Monitoring Plan
Mattole Low Flow Trend Monitoring and Mattole GRTS Stream Channel Monitoring
North Coast IRWM Implementation Grant
Mattole Integrated Water Management Program

AGREEMENT NO. 06-538-550-0

Table of Contents

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I. Introduction

This Monitoring Plan outlines the monitoring approaches used to document trends in low-flow trends and stream channel condition and to determine contract performance and success within the Mattole Integrated Coastal Watershed Management Plan (MICWMP), Water Board contract 05-229-550-0. This monitoring plan complements the Quality Assurance Project Plans for this project (Mattole Restoration Council 2007 and Sanctuary Forest Inc. 2007).

II. Pre-Project Conditions and Water Quality:

Mattole River watershed and water quality conditions have been generally well-known since early investigations such as the 1973 "Character and Uses of Rivers' study (Department of Water Resources 1973) and the 1989 "Elements of Recovery" (Mattole Restoration Council 1989). These assessments pointed to excessive sedimentation of stream channels as the primary water quality issue within the basin, and a key limiting factor to salmonid survival.

In 2003, the California Resources Agency and Cal/EPA released the *Mattole River Watershed Assessment Report* (Downie et al.), an interagency collaboration that presented a salmonid limiting factors analysis for the Mattole watershed through investigations by five agencies: North Coast Regional Water Quality Control Board (NCRWQCB), Dept. of Fish and Game, Dept. of Conservation, Dept. of Water Resources, and Dept. of Forestry and Fire Protection. The *Report* relies heavily on water quality data to determine habitat suitability for salmonids, in particular sediment-related metrics and water temperature. NCRWQCB staff member Elmer Dudik prepared the Water Quality appendix, which contains data relevant to pre-project conditions (Dudik 2002).

Dudik's report confirms that sedimentation and water temperature are the two major water quality issues within the basin. His report describes how the coldwater fisheries beneficial use (COLD) is affected by these nonpoint source pollutants in all life history phases of salmonids. Key conclusions of the report are:

(1) that water temperatures are above Basin Plan objectives, and likely impact salmonids throughout the Mattole, with the exception of the Southern sub-basin (the Mattole River headwaters region).
(2) assessment of upper reaches of most tributaries was incomplete due to access issues, but presumably more favorable habitat conditions occur in some of these reaches because they are utilized by salmonids.
(3) excessive sediment production is an important limiting factor throughout the basin.
(4) other water quality parameters (pH, specific conductance, dissolved oxygen) are likely within acceptable Basin Plan objective ranges throughout most of the basin.

In addition the report concluded that the Mattole is heavily impacted by excessive stream channel sedimentation, which affects key water quality and habitat parameters: stream temperature, aquatic habitat suitability, substrate embeddedness, riparian canopy health and composition, bank stability, lateral channel migration rates, and presence of thermally-stratified pools. (Downie et al., 2003).

The Mattole River watershed has been the focus of a twenty-five year long intensive watershed restoration effort. Much of the work, particularly in the past ten years, has focused on the improvement of aquatic habitats through sediment reduction efforts. This work occurs at discrete upslope and streambank sites, and is intended to reduce the risk of sediment delivery to fish-bearing watercourses. In the past ten years, the Mattole Restoration Council has implemented treatments in approximately 45% of the watershed, completing road decommissioning, streambank stabilization, and road stormproofing at several hundred work sites.

At the same time as this work has been accomplished, natural watershed recovery has improved conditions dramatically. The *Mattole River Watershed Assessment Report* (Downie et al., 2003) documented significant geomorphic improvements in all areas of the watershed. These included decreases in the total length of stream channel affected by an inter-related set of "mapped negative channel characteristics:" displaced riparian vegetation, braided channels, wide channels, and subsurface flows. Between sediment reduction activities and natural channel recovery, significant geomorphic changes are occurring in Mattole tributaries that will likely improve aquatic habitats. Yet, local restorationists have little understanding of these changes, their spatial distribution, and their relationship to salmonid habitat utilization.

All sediment reduction activities are monitored on-site through photographic documentation, the completion of CDFG's qualitative evaluation checklist, and, in some cases, turbidity and stream crossing erosion monitoring. All of these efforts are valuable in evaluating the implementation of sediment treatments, yet tell us nothing about the current condition of stream channels.

