Coastal Watershed Planning and Assessment Program

California Department of Fish and Game (CDFG)

Stream Channel Measurement Methods for Core Attributes

Introduction:

The Coastal Watershed Planning and Assessment Program (CWPAP) was formed in 2003 within the California Department of Fish and Game (CDFG) by executive order. The fishery based program conducts multi-disciplinary large scale watershed assessments. All California watersheds draining directly to the Pacific Ocean are included. The central valley basins (Sacramento and San Joaquin rivers) are not included. Focus is currently placed on basins that support at risk populations of salmon and steelhead, in particular coho salmon and southern steelhead.

The program's goal is to determine the extent and quality of supportive conditions for salmon and steelhead and help determine ways to improve those conditions. The program also investigates the condition and trends in the watershed delivery processes that largely determine the riparian and instream fishery conditions. This approach uses so-called land use "disturbance indicators" and attempts to provide a realistic context for riparian, channel and stream habitat conditions in the subject area. Salmonid population data are also collected and assessed since these fish are sensitive to water quantity and quality, stream/floodplain connectivity, macroinvertebrate production, stream habitat diversity and complexity including estuarine conditions, and aquatic / riparian functionality. This combination of fishery, stream habitat, channel, and watershed condition analysis is used to estimate the overall physical "health" of the watershed or region.

Assessment products provide science based recommendations for fish, stream, and watershed improvement activities that will better protect and recover watershed processes and conditions for beneficial use. These recommendations are determined by the current status of the basin relative to known historic or target reference conditions and processes. The channel condition and habitat status is established by using standard assessment methods to measure core attributes. These core attributes and methods have been adopted in part from collaboration with other members of the Pacific Northwest Aquatic Monitoring Partnership and are becoming widespread as standards in the northwest of the United States (PNAMP, 2005). These methods lend themselves to form base-line information that can be useful to monitor change in the assessed watersheds.

The Aquatic and Riparian Effectiveness Monitoring Program (AREMP) has adopted a suite of core attributes that are described in the literature as being important in defining physical habitat conditions and their relationship with aquatic species. The AREMP *2005 Field Protocol Manual* describes the minimum number of measurements, the frequency of measurements, and the locations to make measurements to ensure consistent data collection efforts (Gallo et al 2005). The actual measurement tools and the techniques for using them are left to the discretion of each data collection program utilizing these protocols. The AREMP manual notes that collecting additional data (taking more measurements) as needed by a program to meet their specific objectives is not affected by the use of these protocols, but should be managed as separate data.

CWPAP would like to join the AREMP and PIBO programs and thank the following authors and acknowledge the original citations for each method, while recognizing that numerous modification have been made (Gallo et al. 2005).

Most of the fundamental stream measurement protocols used by CWPAP are found in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1997), Parts Two and Three. They include Channel Typing (Rosgen 1996), Habitat Typing (McCain et al. 1993), and LWD/Riparian (Downie et al.) protocols. CDFG has used these protocols for many years to conduct reconnaissance surveys for diagnostic and prescriptive surveys.

In 2002 – 04, CWPAP added the Generalized Random Tessellation Sample (GRTS) selection system to create larger scale fractional samples to evaluate and characterize more general conditions in the assessment basins, and augment the extant survey program. The Environmental Protection Agency EMAP lab in Corvallis, OR collaborated with CWPAP and provided us with GRTS site selections in Redwood Creek, Outlet Creek, and the SF Eel River. This also provides a potential basis for a proposed California coastal monitoring program. CWPAP also relied upon the attributes and protocols used by AREMP / PIBO *Stream Channel Methods for Core Attributes*, *2005* as a basis for the pilot random sample project (Gallo et al. 2003, 2005). Like AREMP, we also utilized the literature to determine core attributes and their measurements:

- Harrelson et al. (1994) - Reach layout, bankfull elevation, gradient, and sinuosity.
- Wolman (1954) and Lazorchak et al. (1998) - Streambed particle counts
- Bauer and Burton (1993) and USFS R5 SCI Guidebook (1998) – Pool tail fines
- Kershner et al. (2004) - Defining habitat units
- Lisle (1987) - Residual pool depths
- Hawkins et al. (2003) - Macroinvertebrates
- Moore et al. (2002) and Hankin and Reeves (1988) – Large wood

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CWPAP Stream Measurement Methods

Sample reach selection:

A topographic map of each assessment study area will be supplied with a GIS layer of 50 initial Generalized Random Tessellation Sample (GRTS) Panel One candidate sample sites. The GIS layer will also display several hundred Panel Two over-sample sites. In the lab, select and evaluate Panel One survey sites in numerical order, omitting sites from the sample frame due to:

1. The site is above the established limits of anadromous salmon and steelhead, or is above established gradient / distance standards as portrayed in a GIS model;
2. The GPS point is located in a lake, wetland, marsh or on a dam or glacier;
3. The site is located on an artificial stream, culvert, or irrigation canal;
4. The site is dry during summer flow periods;
5. The site is known to be not safely accessible; i.e. it cannot be reached without putting the crew in danger. Long hikes into steep canyons do not qualify;
6. The stream is too small or cannot be physically sampled. The minimum stream size is 1 meter wide (wetted width) and 0.1 meters deep in riffles;
7. The stream is too large to physically sample and is a safety concern for crews. To qualify, the stream is too swift to safely wade across and/or too deep to gather substrate information or differentiate between habitat types;
8. Travel time (round trip) from camp is over four hours to get to and from the site;
9. Lack of current private property access permission.

Use the GRTS database of all the randomly selected sample sites to replace omitted Panel One sites with Panel Two sites in descending order until the sample frame is populated with the targeted number of sample sites in the assessment study design (e.g., 50). Additional site changes will be made in like manner as needed by a field reconnaissance crew. Based on the criteria above, this crew will be responsible for field verification that a site can be surveyed based on location, condition and access. Additionally, a sample crew leader retains the authority at any time to exclude a site if he/she feels it is unsafe.

During access development, reconnaissance crews contact local, residential landowners and inquire about the stream flow related to the candidate sample reach and the best way to physically access the sample site. The team must simply scout access routes when landowners cannot help.

Field determination of sample reaches:

In the case of a repeat survey, or a survey with a pre-determined start point, a reconnaissance crew will simply locate a sample reach's previously monumented start point, or its pre-set Transect "A" flag to identify the start point of the sample reach. If the original transect or its monument is no longer located on a velocity cross-over due to channel migration, etc., the crew will proceed upstream to the first suitable site and re-establish Transect A as described below.

In the case of an initial visit to the site, the crew will use a USGS 7.5 minute topographic map and GPS receiver to determine the location of the candidate sample reach's start. Use the GPS "Go To" feature to find the selected waypoint's latitude and longitude coordinates. That waypoint will be used to determine the downstream end of the candidate sample reach site. If the GPS receiver indicates the waypoint is tangential to the stream channel, continue along the channel, watching both the distance from the site and its angle to the GPS receiver. The goal is to find the location on the stream that is the shortest distance from the GPS waypoint. This will become the "X" point and will be used to determine the candidate sample reach's most downstream transect.

CWPAP GRTS surveys start and stop at velocity cross-overs (i.e., riffle crests, or pool tail crests). Thus, the candidate reach start point is the first velocity cross-over upstream of the X point. The reach end point is the first velocity cross-over that occurs upstream of the distance selected from the minimum reach sample length table (Table 1). The first encountered velocity cross-over will become Transect "A" of the candidate sample reach, and will be used as such if the reach proves to be suitable as determined by accessibility, safety, flow, and channel attributes (see list above).

<u>Reach and cross section determination and measurement</u>:

- Monument Transect A and temporarily assign it a GRTS site number;
- Proceed upstream measuring the thalweg distance and inspect for suitability considering the criteria listed above;
- Measure the bankfull discharge widths (BFD) at Transect A and the next four upstream velocity cross-over sites encountered;
- Sum and average the BFD from the five sites;
- Use the mean width and Table 1 to determine the minimum reach length;
- Continue upstream along the thalweg and proceed from the minimum reach length end point distance to the first velocity cross-over;
- If the reach is deemed suitable, monument this as Transect E, the upper end of the sample reach, assign the GRTS sample number to the reach, and conduct Rosgen channel typing;
- Rosgen channel typing will also be conducted at Transect A, and at the velocity cross-over <u>nearest</u> the reach mid-point (Transect C), and at velocity cross-overs <u>nearest</u> the mid-points between Transects A and C, and Transects C and E.; these will be transects B and D, respectively. This method provides for a total of five nearly equidistant cross section locations;
- At Transect A, identify a nearby "permanent" reference point like a tributary confluence, bridge, etc., and record the distance and direction from the reference point to Transect A ;
- Describe, photograph, map and GPS all transects, monuments, and reference points.

