table 6.4-2. At each sampling point, determine if the habitat is a "riffle/run" or a "pool/glide" (any area where there is not sufficient current to extend the net is operationally defined as a pool/glide habitat). Record the dominant substrate type (fine/sand, gravel, coarse substrate (coarse gravel or larger) or other (e.g., bedrock, hardpan, wood, aquatic vegetation, etc.) and the habitat type (pool, glide, riffle, or rapid) for each sample collected on the Sample Collection Form as shown in Figure 6.1-2. As you proceed upstream from transect to transect, combine all samples into a bucket. An **additional separate sample will be taken at low gradient streams** to include edge habitat (leaf litter, organic deposits, undercut banks, root wads, macrophyte beds, etc.)

6.4.4 Sample Processing in Field

Use a 500 µm mesh sieve bucket placed inside a larger bucket full of site water while sampling to carry the composite sample as you travel around the site. It is recommended that teams carry a sample bottle containing a small amount of ethanol with them to enable them to immediately preserve larger predaceous invertebrates such as helgramites and water beetles. Doing so will help reduce the chance that other specimens will be consumed or damaged prior to the end of the field day. Once the composite sample from all stations is sieved and reduced in volume, store in a 1-liter jar and preserve with 95% ethanol. Do not fill jars more than 1/3 full of material. Multiple jars may be required if detritus is heavy (Table 6.4-3). Try to use no more than 5 jars per site. If more than one jar is used for a composite sample, use the "extra jar" label provided; record the SAME sample ID number on this "extra jar" label. **DO NOT use two different sample numbers on two jars containing one single sample.** Cover the labels with clear tape. The sample ID number is also recorded with a No. 2 lead pencil on a waterproof label that is placed inside each jar. Be sure the inside label and outside label describe the same sample.

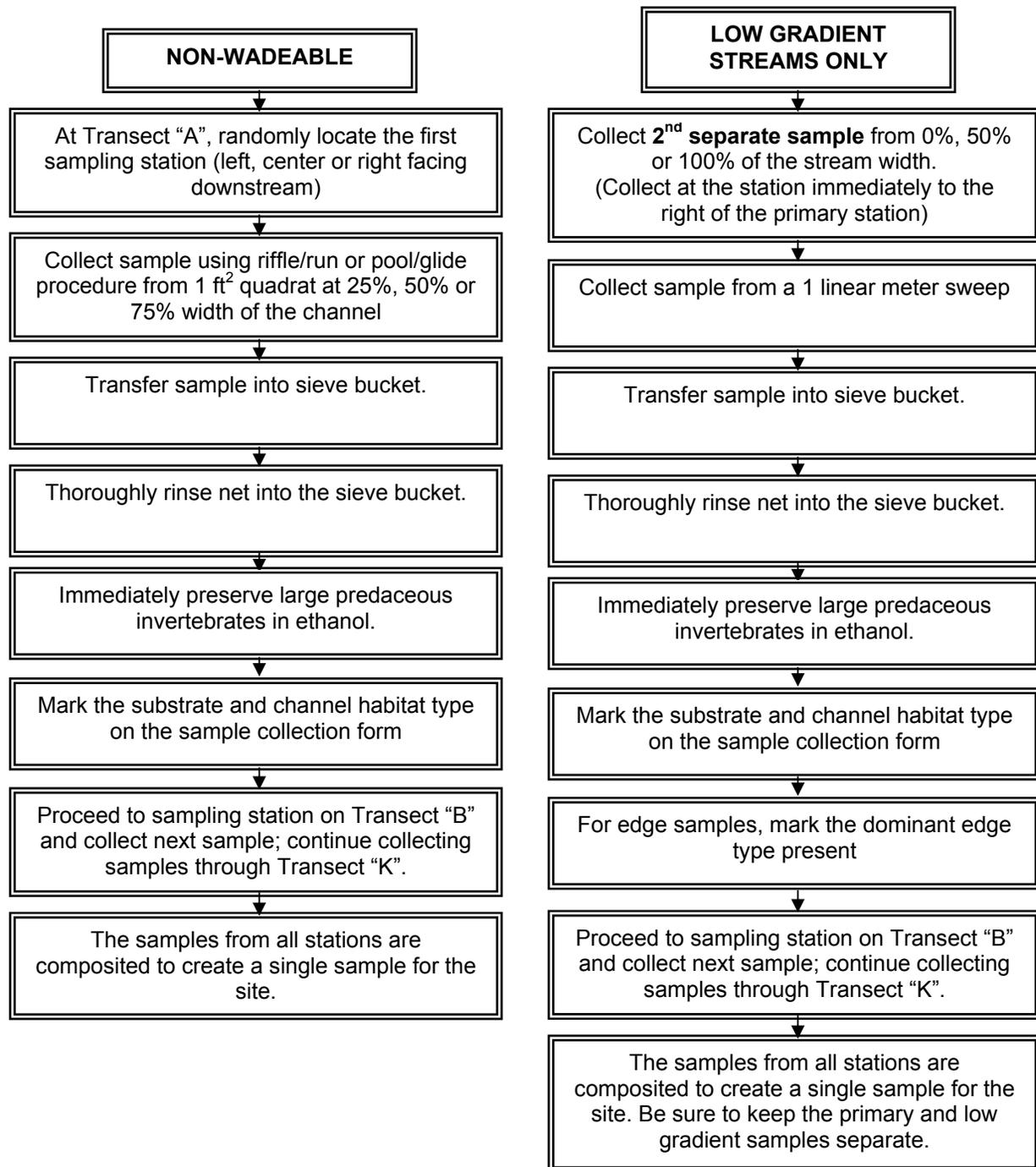
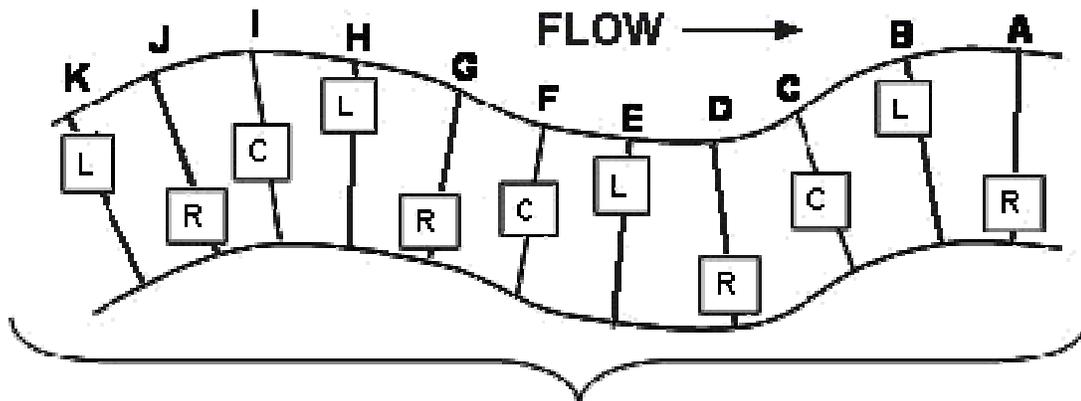


