CONFEDERATED TRIBES OF THE COLVILLE RESERVATION

Okanogan Basin Physical Habitat Monitoring Field Manual

Okanogan Basin Monitoring and Evaluation Program

Version

2.2

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INTRODUCTION

This field manual was developed by the Confederated Tribes of the Colville Reservation (CCT) to provide specific guidance in the evaluation and monitoring of fish habitat in the Okanogan Sub basin for the 2004 Okanogan Basin Monitoring and Evaluation Program (OBMEP). The OBMEP is a long term status and trend monitoring program subject to future adaptive management, therefore, this field manual should be considered to be a "living document" with the following protocols potentially subject to some level of modification over time as new information becomes available. This most recent revision incorporates a few new field methods, including gradient.

The protocols contained within this manual are closely aligned with the Environmental Monitoring and Assessment Program (EMAP) developed by the Environmental Protection Agency (EPA) as adopted into the Upper Columbia Monitoring and Evaluation Strategy. Through refining these protocols, OBMEP addresses specific program needs and is compatible with the Ecosystems Diagnosis and Treatment (EDT) Model developed by Mobrand Biometrics Incorporated. EDT is the primary fish habitat assessment tool used by sub basin planners throughout the Columbia Basin and specifically within the Okanogan Sub basin. Periodic updating of EDT input fields with compatible data will be necessary to assess changes which may occur in habitat conditions over time and is the only known method for evaluating these changes verses productivity benefits.

The protocols for conducting field measurements of physical habitat in the Okanogan Sub basin as described in this field manual have been adopted to address the following Upper Columbia Strategy (UCS) monitoring indicators (Hillman, 2004) and EDT attributes:

Field Measurement	UCS Indicator	EDT Attribute
Wetted Width	Wetted Width	Channel Width - Minimum
Bankfull Width	Bankfull Width, Width/Depth Ratio	Channel Confinement - Natural
Bankfull Depth	Width/ Depth Ratio	Channel Confinement - Natural
Cross-section Depths	Width/Depth Ratio	
Thalweg Depths	Residual Pool Depths	
Floodplain Width		Channel Confinement Natural
Floodplain Depth		Channel Confinement Natural
Canopy Cover	Riparian Condition/Canopy Cover	Riparian Function
Understory	Riparian Condition/Canopy Cover	Riparian Function
Groundcover	Riparian Condition	Riparian Function
Shading	Canopy Cover	Riparian Function
Riparian Width		Riparian Function
Human Influence	Riparian Disturbance	Channel Confinement Hydromodifications
Substrate	Dominant Substrate	Substrate Transportation
Embeddedness	Embeddedness	Embeddedness

Presence of Fines		Fine Sediment
Large Woody Debris	LWD Frequency	Wood
Habitat Type – In Channel	Pool Frequency	Habitat type – Pool tailouts
		Habitat type – Primary Pools
		Habitat type – Beaver Ponds
		Habitat type – Backwater Pools
		Habitat type – Glide
		Habitat type – Large Cobble/Boulder Riffles
		Habitat type – Small Cobble/Gravel Riffles
Habitat Type – Off Channel	Off Channel Habitat	Habitat type – off Channel habitat factor
*Fish Barriers	Habitat Access	Obstructions to Fish Migrations
*Diversion Structures	Habitat Access	Obstructions to Fish Migrations

*Fish Barriers and diversion structures will be flagged under these field procedures but full evaluation will be conducted under a separate set of field protocols.

ACKNOWLEDGEMENTS

Glenn Merritt (DOE), Tracy Hillman (BioAnalysts Inc.), Keith Wolf (KWA Ecological Sciences Inc.) and Phil Larson (EPA) provided valuable advice and insight into the EDT Model, the Upper Columbia Monitoring and Evaluation Strategy, and the EMAP process during the development of this field manual. Carolyn Pearson (EcoAim Inc.) assisted in protocol review during the initial field effort. Sidryn Sam and Swede Albert were the CCT 2004 field crew and provided valuable feedback regarding the implementation and application of these protocols in the field. Oly Zacherle and Vertis Campbell were the CCT 2010 field crew and provided valuable feedback regarding the refinement of field and datalogger protocols.

EQUIPMENT AND SAFETY REQUIREMENTS

EQUIPMENT	USE
Metric Reel Tape Measure	Measuring Transects
Laser Range Finder	Measuring across wide sections of swift current
Trimble Yuma	GPS Lat/Long acquisition/Data recording
3 – 2 ft. pieces of rebar painted flourescent orange	Monumenting site
Surveyor's Flagging Tape	Marking Transects
Permanent Markers	Labeling flagging / Story board
Digital Camera	Photo Archiving record of sites
Field Notebook	Journal of site work
Calculator	Transect section calculation
55 meter/28 meter/15 meter/10 meter Vinyl 7/16ths Diameter Tubing Sections Bucket and funnel	Gradient Calculation
Metric stadia rod with bubble level	Measuring Tool
Gravelometer	Substrate size identification
Waders	Wading
Garmin Rhino 120	Open water distance traveled calculation/communication
Convex Densiometer	% Riparian Cover /Solar input calculation
Folding Metric Ruler	Various Length Measurements
Compass	Bearing
Camera, pencils, extra batteries	Documentation and note taking
HDPE White Plastic Board	Story board for photo archive labeling

SAFETY PRECAUTIONS

In addition to the above listed equipment, personal gear must reflect the environmental conditions encountered during the field season which will stretch from summer into early winter. Technicians must be prepared for the potential hazards associated with working in swift water. Examples of personal gear include: personal floatation devices, backpack, neoprene gloves, sunscreen, polarized sun glasses, wide brimmed hats, proper clothing for the elements, insect repellent, first aid kit, food and water. These are basic precautions and are not a complete list of items necessary to execute a safe field work experience. Give consideration to your work location and plan accordingly.

SECTION 1. METHOD FOR MONUMENTING SAMPLING REACHES

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols.

Within each sampled habitat project reach, a series of 11 transects, "A-K", and 10 sub-transects, "A1-J1", are established perpendicular to the stream bank as points of reference for measuring characteristics of the stream and riparian habitat. Transect metrics are averaged to obtain a mean representation of the stream reach.

SAMPLING DURATION

Sampling should occur during July to September although environmental conditions may affect that time frame. Data should be collected at or near base flow levels when turbidity and visibility are normally at their best. Riparian data should be sampled when vegetation is at its maximum growth.

PROCEDURE

1. Identify the site (Site ID), obtain Lat/Long coordinates from EMAP site selection, the coordinates will be your center point ("transect F") of the stream reach to be surveyed.

2. Navigate to the site with the Yuma.

3. Locate the center point ("transect F") and mark the Site ID # on the Yuma.

4. Monument the center point by hammering a two foot length of rebar on the left bank of the stream (left as you are facing downstream) or on the right bank if the left is inaccessible. Rebar is placed above bankfull height.

5. Flag a permanent structure (i.e. tree) near the center point rebar with a "marking whiskers" or aluminum tag. Write the following info on the aluminum tag: Monument Lat/Long, Monument Transect (A, F or K), and Reach Transect Length. Describe the location of the center point site in your field notebook so that the rebar is easily relocated as the next visit may be five years from now.

6. Measure bankfull width of the stream or river at five representative points (2 upstream, 2 downstream, and 1 at the center point). Calculate the average bankfull width (to the nearest 0.1 meter) from your samples taken.