In 2005, the Mattole Restoration Council and the California Dept. of Fish and Game's Coastal Watershed Planning and Assessment Program (CWPAP) initiated a stream channel trend monitoring program. Using a generalized random tessellation stratified GRTS approach, 80 sampling locations (20 in each of the NCWAP designated subbasins) were determined by CWPAP and the US Environmental Protection Agency, Corvallis, OR (which provides a data randomization service for watershed-scale monitoring).

Monitoring protocols are adapted from the federal Aquatic and Riparian Effectiveness Monitoring Program (AREMP), and include measurements of the following parameters within study reaches that are about twenty (20) bankfull channel widths in length:

- Flow
- Water Temperature
- Conductivity/Dissolved Oxygen
- Gradient
- Rosgen Channel Type at Velocity Cross-over
    - Bank Full Discharge Width
    - Bank Full Discharge Depth
    - Substrate Categorization
- 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

The program aims to determine the extent and quality of supportive conditions for salmon and steelhead and help determine avenues to improve those conditions. Using standardized assesment methods to measure core stream and riparian attributes, survey products will provide science based recommendations for fish, stream, and watershed improvement activities that will better protect and recover watershed processes and habitat conditions for salmonids.

In 2005, MRC monitored 20 of the selected sites in the Mattole's southern sub-basin. In 2007, the Mattole Restoration Council will complete the basin-wide monitoring effort by sampling 20 sites in each of the other three sub-basins (western, eastern and northern). In the larger context of watershed restoration and natural recovery of the Mattole River watershed, this data set will serve as a baseline on existing conditions in 2005 and 2007. The Mattole Restoration Council is committed to re-sampling the basin every decade to track the changes in aquatic habitat suitability. This data has a variety of uses:

- Understanding the relative condition of each Mattole sub-basin [prioritization of future restoration locations, e.g. where should sediment control work take place?]
- Understanding which stream channel and water quality parameters meet target values [prioritization of watershed restoration approaches, e.g. what type of treatment should occur in a given sub-basin?]
- Understanding the role of the Mattole basin in the regional context of coho salmon recovery
- Understanding trends in improvement as roughly correlated to land-use changes.

Stream channel monitoring complements fisheries, stream flow, and water quality monitoring ongoing in the Mattole watershed to provide local restoration organizations and their state and federal partners with important data to manage the watershed. Unlike the case in federally managed watersheds (e.g. the Trinity or Sacramento Rivers), the Mattole's watershed organizations play a central role in the collection, reporting, analysis and use of fisheries and watershed trend monitoring data.

In the late 1990s a new problem arose for Mattole communities and fisheries. In the summer and fall of 1999, low streamflows were observed by many residents and fisheries groups. Longtime residents couldn't remember ever seeing the river so low. Fisheries groups and residents were very concerned about the impacts of inadequate streamflows on the already threatened salmonid populations. Residents were also concerned about the impact of low streamflows on water quality and the inadequate water supplies needed to meet basic human needs. Over the course of the next 5 years, low streamflows would become an annual problem with the most extreme conditions observed in the Mattole Headwaters.

The headwaters of the Mattole is the primary habitat for over summering juvenile coho and steelhead. When water levels get extremely low, thousands of juvenile fish die as pools dry up or become very shallow, making the fish easy prey for raccoons and other natural predators. As flows diminish, water quality for healthy juvenile salmonids is also compromised. Dissolved oxygen levels can drop below minimum requirements and result in poor feeding and weak juveniles with low survival potential.The Mattolelow flow problem is recognized in the North Coast Watershed Assessment Program (NCWAP) report on the Mattole watershed, as well as in the *Recovery Strategy for California Coho Salmon*. (McKee 2004)

People in the Upper Mattole have also been impacted by the low flow problem. Low flows result in poor water quality for human use. The accompanying rise in water temperature causes increased growth of algae and microorganisms. Stagnant pools turn dark in color and begin to putrefy with decaying organic material and small animals (such as rodents) that have fallen in. In 2002 and 2004 some families completely ran out of water. Gardens had to be abandoned and basic daily water needs for cleaning, cooking and indoor plumbing met through gallon jugs and help by neighbors. Tensions in the community ran high and there was a tendency to blame upstream water users for the water shortage. (McKee 2004)

III. Previous/Related Monitoring Efforts:

The earliest information on habitat conditions in tributary streams comes from CDFG surveys conducted on 58 streams in the mid-1960s (CDFG 2003). In the 1970s the BLM conducted 40 stream surveys in the Mattole, the vast majority in the western subbasin, where the bulk of the BLM managed land in the watershed is located. These surveys were largely qualitative evaluations by direct observation. Since 1995 the BLM has also conducted detailed watershed analyses for Bear, Hoineydew, and lower Mill Creeks.