Figure 6.4-1. Benthic macroinvertebrate collection at wadeable sites.



Combine **ALL** kick net samples collected from **ALL** transects

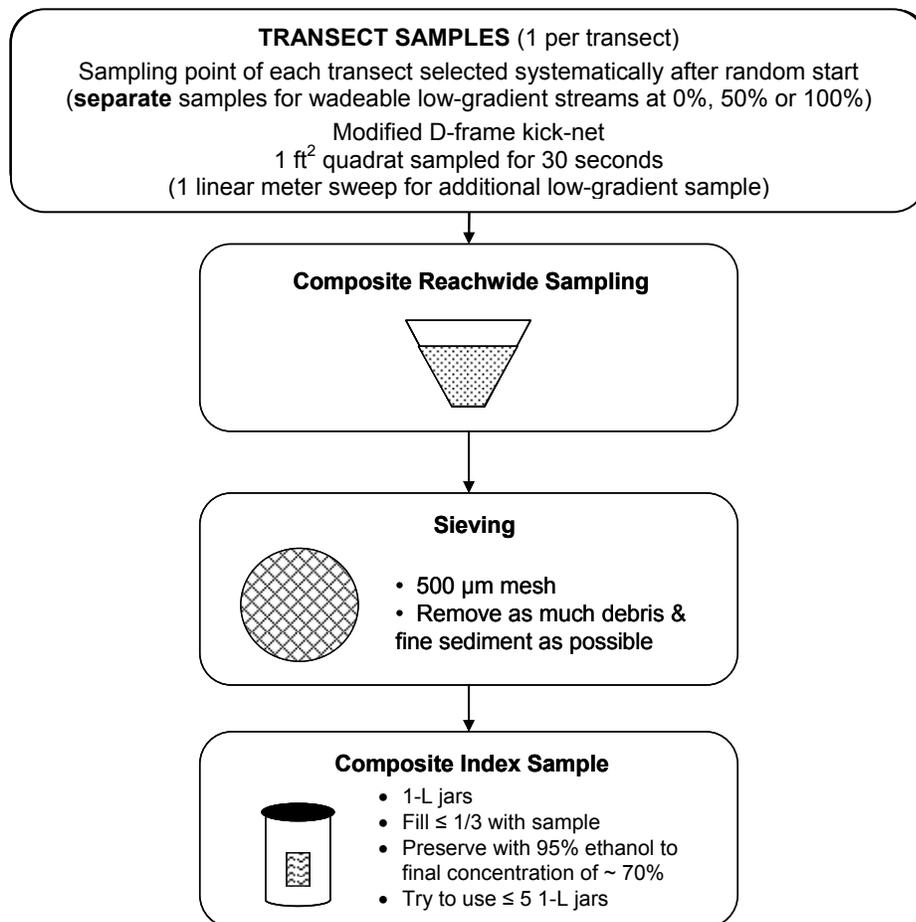


Figure 6.4-2. Transect sample design for collecting benthic macroinvertebrates at wadeable sites.

Table 6.4-2. Procedure for benthic macroinvertebrate sampling at wadeable sites

1. At 1 m downstream of each transect, beginning with Transect "A", randomly locate the first sampling station (Left, Center, or Right as you face downstream) as 25%, 50%, and 75% of the wetted width, respectively. If you cannot collect a sample at the designated point because of deep water or unsafe conditions, relocate to another random point on the same transect.
2. Determine if there is sufficient current in the area at the sampling station to fully extend the net. If so, classify the habitat as "riffle/run" and proceed to Step 3. If not, use the sampling procedure described for "pool/glide" habitats starting at Step 9.

NOTE: If the net cannot be used, hand pick a sample for 30 seconds from about 1 ft² of substrate at the sampling point. For vegetation-choked sampling points, sweep the net through the vegetation within a 1 ft² quadrat for 30 seconds. Place this hand-picked sample directly into the sample container. Assign a "U" flag (non-standard sample) to the sample and indicate which transect(s) required the modified collection procedure in the comments section. Go to Step 13.

Riffle/Run Habitats:

3. With the net opening facing upstream, quickly position the net securely on the stream bottom to eliminate gaps under the frame. Avoid large rocks that prevent the net from seating properly on the stream bottom.

NOTE: If there is too little water to collect the sample with the D-net, randomly pick up 10 rocks from the riffle and pick and wash the organisms off them into a bucket which is half full of water.

4. Holding the net in position on the substrate, visually define a quadrat that is one net width wide and long upstream of the net opening. The area within this quadrat is 1 ft².
5. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball-sized or larger and which are halfway into the quadrat. After scrubbing, place the substrate particles outside of the quadrat.
6. Hold the D-net securely in position. Starting at the upstream end of the quadrat, vigorously kick the remaining finer substrate within the quadrat for 30 seconds (use a stopwatch).

*NOTE: For samples located within dense beds of long, filamentous aquatic vegetation (e.g., algae or moss), kicking within the quadrat may not be sufficient to dislodge organisms in the vegetation. Usually these types of vegetation are lying flat against the substrate due to current. Use a knife or scissors to remove **only the vegetation that lies within the quadrat** (i.e., not entire strands that are rooted within the quadrat) and place it into the net.*

7. Pull the net up out of the water. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. Avoid having any water or material enter the mouth of the net during this operation.
8. Go to Step 13.