7. Locate the upper and lower boundaries of the stream reach. From your center point, go 10 average bankfull widths upstream to the upper boundary and from the center point 10 average bankfull widths downstream to the lower boundary. (Example: if the average bankfull width is 8.0 meters, then the top of the reach will be 80 meters upstream of the center point, and the bottom of the reach will be 80 meters downstream of the center point, making the overall reach length 160 meters). The MINIMUM reach length is 150 meters and the MAXIMUM reach length is 500 meters. Any stream with an average bankfull width of less than 7.5 meters is to be assigned the minimum reach length, and any stream with an average bankfull width of greater than 25 meters is to be assigned the maximum reach length of 500 meters.

8. Monument the upper and lower boundaries of the reach with 2 foot rebar stakes on the left bank (or on the right bank if the left is inaccessible). Note any changes in stake location in the Notes section of the Yuma. Permanent aluminum tags or "marking whiskers" will be placed on a prominent structure near the rebar stake and the stake location marked on the Yuma. Hang flagging tape on either side of the permanent marker to aid in relocating the site.

9. See the method for photo documentation in Section 11.

SECTION 2: METHOD FOR LAYING OUT TRANSECTS IN SAMPLING REACHES

PURPOSE

Dividing the stream reach into transects creates defined increments for measuring habitat characteristics and changes. Habitat changes are documented by re-measuring transects in the exact location each year that the reach is surveyed. Although the left bank starting point of the transect should not change, the transect right bank end point location could potentially shift if the stream channel has shifted due to natural processes. The new bearing taken at that point will capture the channel's sinuosity over time.

PROCEDURE

1. Go 10 bankfull widths downstream from the center point to the rebar you have staked as the end of the stream survey reach. This endpoint is the downstream monument and is flagged as transect "A". Label "A" on the flag with a black permanent felt tip marker. Because the tape will degrade over time, label the tape at the bottom, middle and the top. The three monument sites are flagged with both solid fluorescent orange and striped red and white flagging tape. The survey tape should be long enough to be clearly seen from the opposite bank and the next transect if a line of sight is available.

2. Using the metric tape, measure the distance upstream to the next transect. The distance between transects is equivalent to: a) 1/10th the total reach length in reaches between 150 and

500 meters (also calculated as 2 mean bankfull widths), b) 15 meters in small streams with 150 meter reach length, or c) 50 meters in larger streams with 500 meter reach length. Flag and label this spot as the next transect (transect B). Main transects that are not monument sites are flagged with solid fluorescent orange flagging.

3. Intermediate or sub-transect points must also be flagged and labeled. The sub-transect is exactly halfway from transect A to transect B (also calculated as one mean bankfull width). This halfway point between "A" and "B" is labeled "A1". Sub-transects are flagged with red and white striped survey tape.

4. Proceed upstream with the tape measure and flag and label the remaining transects and sub-transects through transect K.

EXAMPLE REACH LAYOUT

In the below example, if the total reach length (A to K) is 500 meters, the distance between A and B is 50 meters and the distance between A and A1 is 25 meters.

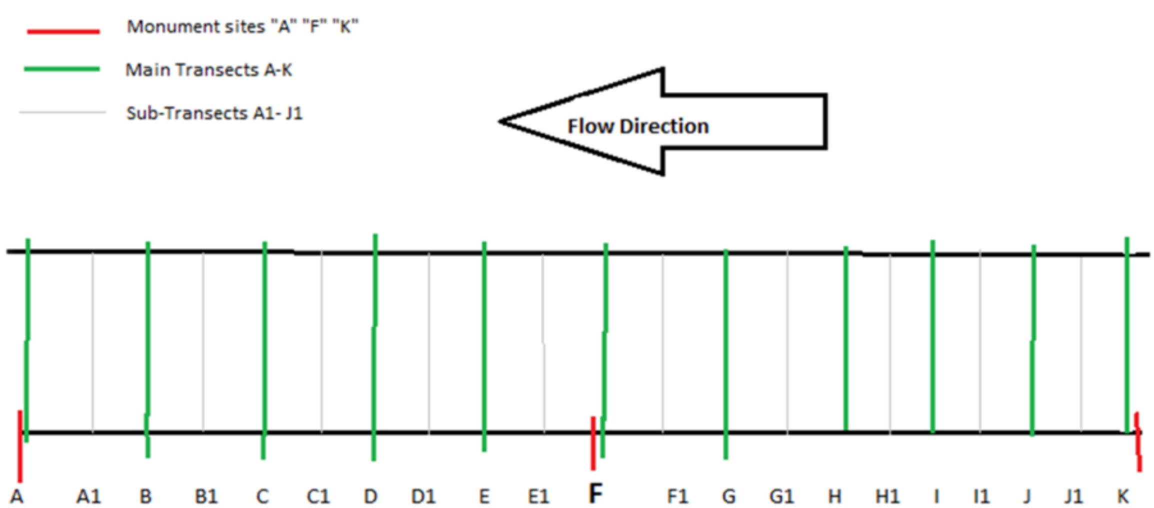

Figure 1: Sample Reach Layout

SECTION 3: METHOD FOR LAYOUT IN REACH WITH SIDE CHANNELS, MID CHANNEL BARS, AND BRAIDED CHANNELS

PURPOSE

The EDT Modeling exercise includes the identification of numbered reach segments for the entire Okanogan Basin. Significant side channels will be singled out as separate measurable reach segments within the reach inventory. If a randomly selected EMAP site happens to contain significant side channels, the side channels will be measured with their own separate habitat survey in order to document their unique habitat. To qualify for a unique habitat survey, a side channel must have a unique EDT reach segment number. This information is pre-determined in the GIS data loaded into the Yuma field data loggers so the field crew will be aware in advance whether the side channel will need to be treated separately. If a side channel is not identified by the GIS data as requiring a unique survey, the area will be treated as a braided channel with any island features considered mid-channel bars.

PROCEDURE

1. **Island-formed side channels** within EMAP reaches having their own unique EDT reach segment numbers identified by the Yuma with an alpha letter after the OBMEP site number (i.e. OBMEP 537a, 537b etc) will be measured just as primary stream channels by monumenting them and taking complete transect data and reach data measurements. The distance interval between transects and Thalweg stations in side channels will be determined separately than for the primary project reach, utilizing the techniques in Laying Out Transects In A Sampling Reach. The following data is collected for these side channels in the same manner as for the primary channel:

    a. Transect bearing, wetted width, bankfull width & bankfull height

    b. Substrate, Densiometer, Riparian Structure, Human Influence

    c. Reach Thalweg, Gradient, LWD, Habitat Type, Backwater features

    d. During primary channel Thalweg Measurements, enter Side Channel Begin and Side Channel End points for each side channel measured.

    e. Photos

2. **Islands** are channel features that are as high or higher than the bank full flow height. Islands are dry during bank full flows. Islands associated with EDT reach segment side channels pre-determined for measuring as separate habitat sites are considered islands. In these cases, data is not collected over the island aside from the riparian structure data required for the side channel. Islands NOT associated with EDT reach segment side channels are considered mid-channel bars.

3. **Mid-Channel Bars** are stream channel features below the bankfull flow height and may be dry during summer field surveys. Mid-channel bars are wet during bankfull flows and are considered part of the wetted channel. Transect data measurements are taken over bars and boulders, just as if they were a part of the wetted channel. Substrate size and embeddedness and densiometer data are recorded normally and stream depth recorded as zero. If your wetted width measurement contains a mid-channel bar, subtract the bar width to get actual wetted width.

4. Sections of streams with complex braided channels are laid out according to Figure 2. When a **braided channel** is encountered at a transect point, locate bankfull height outside the

braided section. Take a compass bearing on a point directly perpendicular to the bankfull height so that the transect bisects the **entire stream** (including side channels) at 90 degrees. Transect flagging is placed at the first channel encountered that contains stream flow. Dry channels are not counted. Transect spacing is measured on the primary stream flow channel but the transect line is formed from outside bankfull height so that it bisects the flagged transect point.