Table 1. Reach sample length based on bankfull width categories

Mean Bankfull Width		Minimum Reach Length		
Meters	feet	Width Category (m)	meters	feet
≤ 8	≤ 26	8	160	520
8.1 – 10	26.1 – 33	10	200	660
10.1 – 12	33.1 – 39	12	240	790
12.1 – 14	39.1 – 46	14	280	920
14.1 – 16	46.1 – 52	16	320	1050
16.1 – 18	52.1 – 59	18	360	1180
18.1 – 20	59.1 – 65	20	400	1320
20.1 – 22	65.1 – 72	22	440	1440
≥ 22.1	≥ 72.1	24	480	1570

The minimum reach length is defined for each width category and is equal to twenty times the mean bankfull width category expressed in meters.

Monument and document reach location (AREMP, CDFG)

The location of Transect A must be monumented with reference points and bench marks for long term use as a monitoring reach site. Tributary confluences and named natural topographic features are the most permanent fixtures in the stream network, and as such are the preferred reference points. Bridges, access roads, diversions, large pump installations, etc. are useful as well, but are not necessarily fixtures on the landscape. Laser or tape measurement from a natural fixture like a tributary confluence to the location of Transect A will enable crews to locate the reach in the future, even in the event of the velocity cross over migrating along the channel length. If that should be the case, repeat crews shall begin at the velocity cross-over nearest the measured distance and go through the procedures outlined above to establish and measure the reach. Refer to AREMP's 2005 Field Protocol Manual (Gallo, et al. 2005), and CDFG *Documenting Salmonid Habitat Restoration Project* Locations (Gerstein et al. 2005) for location techniques and recording forms.

Photo documentation (AREMP, CDFG)

Information about each site will be documented in photographs and on the data sheets. Photographs will be taken at Transect A of each sample site. In addition, photographs should be taken of rare or unique features in sample reach, including culverts, logjams, beaver dams, or vertebrates that are difficult to identify. Take photos that will help give those people who might never visit the area an idea of what it is like. These photos should help show the condition of the areas sampled, species captured at each site, land disturbances, etc. For photo methods and recording forms refer to CDFG *Photographic Monitoring of Salmonid Habitat Restoration Projects* (Gerstein et al. 2005).

Core Channel Attributes for Measurement

- Flow
- Water Temperature
- Conductivity
- Gradient
- Rosgen Channel Type at Velocity Cross-over
    - Bank Full Discharge Width
    - Bank Full Discharge Depth
    - Pebble Counts
- Pool Frequency at CDFG Level Two Habitat Typing
- Maximum Pool Depth*
- Depth at Pool Tail Crest*
- Cobble Embeddedness at Pool Tail Crest
- Percent fines < 2mm at Pool Tail Crest
- Stream Shade Canopy
- Large Wood Debris Presence
- Large Woody Debris and trees within 50' of Floodplain

*** Necessary to calculate maximum residual pool depth**

Measurement Protocols

Flow (CDFG; AREMP)

Unless gage information is available, discharge should be measured at Transect A if suitable for a sample. If Transect A is unsuitable for a flow measurement, sample the nearest suitable site downstream from A unless a tributary joins the stream. If so, use the nearest suitable upstream site. A good site for measuring discharge with the flow meter should have even flow (laminar flow) across the channel, have no eddies on the sides, and be free of large rocks or woody roughness elements. Check near pool tail crests and low gradient riffles for areas with undisturbed flow. Runs and glides often are good sites with laminar flow and sufficient depth for good measurement. Measurements should not be conducted in the middle of a pool. It is permissible to go outside the sample reach to get a good site, however do not go more than 70' from the beginning or end of the reach, and do not sample near a tributary junction. If a tributary joins the creek within the sample site, take the measurement below the junction. Prior to starting the measurements, move rocks or obstructions as necessary to get a clear area to measure. A flume configuration can be built by smoothing the bottom and squaring the channel sides with rocks, sand, or vertical, plastic wing deflectors if necessary. However do not move objects once you have begun taking measurements.

Water Temperature

Thermograph placement (AREMP / CWPAP)

- Temperature data are collected from approximately June 1 through October 1 of an individual calendar year;
- Thermographs must be programmed and calibrated prior to field placement;
- Sample sites occur in fish-bearing tributary streams just above their confluences with larger, receiving streams;
- Sample sites also occur at channel type changes (Rosgen, 1996);
- Thermographs should be placed in the thalweg, in mixed flow, and located where they will remain underwater through the sample period;
- Secure the thermograph with cable to a reliable anchor point and cover with rocks;
- Document the site location with GPS coordinates, photos, and monument clearly with stakes and flagging except in high use areas.