Pool/Glide Habitats:

9. Visually define a quadrat that is one net width wide and long at the sampling point. The area within this quadrat is 1 ft².
10. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by

hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball-sized or larger and which are halfway into the quadrat. After scrubbing, place the substrate particles outside of the quadrat.

11. Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

NOTE: If there is too little water to use the kick net, stir up the substrate with your gloved hands and use a sieve with 500 μ m mesh size to collect the organisms from the water in the same way the net is used in larger pools.

12. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

All samples:

13. Invert the net into a sieve bucket and transfer the sample. Remove as much gravel as possible so that the organisms do not get damaged. Inspect the net for any residual organisms clinging to the net and deposit them into the bucket. Use forceps if necessary to remove organisms from the net. Carefully inspect any large objects (such as rocks, sticks, and leaves) in the bucket and wash any organisms found off of the objects and into the bucket before discarding the object. Remove as much detritus as possible without losing organisms.

14. Determine the **predominant** substrate size/type you within the sampling quadrat. Fill in the appropriate circle for the dominant substrate type for the transect on the Sample Collection Form.

NOTE: If there are co-dominant substrate types, you may fill in more than one circle; note the co-dominants in the comments section of the form.

- **Fine/sand:** not gritty (silt/clay/muck <0.06 mm diam.) to gritty, up to ladybug sized (2 mm)
- **Gravel:** fine to coarse gravel (ladybug to tennis ball sized; 2 mm to 64 mm)
- **Coarse:** Cobble to boulder (tennis ball to car sized; 64 mm to 4000 mm)
- **Other:** bedrock (larger than car sized; > 4000 mm), hardpan (firm, consolidated fine substrate), wood of any size, aquatic vegetation, etc.). Note type of "other" substrate in comments on field form.

15. Identify the habitat type where the sampling quadrat was located. Fill in the appropriate circle for channel habitat type for the transect on the Sample collection Form.

- **P**ool; Still water; low velocity; smooth, glassy surface; usually deep compared to other parts of the channel
- **GL**ide: Water moving slowly, with smooth, unbroken surface; low turbulence
- **R**iffle: Water moving, with small ripples, waves, and eddies; waves not breaking, and surface tension is not broken; "babbling" or "gurgling" sound.
- **RA**pid: Water movement is rapid and turbulent; surface with intermittent "white water" with breaking waves; continuous rushing sound.

16. Thoroughly rinse the net before proceeding to the next sampling station. Proceed upstream to the

next transect (through Transect K, the upstream end of the reach) and repeat steps 1 - 16. Combine all kick net samples from riffle/run and pool/glide habitats into the bucket.

Additional Sample for low gradient streams:

17. At low gradient stream sites, an additional separate composite sample will be taken. The sample will be collected with the same methods above, with the following modifications:
18. Collect the samples at 0, 50, or 100% transect distance to include edge samples (collected from leaf litter, snags, organic deposits, undercut banks, root wads, macrophyte beds, etc.).
19. If the primary sample was collected at the Left at Transect A, collect the additional sample at the Center of Transect A, then continue with Right at Transect B, Left at Transect C, until you collect at every transect rotating through Left, Center, and Right.
20. Collect the samples over 1 linear meter. Vigorously disturb the bank or bottom habitat and quickly sweep the net to collect the loosened material.
21. Composite and label this sample separately from the first sample collected. This will be identified in the lab as two separate samples.
22. Write in the appropriate abbreviation for substrate & channel habitat type on the Sample Collection Form. For samples taken at the left or right edge of the transect, write in the appropriate abbreviation for the dominant edge type present.

Record information for each composite sample on the Sample Collection Form as shown in Figure 6.1-2(a). If a sample requires more than one jar, make sure the correct number of jars for the sample is recorded on the Sample Collection Form. **Do not fill out the collection form until you have collected (or confirmed at the site that you will collect) samples.** If forms are filled out before you arrive at the site, and then no samples are collected, a lot of time is wasted by others later trying to find samples that do not exist. Place the samples in a cooler or other secure container for transporting and/or shipping to the laboratory (see Appendix C).

Table 6.4-3. Procedure for preparing composite samples for benthic macroinvertebrates at wadeable sites

1. Pour the entire contents of the bucket into a sieve bucket with 500 μm mesh size. Remove any large objects and wash off any clinging organisms back into the sieve before discarding. Remove any inorganic material, such as cobble or rocks.
2. Using a wash bottle filled with river water, rinse all the organisms from the bucket into the sieve. This is the composite sample for the reach.
3. Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample (500-mL or 1-L) and how many jars will be required. Try to use no more than 5 jars per site.
4. Fill in a sample label with the Sample ID and date of collection. Attach the completed label to the jar and cover it with a strip of clear tape. Record the sample ID number for the composite sample on the Sample Collection Form. For each composite sample, make sure the number on the form matches the number on the label.
5. Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If

Table 6.4-3. Procedure for preparing composite samples for benthic macroinvertebrates at wadeable sites

the jar is too full pour off some water through the sieve until the jar is not more than 1/3 full, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar.

- *If a second jar is needed, fill in a sample label that does not have a pre-printed ID number on it. Record the ID number from the pre-printed label prepared in Step 4 in the "SAMPLE ID" field of the label. Attach the label to the second jar and cover it with a strip of clear tape. Record the number of jars required for the sample on the Sample Collection Form. **Make sure the number you record matches the actual number of jars used.** Write "Jar N of X" on each sample label using a waterproof marker ("N" is the individual jar number, and "X" is the total number of jars for the sample).*

6. Place a waterproof label inside each jar with the following information written with a number 2 lead pencil:

- Site ID
- Type of sampler and mesh size used
- Name of site
- Date of collection
- Collectors initials
- Number of stations sampled
- Jar "N" of "X"

7. Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%.

NOTE: Composite samples can be transported back to the vehicle before adding ethanol if necessary. In this case, fill the jar with stream water, which is then drained using the net (or sieve) across the opening to prevent loss of organisms, and replace with ethanol.