LAYOUT IN REACH WITH BRAIDED CHANNEL

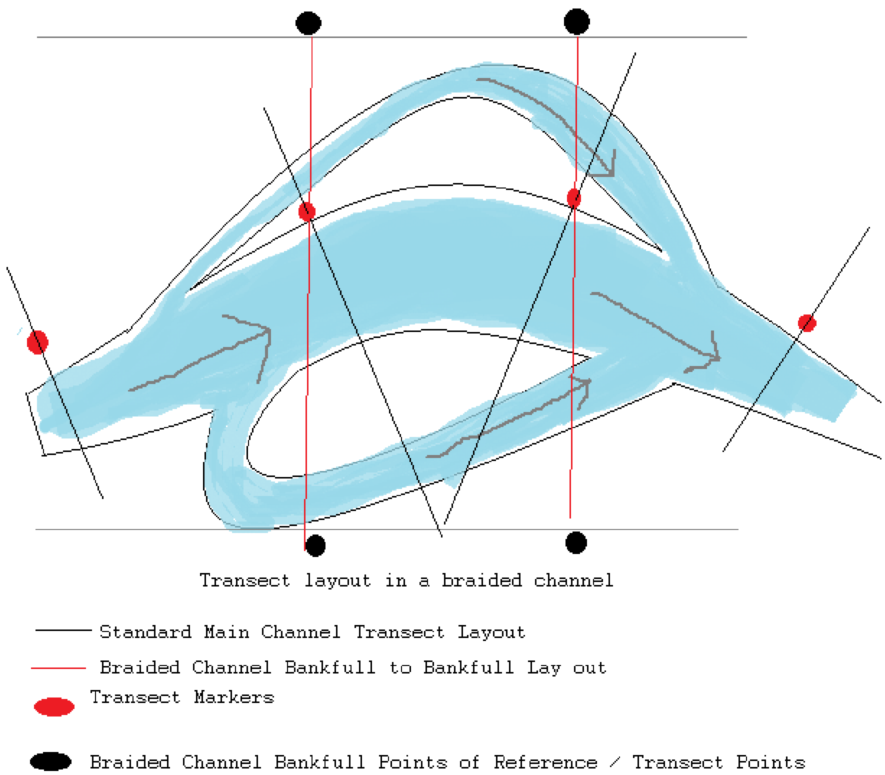

Figure 2: Layout in Reach with Braided Channel

SECTION 4: METHOD FOR MEASURING TRANSECT DATA

PURPOSE

Transect data is measured in precise locations so that it can be revisited annually or, in the case of panel sites, every five years. This data is used to map stream sinuosity and channel movement.

Transect data collected: Bankfull height, Bankfull depth, Wetted Width, Compass Bearing, and Mid-Channel bars/Islands.

PROCEDURE

1. Begin at Transect “A” (downstream monument site). In wadeable streams, first use a reel tape to measure the wetted width, and then locate bankfull height on either bank. Stretch the reel

tape from bankfull height to bankfull height and secure the tape using clamps. In non-wadeable streams, the use of a laser range finder is necessary. Use the photo storyboard as a reflector to define the outside edge of the measurement on the opposite bank and be wary of vegetation that may influence the reading negatively.

2. **Wetted width**: Wetted width is the width of the water's surface measured perpendicular across the stream channel. For dry and intermittent streams where no water is in the channel, record zero for wetted width.

3. **Bankfull height**: Bankfull height is the vertical distance from the water surface at the wetted edge to the point of maximum flow elevation occurring every 1.5 year - indicated by the start of permanent vegetation and the first terrace above the stream channel. Use the stadia rod with a bubble level in place on one end. Place the base of the stadia rod so that it rests horizontally from the physical or flora indication of bankfull height. Extend the stadia rod horizontally until it is directly over the start of the wetted channel. Level the stadia rod using the bubble level. Measure the vertical distance from the stadia rod to the water level at the edge of the wetted channel, this is your bankfull height. Bankfull height added to Thalweg Depth = Bankfull depth.

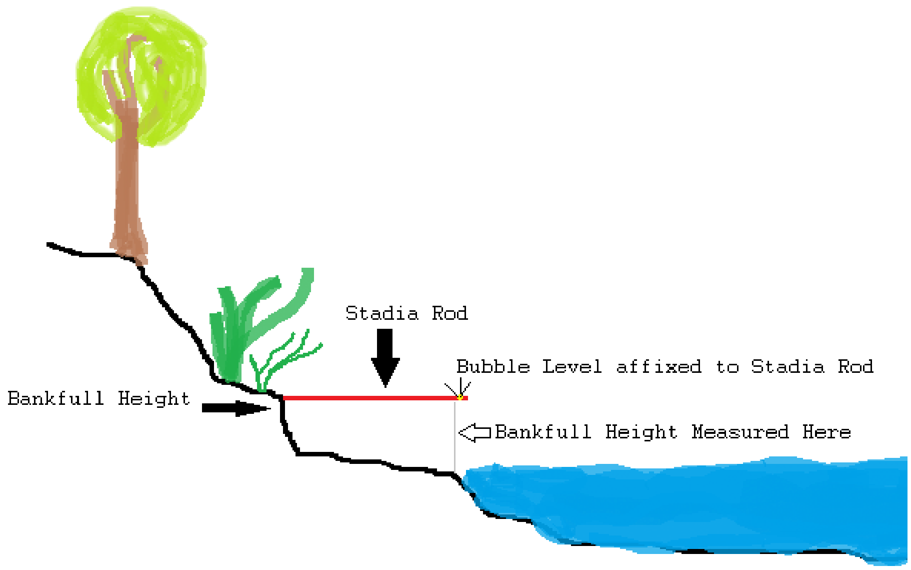

Figure 3: Measuring Bankfull Height

4. **Bankfull width**: Bankfull width is the distance from the bank edge used to measure bankfull height to the same feature on the opposite bank.

5. **Compass bearing**: A directional bearing is taken at each transect at the established bankfull height on the left bank (the same side of the stream as the monument and flagging). The bearing is taken at 90 degrees perpendicular to the stream flow. Transect bearings, if taken at 90 degrees perpendicular to the stream flow, will show whether stream flow orientation has changed from year to year due to natural processes.

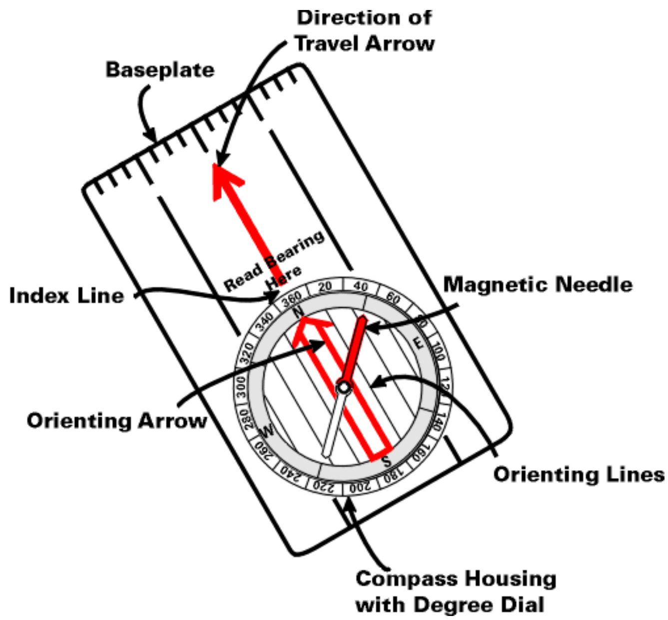

Figure 4: Reading A Compass

a) Hold the compass level so that the magnetic needle moves freely (make sure no metal or magnetic objects are nearby. One source of a strong rare earth magnet is in the lid of a densiometer, make sure this instrument is safely some distance away when using the compass).
b) Keep the direction of travel arrow pointed at the destination, which is a point on the opposite stream bank 90 degrees to the current. Slowly turn the compass bezel so that the red orienting needle and the red magnetic needle overlay each other.
c) The index line will be even with a number from 0 (north) to 360. Determine the number at the index line while the direction of travel arrow is pointing at your target and the orienting needle and the magnetic needle are aligned with each other (north).
d) The number at the index line at this time is your bearing.