Water quality (AREMP)

Measure conductivity and DO at the upstream end of each reach using a hand held conductivity/DO meter. Measure immediately after transects are laid out and upstream of the last transect flag to insure that the channel sediment has not been disturbed. Take the reading in flowing water, near the center of the channel.

Gradient

Water surface gradient will be measured from Transect A to Transect E.

Channel type (Rosgen 1996 as in Flosi et al. 1998)

Channel typing will be conducted at all five transects. If a channel type change or the end of anadromy is encountered within the designated sample reach, the reach should be moved either up or downstream in the direction that preserves as much of the original reach as possible. Be sure that the change meets the criteria for a new channel type before adjusting the reach end points. If a reach re-location adjustment is necessary, Transect A must be relocated to occupy the most downstream pool tail crest in the newly defined sample reach and the other transects must be relocated appropriately.

Pebble counts (CDFG / AREMP)

Substrate samples will be measured at five locations within the sample reach, transects A-E (see above), and will normally occur during Rosgen channel typing. The first measurement should be located at the left bank full elevation pin, facing downstream, of the transect tape. Divide the bankfull width by 20 to determine the sample increment along the suspended tape (e.g., BFW of 25' = 1.25' sample increment). At each sample increment and without looking, reach down to the tip of the meter stick and pick up the first substrate that you touch with the tip of your finger. Record results on the CDFG CWPAP Pebble Count Worksheet, and/or on CDFG Rosgen channel type form.

Habitat typing (CDFG: Flosi, et al. 1998)

Habitat typing will be conducted using a 100% sample for the reach and will capture information for the following habitat attributes:

- Pool Frequency at CDFG Level Two Habitat Typing
- Maximum Pool Depth
- Depth at Pool Tail Crest
- Cobble Embeddedness at Pool Tail Crest
- Stream Shade Canopy
- Large Wood Debris within BFD

Percent Surface Fines on Pool Tails (AREMP)

Objective:

Quantify the percentage of fine sediments < 2mm on the surface of pool tail substrate.

Where to take measurements:

1. Collect measurements in the first ten pools of each reach beginning at the downstream end. Exclude beaver or man-made dam pools.
2. Sample within the wetted area of the channel.
3. Take measurements at 25, 50, and 75% of the distance across the wetted channel, following the shape of the pool tail.
4. Take measurements upstream from the pool-tail crest a distance equal to 10% of the pool's length or one meter, whichever is less.
5. Locations are estimated visually.

Sampling method:

1. Assess surface fines using a 14 x 14 inch grid with 49 evenly distributed intersections. Include the top right corner of the grid and there are a total of 50 intersections.
2. Take 3 measurements per pool.
   a. Place the bottom edge of the grid upstream from the pool-tail crest a distance equal to 10% of the pool's length or one meter, whichever is less (Fig. 4).
   b. Place the center of the grid at 25, 50, and 75% of the distance across the wetted channel, making sure the grid is parallel to and following the shape of the pool-tail crest.
   c. Exclude boulders that extend above the bankfull elevation when determining the width of a pool tail and the (25, 50, 75%) placement of the fines grid (Fig. 5).
3. Record the number of intersections that are underlain with fine sediment < 2 mm in diameter at the b-axis. Place a 2 mm wide piece of electrical tape on a ruler and use this to assess the particle size at each intersection.

4. Aquatic vegetation, organic debris, roots, or wood may be covering the substrate. First attempt to identify the particle size under each intersection. If this is not possible, then record the number of non-measurable intersections.