In the early 1980s, under contract to CDFG the Coastal Headwaters Association conducted stream surveys, including detailed habitat surveys, on 38 perennial tributaries. More recently, from 1991-2002 CDFG surveyed 62 tributary streams, using standardized methodology adopted in 1991, much of which is identical to the parameters used for this project (Downie 2005, Flosi et al. 1998).

In an effort to determine trends in stream channel health and related aquatic habitat parameters, the Mattole Restoration Council initiated a channel monitoring program in 2001 in conjunction with the Mattole Salmon Group. Channel monitoring work between 2001-2004 focused on 13 Mattole headwaters tributaries where extensive upslope sediment control work was underway.

Sanctuary Forest staff have been collecting streamflow data since summer, 2004, and their data form the basis for most analyses contained in the report *Hydrologic Assessment of Low Flows in the Mattole River Basin, 2004-2006* (Klein 2006). Climatic and hydrologic data for the Mattole River is compiled in the *Mattole River Watershed Assessment Report* (Downie et al 2003). The other relevant sources of information are streamflow data collected by the US Geological Survey (USGS) at Petrolia and near Ettersburg, along with rainfall data collected by C. Thompson in the Thompson Creek watershed (Klein 2006).

IV. Assumptions

The monitoring plan makes several assumptions:

(1) **Monitoring Approaches:** Monitoring efforts can be categorized as follows:
  a. Implementation Monitoring: to determine whether watershed restoration treatments were implemented as planned/prescribed, i.e. *was the stream crossing removal conducted as prescribed within the sediment source inventory?*
  b. Effectiveness Monitoring: to determine whether watershed restoration treatments achieved physical habitat improvement goals, i.e. *did upslope sediment reduction treatments result in anticipated changes in aquatic habitat conditions?*
  c. Validation Monitoring: to determine whether watershed restoration treatments resulted in changes in target populations, i.e. *did the suite of watershed restoration treatments result in a change in salmonid populations?*

d. Baseline Condition/Trend Monitoring: to determine the value of a biological, chemical or physical habitat metric, or to determine changes in these metrics over a time period, i.e. *what is the dissolved oxygen level in lower Thompson Creek? how does this value compare to values elsewhere in the watershed? how does this value change seasonally, or over time?*

Monitoring efforts described in this Monitoring Plan are designed to address "Baseline Condition/Trend Monitoring" and "Effectiveness Monitoring" questions.

(2) **Complementary Efforts:** Other monitoring efforts currently taking place within the Mattole River watershed complement these efforts, and provide a context for data collected within this effort. These monitoring efforts include:

a. Basin-wide summertime water temperature monitoring (conducted by the Mattole Salmon Group)
b. Streamflow gauging at Petrolia, Ettersburg, and within the Mattole River headwaters (conducted by Sanctuary Forest, Inc., the California Dept. of Water Resources, the Bureau of Land Management, and the US Geological Survey).
c. Riparian habitat inventory and surveys (conducted by the Mattole Restoration Council).
d. Habitat Typing Surveys (conducted by the California Dept. of Fish and Game, as reported in the various *Basin Reports).*
e. Basin-wide salmonid surveys: outmigrant (juvenile), adult, carcass, spawner/redd, and summertime presence/absence surveys (conducted by the Mattole Salmon Group).
f. Restoration effectiveness monitoring checklists completed at all in-stream, riparian and upslope restoration treatment sites (conducted by the Mattole Restoration Council and California Dept. of Fish and Game).
g. Pre- and post-project photographic documentation at all restoration work sites basin-wide (conducted by the Mattole Restoration Council)

(3) **Comparability of Complementary Efforts:** Complementary monitoring efforts described in (3) were conducted with appropriate quality assurance and quality control procedures to provide validated data. Complementary monitoring efforts are collected within the same time period, spatial scale and environmental conditions to provide comparable and contextual data.