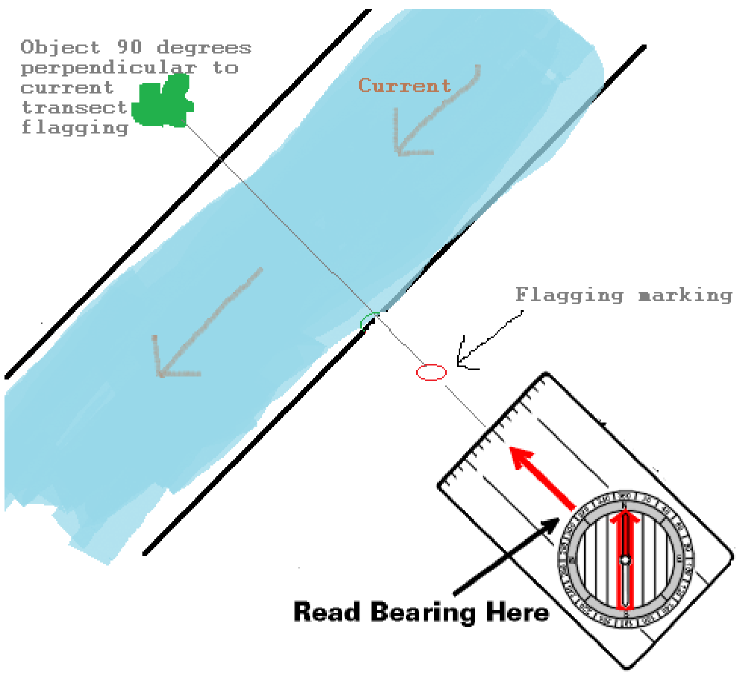

Figure 5: Taking A Transect Compass Bearing

SECTION 5: METHOD FOR MEASURING SUBSTRATE

PURPOSE

Determining the substrate size and monitoring any significant changes in the percentage of fines and embeddedness at 10 equally spaced intervals along each transect and subtransect.

PROCEDURE

1. Substrate data is collected for all transects and sub-transects. Begin at Transect "A" (downstream monument site). Stretch a meter tape across the stream perpendicular to its flow, with the "zero" end of the tape on the left bank,

as viewed when looking downstream. Leave the tape tightly suspended across the stream.

2. To determine interval width, divide the bankfull width by 9. Note that your first measurement interval on the transect is at the point of bankfull height, river left (zero on the reel tape), and in many cases depth may equal 0. For the last interval, the distance will equal the bankfull width and depth may again equal 0. In non-wadeable streams, use the Garmin Rhino "distance traveled" setting to measure the distance between each interval. Collect stream depth, substrate size and embeddedness at each of the ten intervals, ending at bankfull height, river right.

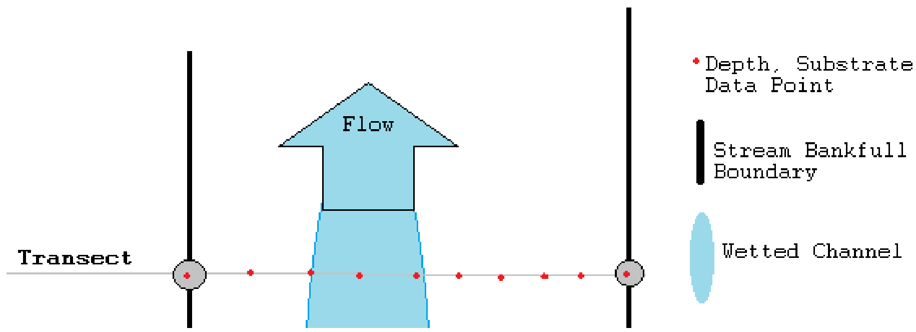

Figure 6: Transect Layout

3. To determine the substrate size, place the Gravelometer on the stream bed at each data collection point. Measure a variety of pieces of the dominant substrate in the area of the square that the gravelometer rests on using the "B" axis of the substrate sample.

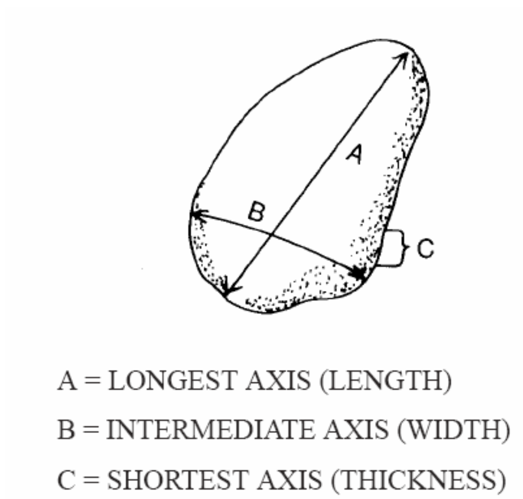

Figure 7: Particle axes (from Potyondy and Bunte, 2002).

Record the dominant substrate size using the following substrate size codes:

Bedrock = BR (larger than a car)
Boulder (250 to 4000 mm, basketball to car) = BL
Large Cobble (127 to 250 mm, softball to basketball) = LCB
Cobble (64 to 127 mm tennis ball to softball) = SCB
Coarse Gravel (16 to 64 mm marble to tennis ball) = GC
Fine Gravel (2 to 16 mm ladybug to marble) = GF

Sand (0.06 to 2 mm gritty to ladybug) = SA
Silt/Clay/Muck (Not Gritty) = FN
Hardpan (Firm, consolidated fine substrate) = HP
Wood (Any size) = WD
Other (Write comment) = OT (describe what the substrate is)

4. If the substrate is coarse gravel, cobble, large cobble, or boulder, determine the level of embeddedness using the following embeddedness classes:

   1 = <10%
   2 = 10-25%
   3 = 25-50%
   4 = 50-90%
   5 = >90%

5. Before removing the substrate from the streambed for gravelometer measurement, estimate the embeddedness before disturbing them, either visually or by touch. Stain lines can be a good indicator of embeddedness. Confirm the embeddedness by picking up the substrate and estimate the percentage of the gravel/cobble volume below the stainline. For boulders, do a visual estimate of embeddeness. Sand and fines are 100% embedded. Bedrock and hardpan are 0% embedded.

6. In wadeable streams, measure the water depth to the nearest 0.01 meter using the stadia rod. In non-wadeable streams, use an electronic depth finder. If a data collection point falls outside the wetted channel, record a 0 for depth.

SECTION 6: METHOD FOR MEASURING CANOPY COVER AND CHARACTERIZING RIPARIAN VEGETATION STRUCTURE

PURPOSE

To determine how shade is distributed on the stream channel and to determine the changes in riparian vegetation.

CANOPY COVER PROCEDURE

1. Canopy cover is determined for the stream reach at each of the 11 cross section transects ("A – K"). A convex spherical densiometer is used. Six measurements are obtained at each cross section. Sub-transects are not included in canopy cover data collection. Densiometer readings

are performed at the same time as substrate measurements are taken.