8. Replace the cap on each jar. Slowly tip the jar to a horizontal position, then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape.

9. Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

6.5 Fish

6.5.1 Summary of Method

The fish sampling method is designed to provide a representative sample of the fish community, collecting all but the rarest fish taxa inhabiting the site. It is assumed to accurately represent species richness, species guilds, relative abundance, and anomalies. The goal is to collect fish community data that will allow the calculation of an Index of Biotic Integrity (IBI) and Observed/Expected (O/E) models. Backpack or barge electrofishing is the preferred method. If electrofishing is not possible due to safety concerns, high turbidity, or extremes in conductivity, complete the "Not Fished" section of the field form and comment why.

Streams with mean wetted widths less than 12.5 m will be electrofished in their entirety, covering all available habitats. However, the time and effort necessary to sample reaches greater than or equal to 12.5 m wide is prohibitive in the context of the survey, thus sub-sampling is required. Sub-sampling is defined by 5-10 sampling zones, each starting at a transect. In all instances electrofishing in wadeable systems should proceed in an upstream

direction using a single anode. Identification and processing of fish should occur at the completion of each subreach.

6.5.2 Equipment and Supplies

Table 6.5-1 shows the checklist of equipment and supplies required to complete the fish assessment. This checklist is similar to the one presented in Appendix A, which is used at the base location to ensure that all of the required equipment is brought to the site. Record fish collection data on the Fish Collection Form, Side 1 (Fig. 6.5-1).

Table 6.5-1. Equipment and supplies — fish assessment at wadeable sites.

For collecting samples	<ul style="list-style-type: none"> ▪ Electrofishing equipment (including variable voltage pulsator unit, wiring cables, generator, electrodes, dip nets, protective linesman gloves, boots, and necessary safety equipment) ▪ Extra electrofishing unit batteries ▪ Scientific collection permit ▪ Digital camera with extra memory card & battery ▪ 1 Laser rangefinder (optional) ▪ Linesman gloves 	<ul style="list-style-type: none"> ▪ 1 Scalpel for slitting open large fish before preservation. ▪ 1 container of 10% buffered formalin ▪ Several Leak-proof HDPE jars for fish voucher specimens (various sizes from 250 mL - 4 L) ▪ 2 non-conducting dip nets with 1/4" mesh ▪ 1 Minnow net for dipping small fish from live well ▪ 2 measuring boards (3 cm size classes) ▪ 1 set Fish ID keys ▪ Field Operations Manual and/or laminated Quick Reference Guide
For recording measurements	<ul style="list-style-type: none"> ▪ Sample labels ▪ Sample Collection Form ▪ Clear tape strips 	<ul style="list-style-type: none"> ▪ Soft (#2) lead pencils ▪ Fine-tip indelible markers

6.5.3 Sampling Procedure

At sites with a total reach length <500m, fishing will occur continuously for all habitats along the entire sample reach (40 times the average stream width), regardless of catch. At sites with a total reach length >500 m, sampling is accomplished using subreaches so that effort is distributed along the entire reach. In these streams, electrofishing will occur in sample zones beginning the zero mark at each transect on alternating banks (Figure 6.5-3). Determination of the initial stream bank sampling location at transect A (i.e., right or left bank) is determined at random. The crew should consist of one electrofishing operator, and one dip netter and an optional bucket carrier (who may also have a net to aid in transferring fish to the livewell). Sampling will proceed in an upstream direction from transect to transect.

The total reach extent fished in large wadeable streams (≥ 12.5 m) is a minimum reach length of 20 times the average stream width (20X) and a maximum reach length of 40 times the average stream width (40X). The subsampling routine is similar to boatables. Fish each subreach for a maximum of 700 seconds or until the next transect is reached. Begin sampling at a randomly determined bank at the beginning of the subreach and fish an area approximately 8m wide in an upstream direction. Fish the subreach thoroughly, covering bank habitat as well as midstream habitat for a maximum of 700 seconds. When 700 seconds are reached, stop electrofishing unless you are “pushing” a large school of fish, in which case continue fishing until you capture them (typically at some form of structure or physical barrier). At a minimum, 5 subreaches or 20 times the mean channel width is sampled. If 500 individuals are caught within this 20X, you may stop sampling. If not, continue sampling subreaches on alternating banks until 500 individuals are captured. Crews must complete each of the additional subreaches as described above, do not stop in the middle of any subreach, even if the 500 fish minimum is attained before the end of the subreach. To reduce stress and mortality, immobilized fish should be netted immediately and deposited into a live-well for processing. For safety, all crew members are required to wear non-breathable waders and insulated gloves. Polarized sunglasses and caps to aid vision are also required. Table 6.5-2 presents the procedure for electrofishing in wadeable streams.

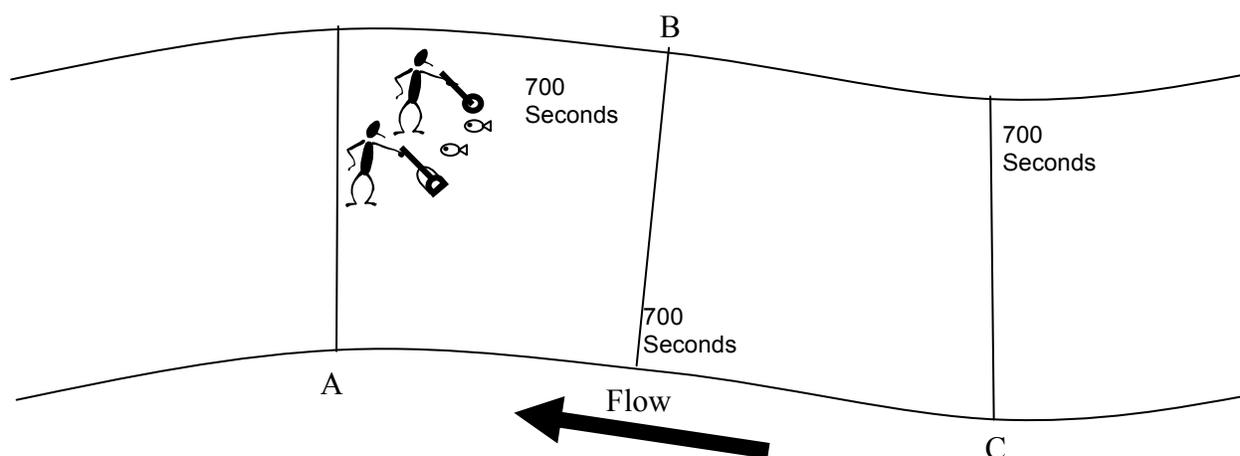


Figure 6.5-3. Transect sample design for fish sampling at wadeable sites ≥ 500 m (≥ 12.5 m width).