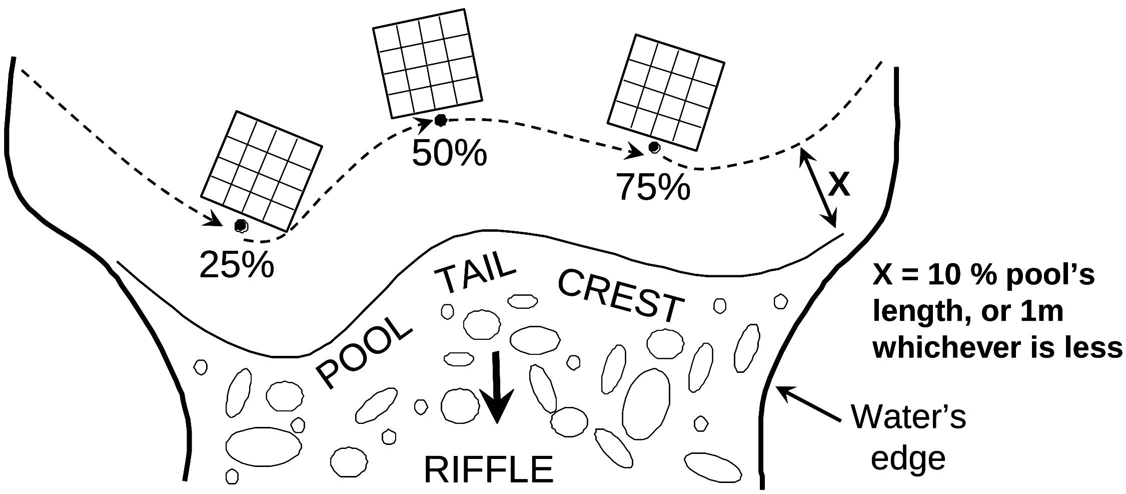

Figure 4. Location and orientation of pool tail fines grids relative to the pool tail crest

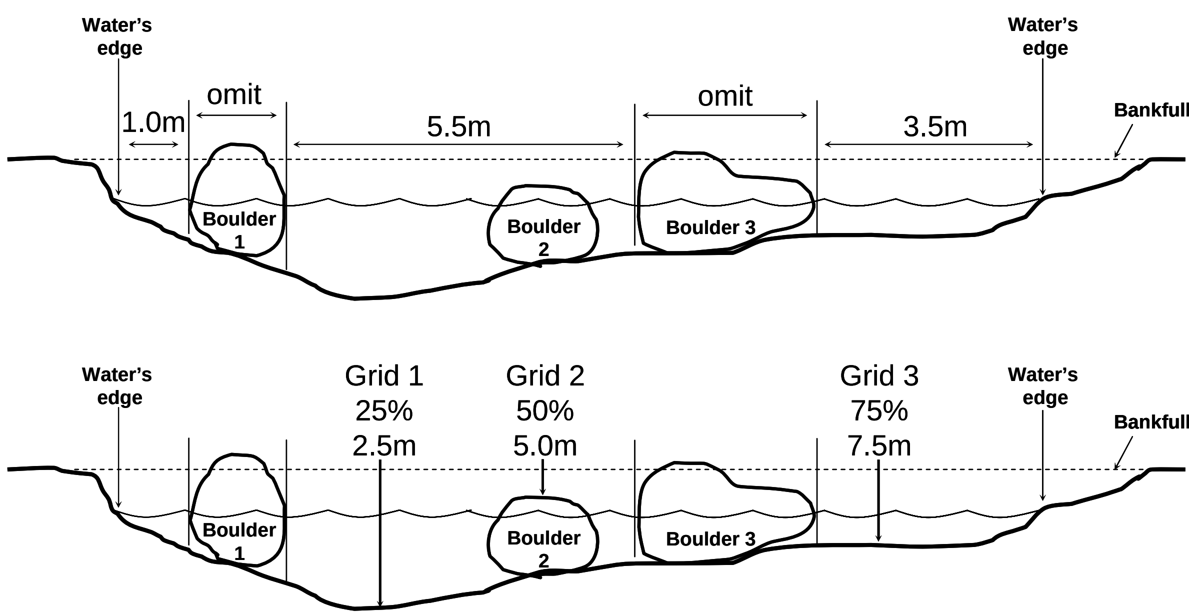

Figure 5. Cross section of pool tail and placement of fines grid. Determine wetted channel width along the pool tail. Omit boulders (and other obstructions) that extend above bankfull elevation (boulders 1 & 3). Boulder 2 extends above the water surface, but not bankfull elevation, so it is NOT omitted. In this example wetted channel width along the pool tail is 10.0m (1.0m + 5.5m + 3.5m). Place pool fines grid at 25% (2.5m), 50% (5.0m) and 75% (7.5m) of the wetted channel width, following the shape of the pool tail.

LWD/Riparian reconnaissance (CDFG: Downie, et al., in Flosi, et al. 1998)

Large wood within the BFD channel, and riparian zone large wood and trees within 50' of the floodplain will be estimated by size and condition using CDFG survey methods.

Biological Measurements

Amphibians

Record amphibian observations made during habitat typing in the comments section of the habitat typing form.

Fish

Sampling of fish within the sample reach should be coordinated with protocols adopted for the California Coastal Salmonid Monitoring Plan (CA Plan) which is in development. Appropriate fisheries parameters to collect could entail: species composition, life stage, size and condition, relative abundance (density), and percent of area (habitat units) occupied. Obtaining this could require a follow site visit.

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