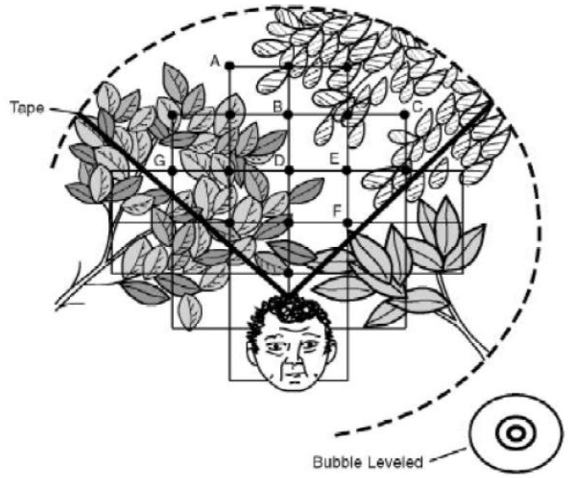

Figure 8: Densiometer (Mulvey et al 1992)

2. Starting at the bankfull height at river left bank, face the bank and hold the densiometer level approximately 18 inches above the substrate or water level. Move the densiometer in front of you so that the top of your head touches the base of the "V".

3. Count the number of grid intersection points within the "V" that are covered by vegetation (a tree, a leaf or a high branch). Record the value (0-17).

4. Upon completion of river left bank reading, proceed to the center point of the transect. Hold the densiometer over the transect tape at the center of the transect and take a reading in each of the four directions, upstream, downstream, river left and river right.

5. Proceed to the bankfull height at river right bank and take one reading facing the bank.

6. If for some reason a reading cannot be taken, indicate it in your field notebook.

RIPARIAN VEGETATION AND STRUCTURE PROCEDURE

1. Begin with transect "A". Facing the bank, estimate a 5 m distance upstream and downstream from the transect (10 m total length). Estimate a distance of 10 m back into the riparian vegetation from the bankfull stage. Within this 10 m X 10 m square, visually divide the riparian

vegetation into three vertical layers: a canopy layer (>5 m high), an understory (0.5 to 5 m high), and a ground cover layer (<0.5 m high). Dead vegetation is counted within all three categories.

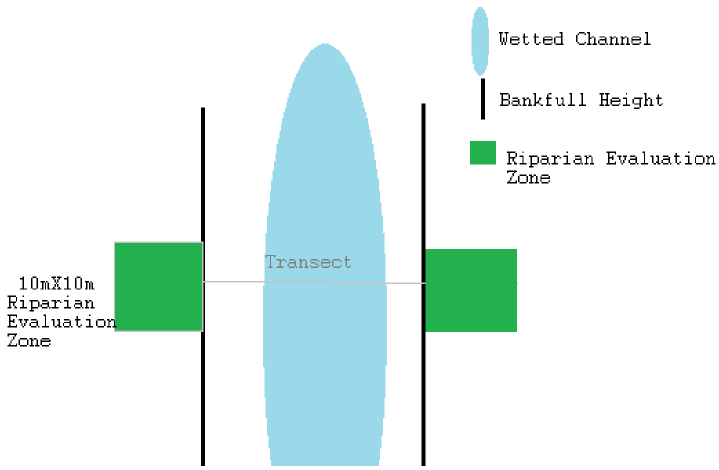

Figure 9: Riparian Structure Zone

2. **Canopy Layer:** Determine and record the dominant vegetation type for the canopy layer as Deciduous (D), Coniferous (C), Broadleaf Evergreen (E), Mixed (M) or None (N). Consider the layer mixed if two or more vegetation types are present. Broadleaf Evergreen species are not common in our area, but are occasionally encountered. An example of a broadleaf evergreen is manzanita which is an evergreen shrub that retains its leaves through the winter.

3. Determine and record separately the aerial cover class of 1) large trees (>0.3 m diameter at breast height [DBH]) and 2) small trees (<.3 m DBH). Estimate the percent aerial cover as the amount of shadow that would be cast on the ground below it by a particular layer alone if the sun were directly overhead.

   Cover class codes:

   0 = Absent: Zero Cover
   1 = Sparse: <10%
   2 = Moderate: 10 – 40%
   3 = Heavy: 40 – 75%
   4 = Very Heavy: >75%

4. **Understory Layer:**   Determine and record the dominant vegetation type for the understory layer as done for the canopy layer. Determine the aerial cover class separately for 1) woody shrubs and seedlings (including canopy tree stems), and 2) non-woody herbs, forbs, and grasses. Total coverage does not need to equal 100% as open spaces are typically present.

5. **Ground Cover Layer:** Determine the cover class for 1) woody shrubs and seedlings, 2) non-woody vegetation, 3) large woody debris, and 4) bare ground or duff. Unlike canopy and understory layers, the four ground cover category rankings should add to at least 100% as ground cover will include non-vegetated spaces.

6. Repeat steps 1 through 5 for the right bank.

7. Repeat steps 1 through 6 for all main cross-section transects (sub-transects are not included).

SECTION 7: METHOD FOR MEASURING HUMAN INFLUENCE

PURPOSE

Document the presence and proximity of various important types of human land use activities in the stream riparian area to be used in combination with mapped watershed land use information to assess the potential degree of disturbance of the sample stream reach.

PROCEDURE

1. At each main transect ("A" – "K"), document the presence / absence of the following categories of human influence.

    a) Walls / dikes / revetments / riprap / dam
    b) Buildings
    c) River access site
    d) Pavement / roads / railroads
    e) Pipes (inlet / outlet)
    f) Garbage pile
    g) Cleared lot / lawns
    h) Orchard / row crops
    i) Pasture / range / hay fields
    j) Logging operations
    k) Mining activities
    l) Fence
    m) Diversion structure

2. **Diversion Structures:** A diversion is any structure or mechanical device removing water from the stream. Record the type of diversion and record whether or not the diversion is screened.

    1. Pump (is the intake screened?)
    2. Rock Dam
    3. Concrete Dam
    4. Head Gate
    5. Ditch
    6. Other (Describe)

3. Observations for human influence and diversions are confined to the stream and riparian area within 5 m upstream and 5 m downstream from each cross section transect. Document human activities and their proximity to the stream channel separately for the left and right sides of the channel. Determine proximity according to whether the activity is within the channel or its margin, within the 10 m X 10 m riparian plot or farther than 10 m from the bank. Record the proximity using the codes:

   0 = not present, B = on the bank, C = present within 10 meters, or P = present between 10 and 30 meters.

SECTION 8. METHOD FOR CHARACTERIZING STREAM MORPHOLOGY AND IN-STREAM HABITAT (Thalweg Profile)

THALWEG PROFILE

Protocol adapted from; Peck et al. (unpubl.), Table 7-3; Kauffman et al. 1999

PURPOSE

The Thalweg profile can detect morphological changes associated with habitat restoration projects designed to improve pool-riffle relationships as well as natural changes as a result of environmental conditions. The Thalweg profile can also detect velocity changes and geomorphic structure conducive to predation cover and holding habitat for salmonids during various life stages. The Thalweg profile is a longitudinal survey of depth, habitat class, and off-channel habitat at 100 equally spaced intervals, or stations, along the Thalweg. The Thalweg refers to the flow path of the deepest water in a stream channel.

PROCEDURE

1. Determine the interval distance between measurement stations by dividing the reach length by 100 (Example: a 170 meter reach/100 = 1.7 meter distance between Thalweg measurements).