Table 6.5-2. Procedure for electrofishing at wadeable sites <500 m

1. Review all collecting permits to determine if any sampling restrictions are in effect for the site. In some cases, you may have to cease sampling if you encounter certain listed species.
2. Search for fish even if the stream is extremely small, and it appears that sampling may produce no specimens. If none are collected, check the "NONE COLLECTED" circle on the Fish Collection Form. Explain why in comments section. Although not required, you may note amphibians and reptiles captured in the Comments.
3. Backpack and barge tote electrofishing will be used in wadeable streams, and direction of fishing will be in an upstream manner. If you do not sample, complete the "NOT FISHED" field on the Fish Collection Form and comment why.
4. At sites with a total reach length <500 m, fishing will occur continuously for all habitats along the entire sample reach. No subsampling.
5. Set unit to pulsed DC. Select initial voltage setting (150-400 V for high conductivity [>300 S/cm]; 500-800 V for medium conductivity [100 to 300 S/cm]; 900-1100 V for low conductivity [< 100 S/cm] waters). In waters with strong-swimming fish (length >200 mm), use a pulse rate of 30 Hz with a pulse width of 2 m/sec. If mostly small fish are expected, use a pulse rate of 60-70 Hz. Start the electrofisher, set the timer, and depress the switch to begin fishing. If fishing success is poor, increase the pulse width first and then the voltage. Increase the pulse rate last to minimize mortality or injury to large fish. If mortalities occur, first decrease pulse rate, then voltage, then pulse width. Start cleared clocks. Note, some electrofishers do not meter all the requested header data; provide what you can. If button time is not metered, estimate it with a stop watch and flag the data.
6. Once the settings on the electrofisher are adjusted properly to sample effectively and minimize injury and mortality, begin sampling at the downstream end of the reach (Transect A) and fish in an upstream direction. Depress the switch and slowly sweep the electrode from side to side. Sample all habitats and available cut-bank and snag habitat as well. Move the anode wand into cover with the current off, turn the anode on when in the cover, and then remove the wand quickly to draw fish out. In fast, shallow water, sweep the anode and fish downstream into a net. Be sure that deep, shallow, fast, slow, complex, and simple habitats are all sampled. In stretches with deep pools, fish the margins of the pool as much as possible, being extremely careful not to step or slide into deep water. Keep the cathode near the anode if fish catch is low.
7. Depending upon crew size, there may be from 2 to 3 people fishing small wadeable sites. Crews may choose to have more than one person holding a net, but **no more than one person should be netting at any one time**. For example, in a wide stream there may be a netter on both sides of an operator. As the operator moves the probe from the left bank to the right bank the netters will remain on one side or the other and only one netter will be actively netting at any one time. The same fishing effort can be accomplished with 1 netter moving from side to side with the probe.
8. The netter, with the net 1 to 2 ft from the anode, follows the operator, nets stunned individuals, and places them in a bucket.
9. Continue upstream until the next transect is reached. Process fish and/or change water after each subreach to reduce mortality and track sampling effort.
10. Complete header information on the Fish Collection Form Small Wadeable.
11. Repeat Steps 6 through 9 until the last subreach is finished.

Table 6.5-3. Procedure for electrofishing at wadeable sites >500 m

1. Review all collecting permits to determine if any sampling restrictions are in effect for the site. In some cases, you may have to cease sampling if you encounter certain listed species.
2. Search for fish even if the stream is extremely small, and it appears that sampling may produce no specimens. If none are collected, check the "NONE COLLECTED" circle on the Fish Collection Form. Explain why in comments section. Although not required, you may note amphibians and reptiles captured in the Comments.
3. Backpack and barge tote electrofishing will be used in wadeable streams, and direction of fishing will be in an upstream manner. If you do not sample, complete the "NOT FISHED" field on the Fish Collection Form and comment why.
4. Fishing will occur in sample zones of approximately 8M in width with the zero mark at each transect on alternating banks.
5. Set unit to pulsed DC. Select initial voltage setting (150-400 V for high conductivity [>300 S/cm]; 500-800 V for medium conductivity [100 to 300 S/cm]; 900-1100 V for low conductivity [< 100 S/cm] waters). In waters with strong-swimming fish (length >200 mm), use a pulse rate of 30 Hz with a pulse width of 2 m/sec. If mostly small fish are expected, use a pulse rate of 60-70 Hz. Start the electrofisher, set the timer, and depress the switch to begin fishing. If fishing success is poor, increase the pulse width first and then the voltage. Increase the pulse rate last to minimize mortality or injury to large fish. If mortalities occur, first decrease pulse rate, then voltage, then pulse width. Start cleared clocks. Note, some electrofishers do not meter all the requested header data; provide what you can. If button time is not metered, estimate it with a stop watch and flag the data.
6. Once the settings on the electrofisher are adjusted properly to sample effectively and minimize injury and mortality, begin sampling at the downstream end of the reach (Transect A). Randomly choose a bank on which to start and fish in an upstream direction within 8 M of the chosen bank. Depress the switch and slowly sweep the electrode from side to side sampling all habitats thoroughly and available cut-bank and snag habitat as well. Move the anode wand into cover with the current off, turn the anode on when in the cover, and then remove the wand quickly to draw fish out. In fast, shallow water, sweep the anode and fish downstream into a net. Be sure that deep, shallow, fast, slow, complex, and simple habitats are all sampled. In stretches with deep pools, fish the margins of the pool as much as possible, being extremely careful not to step or slide into deep water. Keep the cathode near the anode if fish catch is low.
7. **When using a barge or pram, the minimum crew size for electrofishing is three.** The barge operator must remain actively at the control box and navigate the barge. The probe operator will use one probe. Depending upon crew size, there may be from 1 to 2 people additional crew members. Crews may choose to have more than one person holding a net, but **no more than one person should be netting at any one time.** For example, in a wide stream there may be a netter on both sides of an operator. As the operator moves the probe from the left bank to the right bank the netters will remain on one side or the other and only one netter will be actively netting at any one time. The idle netter can assist the active netter by depositing fish into the live well. The same fishing effort can be accomplished with one netter moving from side to side with the probe.
8. Continue upstream for a maximum of 700 seconds. Process fish **after each transect** to reduce mortality and track sampling effort by transect.
9. Continue sampling subreaches at alternating banks until Transect F is reached. If less than 500 fish have been collected from the first five subreaches, continue sampling additional subreaches along alternating banks until 500 individuals are captured, or at a maximum, subreach J-K is finished. Crews must complete each of the additional subreaches as described above, do not stop in the middle of any subreach, even if the 500 fish minimum is attained before the end of the subreach.
10. Complete header information on the Fish Collection Form Large Wadeable/Boatable/Raftable.