(4) **QAPP:** Current data collection efforts described in this Monitoring Plan will comply with approved Quality Assurance Project Plans.

(5) **Multiple Scales:** Basin-wide water quality and watershed condition monitoring should occur at multiple spatial and temporal scales.

(6) **Temporal Scale:** For trend monitoring purposes, temporal scales may have to be very large (i.e. across multiple large storm events, perhaps over a period of 5-25 years) to demonstrate statistically-significant trends. This scale is likely to exceed the work period of this grant agreement, and thus ongoing and future monitoring efforts must be completed to demonstrate statistical significance.

(7) **Spatial Scale:** For comparative purposes, spatial scales may have to be very large (basin-wide) to demonstrate statistically-significant differences in water quality and watershed metrics, thus ongoing and future monitoring efforts must be completed to demonstrate statistical

significance. In consultation with the Mattole Technical Advisory Committee, USEPA, and CDFG, twenty GRTS selected sites per subbasin (80 total) were chosen as a sufficient number of sampling sites to demonstrate statistical significance.

(8) **Variability:** Environmental variability inherent within a dynamic, complex watershed system can obscure detection of trends in water quality and watershed health metrics.

(9) **Stream Channel Monitoring Spatial Comparability:** Stream channel metrics selected for sampling within the Monitoring Plan and associated Quality Assurance Project Plan will likely demonstrate differences in water quality and watershed health conditions between sub-basins and tributaries within the Mattole River watershed at the density of sampling sites proposed within the Plans. This assumption is also based on preliminary data collected in efforts described in (3).

(10) **Trends in Stream Channel Metrics:** The current proposed scope of work for stream channel monitoring (within and beyond this grant agreement) includes the collection of data at 80 sites within the basin. No sites are planned to be re-sampled within the current proposed scope of work, and thus trends will not be detected until follow-up monitoring is completed. This is planned to occur within 7-10 years, or possibly sooner if major storm events occur that might significantly change stream channel conditions.

V. Research Questions

Monitoring efforts are conducted in the service of answering one or more research questions. Research questions are formulated prior to any phase of the monitoring effort, and form the basis for monitoring methodology, study design, analysis, and reporting. The stream channel portion of this monitoring effort will be undertaken to answer the following questions:

(1) What is the status of selected biophysical indicators of salmonid habitat suitability within the Mattole River watershed, stratified by sub-basin and tributary watershed? (see “Methodology” below for more information on the biophysical parameters)

(2) Are there statistically-significant differences in salmonid habitat suitability within the Mattole River watershed’s sub-basins?

(3) Are there correlations between salmonid habitat suitability within various sub-basins and potential causal factors such as geology, land-use history, and topography?

The objectives and questions to be addressed by the low-flow program are:

1) Collect data to compare with the existing four years of monitoring data and build a dataset that can be used to predict flow patterns in a low flow year. Dataset will be used to assess effectiveness of tank and forbearance program.

2) What are the flows for the upstream and downstream ends of the critical reaches identified by Sanctuary Forest in 2004 over the course of the low flow season?

3a) How do mainstem low flows correlate with tributary flows?

3b) What is the flow contribution from the main headwaters tributaries at the beginning and end of the low flow season and how do they compare with each other?

4) How does water quality change at the beginning of the low flow season as compared to the end?

5) How does the low flow effect the fish survival due to unconnected pools?

VI. Methodologies and Data Accuracy

Monitoring activities will correspond to those described within the *GRTS Stream Channel Sampling Quality Assurance Project Plan* and the *Mattole Low Flow Trend Monitoring QAPP*.

Study Design/Sampling Locations: Study design for stream channel sampling was developed jointly by the Mattole Restoration Council, Council sub-contractor Salmon Solutions LLC, the California Dept. of Fish and Game, and the US Environmental Protection Agency (USEPA). The study design was presented to the Mattole Technical Advisory Committee on July 28, 2005. The study uses a generalized randomized tesselation sampling strategy (GRTS). Within a GRTS strategy, sampling sites are selected randomly within a network of anadromous stream reaches. Selected sites are sampled if they meet basic criteria. Otherwise, the next site on an "oversample" list is selected. Disqualifying criteria are as follows:

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.