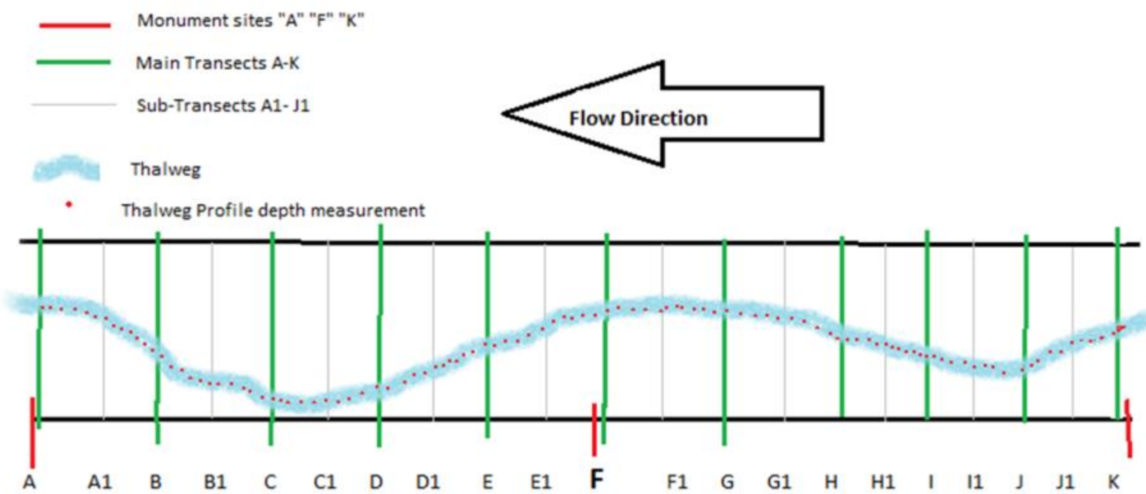

Figure 10: Thalweg Profile

2. Begin at Transect "K" (upstream monument site). In wadeable streams, use the stadia rod to measure the Thalweg depth at each distance interval. In non-wadeable streams, use a depth finder. Work downstream until ten Thalweg Profile depth measurements have been recorded. If correctly executed, the last measurement should be recorded with the established distance interval remaining between the last measurement and the next transect. Continue measurements for the entire reach. In the mainstem Okanogan River, when a raft is necessary, the following technique is useful. Mark a rope with meters and tenths of meters, tying one end to the raft and the other end to netting from a basketball net. Fill the net with rocks to use as an anchor. Let the raft move down the Thalweg the appropriate distance interval, pausing to take each measurement.

3. Determine the habitat type for each Thalweg distance interval. Habitat type codes:

   G=Glide
   SCR=Small Cobble/Gravel Riffle
   LCR=Large Cobble/Boulder Riffle
   P=Primary Pool
   PT=Poot Tailout
   BP=Beaver Pond
   RA=Rapid
   DR=Dry
   CA/FA=Cascade or Falls

   For dry and intermittent streams where no water is in the channel, record habitat type as dry channel. For primary pools, determine if the station is in the pool or pool tailout (the ascending portion of the pool to the pool crest) and enter the appropriate code. For a pool to be counted it must: 1) occur within the channel Thalweg 2) be wider than one half the wetted width, and 3) have a maximum depth equal to or greater than 1.5 times the crest depth. Glides can seem similar to pools in that they are often slow water areas but glides have consistent depths while pools will have a defined deep spot and tailout. Glides will always be longer than they are wide while with pools this may not necessarily be true. Record riffles as either Large Cobble/Boulder or Small Cobble/Gravel based upon the dominant substrate present (see substrate classifications in Section 5). Beaver ponds should include the entire area affected by the beaver pond from the upstream dam face to the end of inundation impacts. Rapids are whitewater areas without defined vertical drops - if vertical drops exist then these areas would be classified as falls/cascades. Specific definitions of habitat types can be found in the Definitions Section.

4. Indicate the presence of a side channel at the station's cross-section. See Section 3 for Side Channel methods.

5. Indicate the presence of quiet, off-channel aquatic habitats; including backwaters, sloughs, alcoves, oxbows, and backwater ponds or pools in the "BACKWATER" section of the Yuma.

SECTION 9: METHOD FOR MEASURING LARGE WOODY DEBRIS (LWD)

PURPOSE

Tally all large woody debris (LWD) pieces within the reach that are within the baseflow channel (the active channel) or that span the active channel but are outside the bankfull channel (active channel is defined as the area that is wetted under ordinary baseflow, and is denoted by the boundary of terrestrial vegetation). LWD is tallied over the entire length of the reach.

PROCEDURE

1. Scan the stream segment between the two transects when Thalweg profile measurements are being made.

2. Tally all LWD pieces within the segment that are at least partially within the active channel. Large Woody Debris is defined as wood that is at least 1 m in length and 10 cm in diameter (large end).

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

    - >0.1 m(4 in) large end diameter and >1 m(3.28 ft) long
    - >0.1 m(4 in) large end diameter and >2 m (6.56 ft) long

When counting LWD:

a) Wood that is embedded within the stream bank is counted only if the exposed portion meets the length and width requirements.
b) Do not count a piece if only the roots (but not the stem/bole) extend within the active channel.

c) Some pieces crack or break when they fall. Count the entire length of the piece when the two pieces are still connected at any point along the break, and only the portion within the active channel when they are no longer connected.
d) When determining lengths, consider only the length of the main stem and not branches or roots. If roots are still connected, begin measurements where the roots attach to the base of the stem.
e) Trees that are alive but leaning into the active channel are not to be counted
f) Count dead trees that span the channel but may not be in the channel.
g) If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with a complete circular cross section.

4. Make note of whether the LWD in a reach segment exists singly or is part of a log jam. Photo document log jams, using a story board to label the reach segment, site I.D. and date of photograph.

Omak Creek
Site 399
Transect "J"
2011

Figure 11: Log Jam Photo Storyboard Example

SECTION 10: METHOD FOR MEASURING GRADIENT

PURPOSE

Surface gradient is used to model stream reach physical processes such as bed load movement.

PROCEDURE

1. The vinyl tubing used for gradient should be free of hard water stains that make water level measurements difficult to see. Replace the tubing if it cannot be cleaned. The length of vinyl tubing must be longer than the site's average bankfull width. Mark the site's average bankfull width on the tubing with a sharpie. The gradient measurement must be made with

the upstream end held at the center of the channel/transect where the current is represented and the sharpie marked end at the center of the downstream transect.

2. Starting at transect "K", stretch vinyl tubing so that it extends to the downstream sub-transect, "J1." Fill the tubing from the upstream end with the bucket and funnel. To ensure that all air bubbles are removed from the system, hold the tubing taut while filling. When the tubing is filled and all air bubbles removed, the upstream technician holds the tube opening in the shape of a "U" so that the opening points downstream and is submerged. The length of the tubing will rest at or just below the surface of the water.

3. The downstream technician raises their end of the tubing straight out of the water at the lower transect. The rise of the water column in the tubing will be level with the upstream end of the tubing. Measure from the water's surface to the height of the vertical rise of water in the tubing to the 0.1 of a centimeter. One gradient measurement is made between each transect and subtransect.