6.5.4 Processing Fish

Processing of fish must be completed at the end of each transect; however, if fish show signs of stress (e.g., loss of righting response, gaping, gulping air, excessive mucus), change water or stop fishing and initiate processing. Similarly, State- and Federally-listed threatened or endangered species or large game fish should be processed and released as they are captured. If periodic processing is required, fish should be released in a location that prevents the likelihood of their recapture.

For streams <12.5 m wide, use the Fish Collection Form Small Wadeable. For streams \geq 12.5 m wide, use the Fish Collection Form – Large Wadeable/Boatable/Raftable. Taxonomic identification and processing should only be completed on specimens greater than 25 mm total length and by crew members designated as “fish taxonomic specialists” by EPA regional coordinators. Fish are tallied by species, evaluated for maximum and minimum length, and examined for the presence of DELT (Deformities, Eroded Fins, Lesions and Tumors) anomalies. Common names of species should follow those established under the American Fisheries Society’s publication, “Common and Scientific Names of Fishes from the United States, Canada and Mexico” (Nelson, et al. 2004). A list of species common to freshwater systems of the United States is presented in Appendix D.

Species not positively identified in the field should be separately retained (up to 20 individuals per species) for laboratory identification. Common names for retained species should be assigned as “unknown”, followed by its common family name and sequential lettering to designate separate species (e.g., UNKNOWN SCULPIN A). For large wadeable streams, each transect has its own form. Following positive laboratory identification, field form information should be updated to reflect the actual species count and number in the Final Count field. For example, if a sample of 20 specimens of species A is later identified as 15 individuals of species A and 5 of species B, the Final Count of species A should be corrected by assigning 25% to species B and 75% to species A. Table 6.5-4 presents the procedure for processing fish.

Table 6.5-4. Procedure for processing fish at wadeable sites

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| <ol style="list-style-type: none">1. Complete all header information accurately and completely. If no fish were collected, complete the “NONE COLLECTED” field on the Fish Collection Form.2. Complete the information on the Fish Gear and Voucher/Tissue Sample Information Form.3. For small wadeable streams (<12.5 m) use the Fish Collection Form - Small Wadeable. For large wadeable streams (\geq12.5 m) use the Fish Collection Form – Large Wadeable/Boatable/ Raftable.4. For small wadeables, use one form for the entire reach.5. For large wadeables, use one form per subreach and indicate Subreach on form in “SUBREACH” Field.6. Only identify and process individuals > 25mm in total length, ideally handling specimens only once. Record the common name on the first blank line in the “COMMON NAME” Field of the Fish Collection Form.7. Fill in the Tag Number. The tag number is a number starting with 01 and continuing sequentially to a number equal to the total number of species collected within the entire sample reach. Each reoccurrence of a species within the entire reach should be assigned the same tag number as it was |
|--|

assigned initially. For example, if a bluegill is assigned tag number 01 when processing fish from the first subreach, all bluegills from the other subreaches will also be assigned tag number 01. The purpose of the tag number is to connect species identifications with subsequent verification and voucher collections.

8. If a species cannot be positively identified, assign it a sequential tag number in the Tag Number Field and leave the "COMMON NAME" Field Blank. Flag this line and indicate in the "COMMENT" field its common family name (e.g., UNKNOWN SCULPIN A). Retain a maximum subsample of 20 individuals for in-house laboratory identification of Unknowns. Do not include the number of each species retained solely for in-house lab verification in the Voucher Count column of the fish collection form. This column is reserved only for those fish that are to be sent in for independent re-identification as part of a complete voucher collection.
9. Process species listed as threatened and endangered first and return individuals immediately to the stream. Photograph specimens for verification purposes if conditions permit and stress to individuals will be minimal. Indicate if photographed on Fish Collection Form. If individuals are killed, prepare them as verification specimens and preserve noting them in the "MORTALITY COUNT" field.
10. Tally the number of individuals of each species collected in the "TALLY" box on the Fish Collection Form and record the total number in the "COUNT" field on the form.
11. Measure the total length of the largest and smallest individual to provide a size range for the species. Record these values in the "LENGTH" area of the Fish Collection Form. For small wadeables, this is done for the entire reach. For large wadeables, this is recorded by transect.
12. Examine each individual for external anomalies and tally those observed. Identify external anomalies including missing organs (eye, fin), skeletal deformities, shortened operculum, eroded fins, irregular fin rays or scales, tumors, lesions, ulcerous sores, blisters, cysts, blackening, white spots, bleeding or reddening, excessive mucus, and fungus. After all of the individuals of a species have been processed, record the total number of individuals affected in the "ANOMALIES" area of the Fish Collection Form. For small wadeables, this is done for the entire reach. For large wadeables, this is recorded by transect
13. Record total number of mortalities in the "MORTALITY COUNT" field due to electrofishing or handling on the Fish Collection Form.
14. Follow the appropriate procedure to prepare voucher specimens and/or to select specimens for tissue samples. Release all remaining individuals so as to avoid their recapture.
15. For any line with a fish name on the Fish Collection Form, ensure that all spaces on that line are filled in with a number, even if it is zero.
16. Repeat Steps 1 through 10 for all other species and subreaches.