Parameters monitored at each site are defined by the California Dept. of Fish and Game's "Core Attributes" paper (see Appendix 1). The USEPA determined that 80 sampling locations (20 in each of four Mattole sub-basins, excluding the Estuary sub-basin) would be sufficient to detect statistically-significant differences in "core attributes" between sub-basins. Each site is monitored once, and all data is presented by individual site, and aggregated by sub-basin.

The Mattole Low Flow monitoring program has been operating since 2004. Study design and scope of work for the program have been determined under guidance from consulting hydrologist Randy Klein, staff hydrologist Karen Endres, and the Mattole TAC.

1) Quantitative monitoring of most mainstem sites since 2004. This data will be used to compare with 2004, 2005, 2006, and 2007 data. Monitoring to begin by July 15th or when flows drop to 5 cfs at site MS6. Monitoring to continue until streamflows recover from the low-flow season (when flows rise to 5 cfs at site MS6). Monitor at two- week intervals. Include descriptive notes on the monitoring sheets to include condition of river and vegetation (for example: isolated pools, stagnant or discolored water, trees turning color, etc.).

2) Monitor the upstream end and downstream end of the two critical reaches (MS1, MS2, MS5 and MS6). Install continuous data logger pressure transducers at both ends of the Gopherville critical reach (MS1 & MS2) for the 2008 low flow season. Install stage gages and data loggers at both ends of both critical reaches for the 2008 low flow season. Monitor all sites with the current meter at two-week intervals. These measurements will provide data needed to establish stage discharge relationship at the datalogger sites.

Note: The Junction critical reach has McKee Creek flowing into the middle of it. McKee Creek flows will need to be measured every time the junction critical reach is measured.

3) Monitor all main tributaries quantitatively at the beginning and end of the low flow season. (1.0 cfs at MS6 and 0.2 cfs and 0 cfs at MS6)

4) Include qualitative monitoring (photos) in every monitoring of mainstem and tributaries to document conditions associated with flows. Photograph every monitoring site and the stream channel on both sides of the shadowbrook bridge.

5) Monitor water quality parameters of dissolved oxygen, temperature and pH along with flow measurements at the mainstem sites twice at the beginning and end of the low flow season (1.0 cfs at MS6 and 0.2 cfs at MS6).

Parameters Monitored: Data on the following parameters is collected at each stream channel sampling site:

Parameter	**Method/ Range**	**Units**	**Detection Limit**	**Resolution**	**Precision**	**Accuracy**	**Complete-ness**
Flow	Timed float	Cubic feet per second (cfs)	.2 cfs	0.1 cfs timed float	± 20%	± 20%	90%
Temperature	Thermometer (20 to 120)	^{o} F	20	1.0 ^{o} F	± 1.0 ^{o} F	± 1.0 ^{o} F	90%
Conductivity	conductivity meter	µS/cm	10	10 µS/cm	± 5%	± 5%	90%
Dissolved Oxygen	DO meter	mg/L	0.0	0.01 mg/L (ppm)	± 0.5 mg/L	± 0.5 mg/L	90%
Gradient*	Hand level & stadia rod	Percent (elev. change ÷ distance)	0.0	0.1%	± 10%	± 10%	90%
Bankfull Discharge Width*	Tape measure	feet	0.0	0.1’	± 10%	± 10%	90%

Bankfull Discharge Depth*	Stadia rod	feet	0.0	0.1’	± 10%	± 10%	90%
Substrate Categorization *	Tape measure, meter stick	Substrate categories	0	<.08	± 10%	± 10%	90%
Pool Freq.	Tally	# pools per unit distance	0	1	± 10%	± 10%	90%
Max. Pool Depth	Stadia rod	feet	0.0	0.1’	± 10%	± 10%	90%
Depth at Pool Tail Crest	Stadia rod	feet	0.0	0.1’	± 10%	± 10%	90%
Cobble Embeddedness	Ocular assessment	Percent	0	25%	± 25%	± 25%	90%
% Pool-Tail Surface Fines <2mm	Sampling grid	Tally number	0	1	± 10%	± 10%	90%
Stream Shade Canopy	Convex densitometer, Type A	percent	0	1	± 10%	± 10%	90%
LWD Inventory	Tally	Tally number	0	1	± 10%	± 10%	90%

*These measurements are used to determine stream channel type according to Flosi et al 1998 – see appendix 1, part 2

Data Collection Procedure: For information on data precision, accuracy, and completeness please refer to the table above. Descriptions of the data collection procedures are contained in Appendix 1, Standard Operating Procedures, in the documents *Stream Channel Measurement Methods for Core Attributes* and chapter three of the *Salmonid Stream Habitat Restoration Manual* (3rd edition, 1998, and subsequent updates).