GRADIENT CALCULATION **Rise ÷ Run x 100 = % grade**

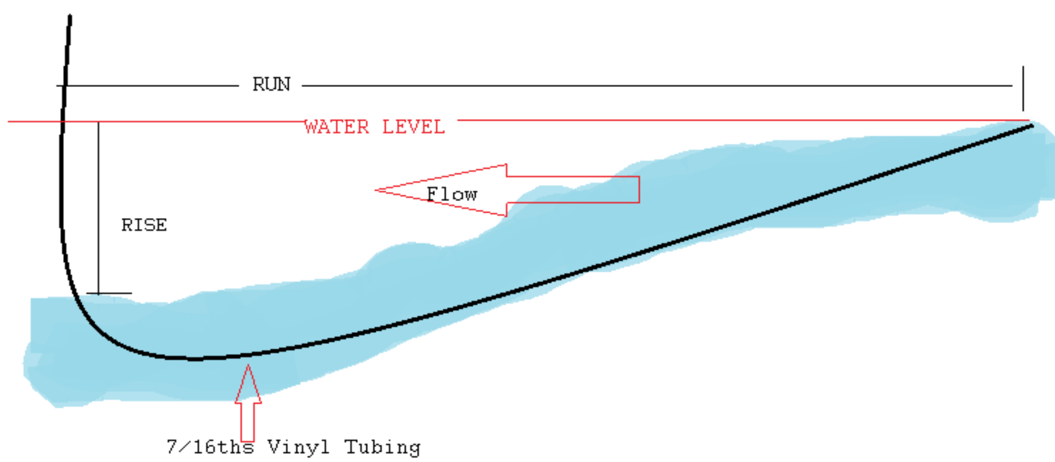

Figure 12: Measuring Gradient

SECTION 11: METHOD FOR PHOTO DOCUMENTATION

PURPOSE

Create an historical photo archive of the habitat site.

PROCEDURE

1. A total of four photos are required. At transect "A", photograph the site facing upstream. At transect "F", photograph the site facing upstream and downstream. At transect "K", photograph the site facing downstream. Photographs should be taken from the center of the stream at each transect, position yourself by walking perpendicular from the monument stake to the center of the stream. Place the storyboard so that it is clearly visible in the

photo and is labeled with the stream name, site ID, date, transect letter, and upstream or downstream aspect of the photo.

2. In addition to the required photo documentation, properly labeled photos documenting any new or unique feature of the reach are encouraged.

3. Photo document any logjams in the reach (See section 9).

QUALITY ASSURANCE / QUALITY CONTROL

Data quality control is maintained daily by the crew members as they collect data by ensuring the metrics are taken carefully and recorded accurately. A field biologist supervises the crew at each site and participates in data collection. The crew supervisor maintains quality assurance by selecting random sites to re-visit and verify data collected. If the crew supervisor discovers unacceptable differences between original visit and re-visited data sets, the entire habitat survey or questionable portions may need to be repeated.

DATA MANAGEMENT

Site ID information is uploaded into the Yuma prior to heading out into the field. At the end of the work week, or as often as possible, the Yuma will be connected to office computer and multiple site's data is downloaded onto the office computer's hard drive. Making a backup copy of the data files is recommended. The data is then imported into the OBMEP database.

DEFINITION OF TERMS

Active Channel

(1) Short term geomorphic feature, defined by the bank break, which marks a change to permanent vegetation. (2) The portion of a channel in which flows occur frequently enough to keep vegetation from becoming established. An active channel is formed and maintained by normal water and sediment processes (Armantrout 1998). The active channel is the channel area wetted under ordinary baseflow conditions. This is usually denoted by the start of terrestrial vegetation (Williams and Thom 2001, Nightengale and Simenstad 2001, Konar 1998).

Backwater

(1) Water backed up or retarded in its course compared with its normal or natural condition or flow. (2) A naturally or artificially formed arm or area of standing or slow moving water partially isolated from the flow of the main channel of a river. (3) Seasonal or permanent water bodies found in the lowest parts of floodplains, tpically circular or oval in shape (Armantrout 1998).

Backwater Pools

Backwater pools are habitat units located along the channel margins but are otherwise enclosed – though still connected to the main channel (or side channel). Backwater pools as defined here include "alcoves" as described by Nickleson et al. (1992) (2) A pool type formed by an eddy along channel margins downstream from obstructions such as bars, rootwads or boulders, or resulting from an obstruction blockage (Berkley.edu 2004).

Bankfull Height

The bankfull height can be identified through examination of the reach for the following indicators as described below. Note that all six indicators are rarely present at an individual site.

* Examine stream banks for an active floodplain. This is a relatively flat, depositional area that is commonly vegetated and above the current water level.

* Examine depositional features such as point bars. The highest elevation of a point bar usually indicates the lowest possible elevation for a bankfull stage. However, depositional features can form both above and below the bankfull elevation when unusual flows occur during years preceding the survey. Large floods can form bars that extend above bankfull whereas several years of low flows can result in bars forming below bankfull elevation.

* A break in slope of the banks and/or change in the particle size distribution from coarser bed load particles to finer particles deposited during bank overflow conditions.

* A defined elevation where mature key riparian woody vegetation exists. The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.

* Examine the ceiling of undercut banks. This elevation is normally below the bankfull elevation.

* Stream channels actively attempt to reform bankfull features such as floodplains after shifts or down cutting in the channel. Be careful not to confuse old floodplains and terraces with the present indicators (AREMP 2004).

Bankfull Width

Channel width between the tops of the most pronounced banks on either side of a stream reach (Armantrout 1998). Defined as the high streamflow event occurring every 1.5 years on average.

Bar

A submerged or exposed ridge-like accumulation of sand, gravel, or other alluvial material formed in the channel, along the banks, or at the mouth of a stream where a decrease in velocity induces deposition (Armantrout 1998).

Beaver pond

Ponds containing water impounded by a dam built by a beaver (Armantrout 1998).

Braided Stream

A complex tangle of converging stream channels separated by sand bars or islands. Characteristic of floodplains where the amount of debris is large in relation to the discharge (Streamnet 2004)

Canopy Cover

Percentage of ground or water covered by shade from the outermost perimeter or natural spread of foliage from plants. Small openings within the canopy are excluded if the sky is visible through them. Total canopy coverage may exceed 100% due to the layering of different vegetation strata such as understory and groundcover (Armantrout 1998).

Cascade

(1) Highly turbulent series of short falls and small scour basins with very rapid water movement as it passes over a steep channel bottom with gradients exceeding 8%. Most of the water surface is broken by short, irregular plunges creating white water, frequently characterized by very large substrate, and a well-defined stepped longitudinal profile that exceeds 50% in supercritical flows (Armantrout 1998). (2) Water movement is rapid and very turbulent over steep channel bottom. Most of the water surface broken in short irregular plunges, mostly whitewater (Kaufman et al. 1999). (3) A habitat type characterized by swift current, exposed rocks and boulders, high gradient and considerable turbulence and surface agitation, and consisting of a stepped series of drops (AFS 1985). See definition of Waterfall for how to treat Cascades in the field.

Clay

Substrate particles that are smaller than silt and generally less than 0.004 mm in diameter (Streamnet 2004).

Cobble

Substrate particles that are smaller than boulders and are generally 64-246 mm in diameter. Can be further classified as small and large cobble. Commonly used by salmon in the construction of a redd (Streamnet 2004).

Confluence

(1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams (Streamnet 2004).

Dam

A concrete or earthen barrier constructed across a river and designed to control water flow or create a reservoir (Stramnet 2004).

Dike

(1) (Engineering) an embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands, a levee (Streamnet 2004). (2) A tabular body of igneous rock that cuts across the structure of adjacent rocks. (3) A massive wall or embankment built around a low – lying area to prevent flooding (Bates and Jackman 1984).

Diversion

The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system (Streamnet 2004).

Diversion dam

A barrier built to divert all or part of the water from a stream into a different course (Streamnet 2004).

Embeddedness

The extent that boulders, cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that boulders, cobble and gravel particles on the substrate surface are buried by fine sediments (Lestelle 2004).

Ephemeral Flow

Streamflows in channels that are short lived or transitory and occur from precipitation, snow melt, or short term water releases (Armantrout 1998).