6.5.5 Taxonomic Quality Assurance/Quality Control

6.5.5.1 Sample Preservation

Fish retained for laboratory identification/verification or voucher purposes should be placed in a large sample jar containing a 10% buffered formalin solution in a volume equal to or greater than the total volume of specimens. Individuals larger than 200 mm in total length should be slit along the right side of the fish in the lower abdominal cavity to allow penetration of the solution.

Fish retained for laboratory identification or as vouchers should be preserved in the field following the precautions outlined in the MSDS. All personnel handling 10% buffered formalin must read the MSDS (Appendix D). **Formalin is a potential carcinogen and should be used with extreme caution, as vapors and solution are highly caustic and may cause severe irritation on contact with skin, eyes, or mucus membranes. Wear vinyl or nitrile gloves and safety glasses, and always work in a well-ventilated area.**

6.5.5.2 Laboratory Identification

Fish that are difficult to identify in the field should be kept for laboratory identification or to verify difficult field identifications. Table 6.5-5 outlines the laboratory identification process and completing the Fish Collection Form. Field crews may use a supplemental Fish Identification Lab sheet such as that shown in Figure 6.5-4 for internal laboratory use only. Crews should retain the Fish verification sample – contact your regional EPA coordinator if you cannot store the samples at your facility.

Do not include the number of each species retained solely for in-house lab verification in the Voucher Count column of the fish collection form. This column is reserved only for those fish that are to be sent in for independent re-identification as part of a complete voucher collection.

Field crews should not retain the Fish Collection Form(s) if the laboratory identification process cannot be completed within a short period of time. If the time needed to complete the identification/verification is expected to exceed two weeks, make copies of the Fish Collection Form(s) and send the entire pack of original data forms to the Information Management Coordinator. When the identification/verification process is complete, make the necessary changes to the copied Fish Collection Form(s) and send them as soon as possible to the Information Management Coordinator as well.

Table 6.5-5. Procedure for laboratory identification of fish samples.

1. Fish may be retained for routine laboratory identification and verification purposes. Fish tags are provided with each site kit. Crews may use these tags at their discretion in order to identify fish at their laboratory.
2. Retained fish should be placed in a large sample jar containing a 10% buffered formalin solution in a volume equal to or greater than the total volume of specimens. Individuals larger than 200mm in total length should be slit along the right side of the fish in the lower abdominal cavity to allow penetration of the solution.
3. Following fixation for 5 to 7 days, the volume of formalin should be properly discarded and replaced with tap water for soaking specimens over a 4-5 day period. Soaking may require periodic water changes and should continue until the odor of formalin is barely detectable. Final storage of specimens is done in 45%-50% isopropyl alcohol or 70% ethanol. Formalin is a potential carcinogen and should be used with extreme caution, as vapors and solution are highly caustic and may cause severe irritation on contact with skin, eyes, or mucus membranes. Wear vinyl or nitrile gloves and safety glasses, and always work in a well-ventilated area.
4. Formalin must be disposed of properly. Contact your regional EPA coordinator if your laboratory does not have the capability of handling waste formalin.
5. Unknown fish are identified to species in the laboratory. You may use a Fish Identification Lab Sheet such as the one presented in Figure 6.5-4.

6. Fill in the Unknown species name in the “COMMON NAME” field of the Fish Collection Form and make certain the “FINAL COUNT” field is correct.
7. If species field identifications were incorrect, correct the “COMMON NAME” Field by completely erasing the Common Name and replacing the correct name. Add an additional Common Name if needed. Make certain the “FINAL COUNT” field is correct. If the “COMMON NAME” Field was incorrect or cannot be cleanly erased, cross out the line of data and fill out a new line with the correct “COMMON NAME” and “FINAL COUNT”.

6.5.5.3 Voucher Specimens

Approximately 10% of each field crews' sites will be randomly pre-selected for re-identification by an independent taxonomist. A minimum of one complete voucher is required for each person performing field taxonomy and will consist of either preserved specimen(s) or digital images representative of all species in the sample, including common species. Multiple specimens per species can be used as vouchers, if necessary (i.e., to document different life or growth stages, or sexes). Note that a complete sample voucher does not mean that all individuals of each species will be vouchered, only enough so that independent verification can be achieved.

Digital images should be taken as voucher documentation for species that are recognized as Rare, Threatened, or Endangered – they should not be killed. Digital images should also be taken of fish specimens too large for preservation.

Certain states or regions may require that more fish vouchers are taken. Check with your state/regional coordinators to determine if your team will be required to collect complete vouchers at more than 10% of your sites.

For the sample voucher, specimen containers should be labeled with the sample number, site ID number, site name, and collection date. There should be no taxonomic identification labels in or on the container, or in any of the digital photos.

Choose individual specimens that are intact and in good condition, such that re-identification will be possible. Fish that are damaged, have significant scale loss or those that have been dead for a significant amount of time prior to preservation should be avoided if possible. Fish in pristine condition and those possessing clear identification characteristics are preferred. Additionally, fish that are preserved while still live will typically flare their fins and gills and will allow for easier re-identification in the laboratory.

Place one or more representative specimens of each species in plastic mesh sleeves along with one of the corresponding tag number labels provided in your site kit. (Several fish may be placed in a single mesh sleeve, as long as they are of the same species). Ensure that the tag numbers in the voucher collection match the tag numbers on the fish collection data forms. Seal both ends of the mesh sleeve with zip ties and place it inside the voucher collection jar with the appropriate preservative. Unknown fish may be identified in the laboratory as described in section 5.5.5.2 and subsequently included in the voucher collection.

Record the total number of each fish species retained for voucher purposes in each subreach on the fish collection form. Record the voucher sample ID number on the fish gear /

voucher / fish tissue collection form. If no voucher is prepared for the site, fill in the “no vouchers preserved” circle on the fish gear form.