Methodology for streamflow measurements: For more information on methodology, please refer to the *Mattole Low Flow Trend Monitoring QAPP*

Instrumentation:

Current Meters: Because the streamflow velocities drop lower than can be accurately measured by standard streamflow instrumentation a combination of two methods will be used. Streamflow current meters will be used to measure flows until flows are low enough to use bucket stopwatch method.

Procedure: The DFG procedure will be employed when using current meters. Wing walls or sand bags will be used as needed to establish a narrow regular cross-section of adequate velocity. Velocities will be read at 0.6 of stream depth and at least 10 readings will be obtained per monitoring site.

Cross-Sectional Survey Procedure: A level tape will be taught across the bankfull points of the creek. Measurements to the bed surface will be taken at 10 points across the stream corridor with notation of stream centerline and flood plain extents. A measurement of water surface will be taken from the level tape at each monitoring.

Pressure Transducer Data loggers:
Global Water WL16 Water Level Data Loggers 0-3' range will be installed at sites all monitoring sites with staff gages.

Site selection: Sites will be selected for the instrumentation method based on the following criteria: 1) For sites representing the 2004 sites: within close proximity of the 2004 bedrock sites and close enough to avoid any influence from nearby pumps or tributaries. 2) For all sites: select narrow and relatively shallow reaches (8 inches to 3 feet deep adjacent to bedrock. Avoid sites with extensive gravel deposits and obvious sub surface flow. If wing walls are needed, select sites with gravel bottom to ensure adequate seal between plastic and streambottom. Tributaries will be measured near the confluence with the mainstem (between 50 ft and 500 ft upstream)

VII. Project Evaluation

Stream Channel Monitoring: The success of the project will be evaluated based on the extent of completion of sampling work. It is expected that sampling for all stream channel monitoring parameters will be completed at 20 sites each in the western, eastern, and northern subbasins. It is also expected that data collected will meet the targets for precision and accuracy. More information on QA/QC targets and methodology is included in the QAPP for these projects.

The information collected in the stream channel monitoring project will assist in the evaluation of the effectiveness of MRC restoration work in the following ways:

- Understanding the relative condition of each Mattole sub-basin [prioritization of future restoration locations, e.g. where should sediment control work take place?]
- Understanding which stream channel and water quality parameters meet target values [prioritization of watershed restoration approaches, e.g. what type of treatment should occur in a given sub-basin?]
- Understanding the role of the Mattole basin in the regional context of coho salmon recovery
- Understanding trends in improvement as roughly correlated to land-use changes

Since much of the data collected will be baseline data, its applicability to evaluate the effectiveness of specific projects will be limited. The ability to evaluate the effectiveness of restoration work will be increase by analyzing the data in conjunction with the data from complementary monitoring efforts (see item IV (2), above).

Low Flow Monitoring:
This project’s success will be judged by the extent to which monitoring is completed at the sites’ outlined above, and the extent to which the data helps answer the research questions. It is expected that this data will help evaluate the effectiveness of the tank and forbearance program, build a dataset that can be used to predict flow patterns in a low flow year, and provide more information on the correlation of mainstem low flows with tributary flows, relative low flows in different tributaries, changes in water quality throughout the low flow season, and how low flow effects fish survival.

VIII. External Factors

The planning and design of the stream channel monitoring project accounts for a number of external factors. Sampling will be conducted during low-flows, approximately July-September. This will allow for more complete, comprehensive measurements, and is also the safest time of year for crews to be working in the stream channel. Sampling will be completed before significant leaf fall occurs in late-September - October. Significant numbers of fallen leaves in the stream channel obscure the substrate, making the measurement of certain parameters difficult.

Landowner permission for site access will be secured well before the beginning of the field season. In the case of a landowner denying access to a particular sampling site, the next site on the GRTS generated "over-sample" list will be chosen. The MRC has established procedures for securing access to work sites, and established relationships with a large number of landowners in the watershed.