Falls

(1) Free falling water with vertical or nearly vertical drops as it falls over an obstruction. Falling water is turbulent and appears white in color with trapped air bubbles (Armantrout 1998) (2) Free falling water over vertical or near vertical drop into plunge pool, water is turbulent and white over high falls (Kaufman et al. 1999).

Floodplain

The area that parallels the stream course and that is inundated by flood waters on an infrequent basis (more than every 2 years on average to once in 100 years or more). The floodplain is typically confined by topographic features and can cover the entire valley floor from terrace to terrace or only a small portion when dikes or levees are present.

Floodprone Depth

Equal to two times the bankfull depth (Rosgen 1996).

Floodprone Width

Equal to the valley width at floodprone depth (Rosgen 1996).

Geomorphology

The shape or form of a natural surface or object, also, the study of the land surface and the processes producing them (e-streams 2004).

Glides

Hawkins et al. (1993) indicates that there is a general lack of consensus regarding the definition of glides, despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The ODFW habitat survey manual (Moore et al. 1999) defines a glide as an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity (Lestelle 2004). Glides generally appear as low turbulent moving water with a smooth, unbroken surface (Kaufman et al. 1999).

Gradient

Average change in vertical elevation per unit of horizontal distance (e-streams 2004).

Intermittent Flow

Flows that occur at certain times of the year only when groundwater levels are adequate but may cease entirely in low water years or be reduced to a series of separate pools (Armantrout 1998).

Island

Islands are defined as surrounded by water and containing permanent vegetation. Islands are channel features that are as high or higher than the bankfull flow height. Islands are dry during bankfull flows.

Large Woody Debris (LWD)

LWD is defined here as non-living woody material with small end diameter of at least 10 cm (4 in), and length of at least 1.5 m (5 ft) (Kaufman et al. 1999).

Mid-Channel Bar

Bar formed in the mid-channel zone, not extending completely across the channel. (Armantrout 1998). The highest elevation of a bar often indicates the lowest possible elevation for bankfull stage. Bars are defined as bare gravel or sand surrounded by water, inundated during higher water events to an extent that no permanent vegetation exists. Bars are stream channel features below the bankfull flow height and may be dry during summer field surveys. Bars are wet during bankfull flows.

Pool Tailout

Defined as a distinct break or "crest" in streambed slope occurring downstream from a pool (AREMP 2004).

Primary Pool

(1) Having a maximum depth equal to or greater than 1.5 times the crest depth. Pools are generally characterized by still water, low velocity, smooth, glassy surface, and deep compared to other parts of the channel (Kaufman et al. 1999). (2) AREMP (2004) further describes pool characteristics as observed under low flow conditions as follows:

***** Pools are depressions in the streambed that are concave in profile, laterally and longitudinally.
***** Pools are bounded by a head crest (upstream break in streambed slope) and a tail crest (downstream break in streambed slope).
***** Pools have a water surface gradient close to "0" and are associated with "slower" flowing water.
***** Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
***** Pools span at least 90% of the wetted channel width at any location within the pool.
***** Pool length, measured along the thalweg, is greater than its width, measured perpendicular to the thalweg, at the widest point.
***** Maximum pool depth is at least 1.5 times the pool tail depth.

Rapids

(1) Moderately steep stream area (4-8% gradient) with supercritical flow between 15% and 50%, rapid and turbulent water movement, surface with intermittent whitewater, with breaking waves, coarse substrate, with exposed boulders at low flows and a planar longitudinal profile (Armantrout 1998). (2) Water movement rapid and turbulent, surface with intermittent whitewater with breaking waves (Kaufman et al. 1999).

Revetment

A sloped face built to protect existing land or newly created embankments against erosion or wave action, currents, or weather. Revetments are usually placed parallel to the natural shoreline (e-streams 2004)

Riffle

(1) Shallow reaches with low sub-critical flow (1-4% gradient) in alluvial channels of finer particles that are unstable, characterized by small hydraulic jumps over rough bed material, causing small ripples, waves and eddies without breaking the surface tension. Stable riffles are important in maintaining the water level in the pool immediately upstream of the pool (Armantrout 1998). (2) Riffles can be generally characterized by moving water with small ripples, waves and eddies – waves not breaking, surface tension not broken (Kaufman et al. 1999).

Rip Rap

Boulders or rubble used to construct a jetty or revetment (California Coastal Comm. 1987).

Riparian Vegetation

Vegetation that is growing on or near the banks of a stream that is more dependent on water than vegetation that is found further upslope (Armantrout 1998).

Run

An area of swiftly flowing water without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach (AFS 1985). Runs are considered to be part of the glide designation for this program.

Sediment

Fine grained material and organic material in suspension, in transition or deposited by air, water, or ice on the earth's surface (California Coastal Comm. 1987).

Side Channel

A side or secondary channel is any channel separated directly from the main channel at the upstream end by an island/bar with an elevation above bankfull. There must be clearly defined bankfull indicators at some point along the side channel (AREMP 2004).

Substrate

Mineral and organic material forming the bottom of a waterway (Armantrout 1998).

Thalweg

Path of a stream that follows the deepest part of the channel (Armantrout 1998).

Thalweg Depth

Vertical distance from the water surface to the deepest point of a channel cross-section (Armantrout 1998).

Waterfall

Waterfalls and cascades present potential barriers to anadromous fish migration. Therefore, baseline data should be collected in the field when these habitats are encountered to allow managers to determine if an additional full barrier assessment is warranted (for full barrier assessment protocols see WDFW 2000). Note that waterfalls with a vertical drop exceeding 3.7 meters or cascades with a gradient exceeding 20% (16% in streams with bankfull widths less than 0.9 meters) for 160 meters or more are considered to be complete blockages to anadromous salmonids (WDFW 2000).
If a waterfall or cascades is present, measure and record the following information:

Waterfalls: Measure the vertical drop from water surface to water surface to the nearest 0.1 meter using a stadia rod placed vertically at the base of the falls. Measure the horizontal length from the base of the falls from this stadia rod to the crest of the falls using a second stadia rod. Record in the appropriate section of the field form.

Cascades: Measure the length of the cascade (up to a maximum of 160 meters) and record the length in meters. The entire length of cascades (up to 160 meters) should be measured even if the cascades extends outside of the sampling reach. Convert this measurement to centimeters by multiplying by 100 and record in the appropriate section of the field form. Position one person at the upstream end and one person at the downstream end of the cascade (or at 0 and 160 meters for cascades 160 meters or more) and determine the elevation change in centimeters. This will require the use of an Abney hand level and two stadia rods. Each person will stand on the same bank and will position their respective stadia rods at the water surface along the wetted edge. The person upstream will hold the Abney hand level against the stadia rod and backsite to the stadia rod downstream after noting the elevation of the hand level in centimeters above the water surface. The person at the downstream end will assist the person upstream by moving a finger up and down the stadia rod until the person upstream indicates level. The person downstream will then note the elevation at level (location of his/her finger along the stadia rod). Note: A laser level or laser range finder can measure both gradient and length much more easily but requires following the appropriate methods for the equipment being used.

For long cascades where single line of sight measurements cannot be made, break the cascade into measurable length increments and measure respective elevation changes for each increment. Record both the increment length with each corresponding change in elevation (i.e., 62cm X 30meters, 127cm X 25meters, etc.).

To calculate the percent slope, subtract the upstream elevation of the Abney hand level (centimeters) from the downstream elevation at level (centimeters) and divide by the length of the cascade (centimeters). Note: These calculations may not be necessary if using laser levels or rangefinders.

Wetted Width

Width of water surface measured perpendicular to the direction of flow at a specific discharge. Widths of multiple channels are summed to represent the total wetted width (Armantrout 1998).

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