Table 6.5-6. Procedure for vouchering fish samples.

1. Approximately 10% of each field crews' sites will be randomly pre-selected for re-identification by an independent taxonomist. A minimum of one complete voucher is required for each person performing field taxonomy and will consist of either preserved specimen(s) and/or digital images representative of all species in the sample, even common species.
2. Take digital images as voucher documentation for species that are recognized as Rare, Threatened, or Endangered; or when fish specimens are too large for preservation.
3. For the sample voucher, label the specimen containers with the sample number, site ID number, site name, and collection date. Do not put taxonomic identification labels in or on the container.
4. Place one or more representative specimens of each species in plastic mesh sleeves along with one of the corresponding tag number labels provided in your site kit. (Several fish may be placed in a single mesh sleeve, as long as they are of the same species).
5. Ensure that the tag numbers in the voucher collection match the tag numbers on the fish collection data forms.
6. Seal both ends of the mesh sleeve with zip ties and place it inside the voucher collection jar with the appropriate preservative.
7. Unknown fish may be identified in the laboratory as described in section 5.5.5.2 and subsequently included in the voucher collection.
8. Record the total number of each fish species retained for voucher purposes in each subreach on the fish collection form.
9. Record the voucher sample ID number on the fish gear / voucher / fish tissue collection form.
10. If no voucher is prepared for the site, fill in the “no vouchers preserved” circle on the fish gear form.

6.5.5.4 Photovouchering

Digital imagery should be used for fish species that cannot be retained as preserved specimens (e.g., RTE species; very large bodied; or very common). Views appropriate and necessary for an independent taxonomist to accurately identify the specimen should be the primary goal of the photography. Additional detail for these guidelines is provided in Stauffer et al. (2001), and is provided to all field crews as a handout.

The recommended specifications for digital images to be used for photovouchering include: 16-bit color at a minimum resolution of 1024x768 pixels; macro lens capability allowing for images to be recorded at a distance of less than 4 cm; and built-in or external flash for use in low-light conditions. Specimens should occupy as much of the field of view as possible, and the use of a fish board is recommended to provide a reference to scale (i.e., ruler or some calibrated device) and an adequate background color for photographs. Information on Station ID, Site Name, Date and a unique species ID (i.e., A, B, C, etc.) should also be captured in the photograph, so that photos can be identified if file names become corrupted. All photovouchered species should have at least a full-body photo (preferably of the left side of the fish) and other zoom images as necessary for individual species, such as lateral line, ocular/oral orientation, fin rays, gill arches, or others. It may also be necessary to photograph males, females, or juveniles.

Images should be saved in medium- to high-quality jpeg format, with the resulting file name of each picture noted on the Fish Collection Form. It is important that time and date stamps are accurate as this information can also be useful in tracking the origin of photographs. It is recommended that images stored in the camera be transferred to a PC or storage device at the first available opportunity. At this time the original file should be renamed to follow the logic presented below:

F01_CT003_20080326_A.jpg

Where:

F = fish

01 = tag number

CT003 = state (Connecticut) and site number

20080326 = date (yyyymmdd)

A = first of several pictures of same fish (e.g., A, B, C)

Field crews should maintain files for the duration of the sampling season. Notification regarding the transfer of all images to the existing database will be provided at the conclusion of the sampling.

6.6 Fecal Indicator (Enterococci)

6.6.1 Summary of Method

You will collect a fecal indicator sample at the last transect (Transect K) after all other sampling is completed. Use a pre-sterilized, 250 ml bottle and collect the sample approximately 1 m off the bank at about 0.3 meter (12 inches) below the water. Following collection, place the sample in a cooler, chill for at least 15 minutes, and maintain on ice prior to filtration of four 50 mL volumes. (Samples must be filtered and frozen on dry ice within 6 hours of collection). In addition to collecting the sample, look for signs of disturbance throughout the reach that would contribute to the presence of fecal contamination to the waterbody. Record these disturbances on the Site Assessment Form (Figure 7-2).

6.6.2 Equipment and Supplies

Table 6.6-1 provides the equipment and supplies needed for field crews to collect the fecal indicator sample. Record the fecal indicator sample data on the Sample Collection Form (Figure 6.1-3).

Table 6.6-1. Equipment and supplies list for fecal indicator sampling at wadeable sites

For collecting samples	<ul style="list-style-type: none"> ▪ nitrile gloves ▪ pre-sterilized, 250 ml sample bottle ▪ sodium thiosulfate tablet ▪ Wet ice ▪ cooler
For recording measurements	<ul style="list-style-type: none"> ▪ Sample Collection Form ▪ Site Assessment Form ▪ Fecal Indicator sample labels (4 vial labels and 1 bag label) ▪ Pencils (for data forms) ▪ Fine-tipped indelible markers (for labels) ▪ Clear tape strips

6.6.3 Sampling Procedure

Table 6.6-2 provides the procedure for collecting fecal indicator (i.e., Enterococci) samples at wadeable sites.

Table 6.6-2. Procedure for fecal indicator (Enterococci) sample collection at wadeable sites

<p><i>Collect the Enterococci Sample</i></p> <ol style="list-style-type: none"> 1. Put on nitrile gloves. 2. Select a sampling location at transect K that is approximately 1 m from the bank and approximately 1 m deep. Approach the sampling location slowly from downstream or downwind. 3. Lower the un-capped, inverted 250 ml sample bottle to a depth of 1 foot below the water surface, avoiding surface scum, vegetation, and substrates. Point the mouth of the container away from the

body or boat. Right the bottle and raise it through the water column, allowing bottle to fill completely. If the depth does not reach 1 foot along the transect at 1 m from the bank, take the sample and flag it on the field form.

4. After removing the container from the water, discard a small portion of the sample to allow for proper mixing before analyses.
5. Add the sodium thiosulfate tablet, cap, and shake bottle 25 times.
6. Store the sample in a cooler on ice to chill (not freeze). Chill for at least 15 minutes and do not hold samples longer than 6 hours before filtration and freezing.