Sanctuary Forest's four years of experience in conducting the low flow monitoring program will help minimize external factors. The timing of monitoring is to coincide with appropriate flows for taking flow measurements, and relationships with key landowners are already established.

IX. Handling, Storage, and Reporting of Data:

Following sampling of individual stream reaches, field data sheets will be inspected by the field leader and project manager to verify completeness, and check for any obvious outliers in the data collected. If any irregularities are detected in the field data forms, the project manager will meet with the individuals who collected the data to determine how to correct the irregularities. Following the field data collection season, data from the hard-copy data forms will be entered into the MRC computer system following standardized procedures. The stream channel sampling project manager and MRC's data management supervisor will both be involved in the data transfer to allow for improved oversight of handling and storage.

Data will be analyzed and assembled in a final project report. The 20 sites in the Southern subbasin sampled in 2005 will be included in the analysis, as will data from the benchmarked stream channel reaches sampled in 2001-2003, if applicable (see section III, above). Collected data will be compared with salmonid habitat target values from the *California Coho Recovery Strategy* and the NCRWQB's *Salmonid Freshwater Habitat Targets for Sediment-Related Parameters*, and to other "Core Attribute" data collected within the region.

All channel sampling and data management will be conducted in accordance with an approved QAPP. The QAPP will incorporate SWAMP data collection and handling requirements. Project data will be entered into the *Mattole Data Management Framework*, accessible through a web-based portal at www.mattole.org.

For more information on handling, storage, and reporting of data, please refer to the associated QAPPs.

X. References

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Appendix 1
Standard Operating Procedures, Part 1

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:

10. 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;
11. The GPS point is located in a lake, wetland, marsh or on a dam or glacier;
12. The site is located on an artificial stream, culvert, or irrigation canal;
13. The site is dry during summer flow periods;
14. 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;
15. The stream is too small or cannot be physically sampled. The minimum stream size is 1 meter wide (wetted width) and 0.01 meters deep in riffles;
16. 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;
17. Travel time (round trip) from camp is over four hours to get to and from the site;
18. 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).

Reach and cross section determination and measurement:

- 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 nearest the reach mid-point (Transect C), and at velocity cross-overs nearest 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
    - Substrate Categorization
- 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

1. **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 (Dissolved Oxygen measurement not applicable for 2005). 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.

Substrate Categorization (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

B. 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.

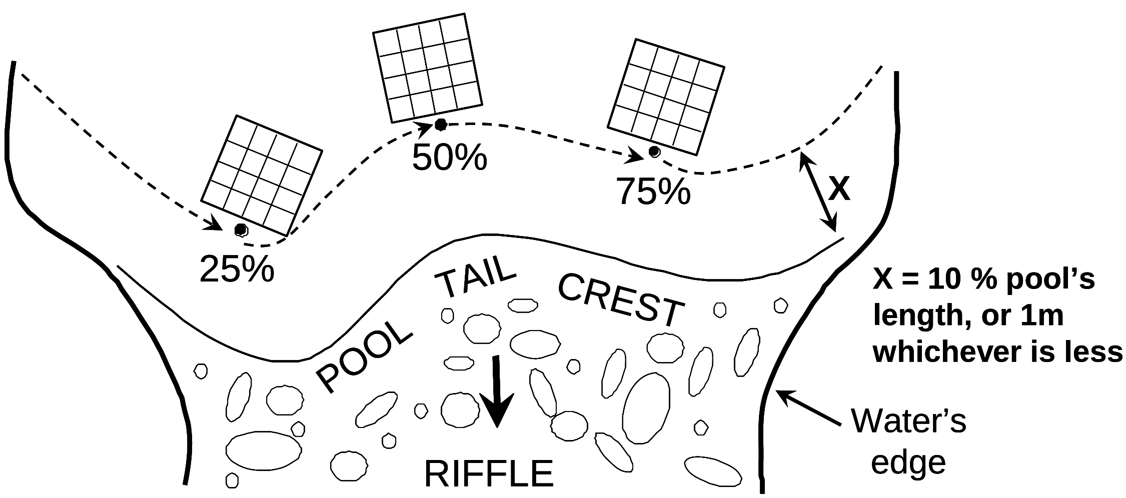

Figure 4. Location and orientation of pool tail fines grids relative to the pool tail crest

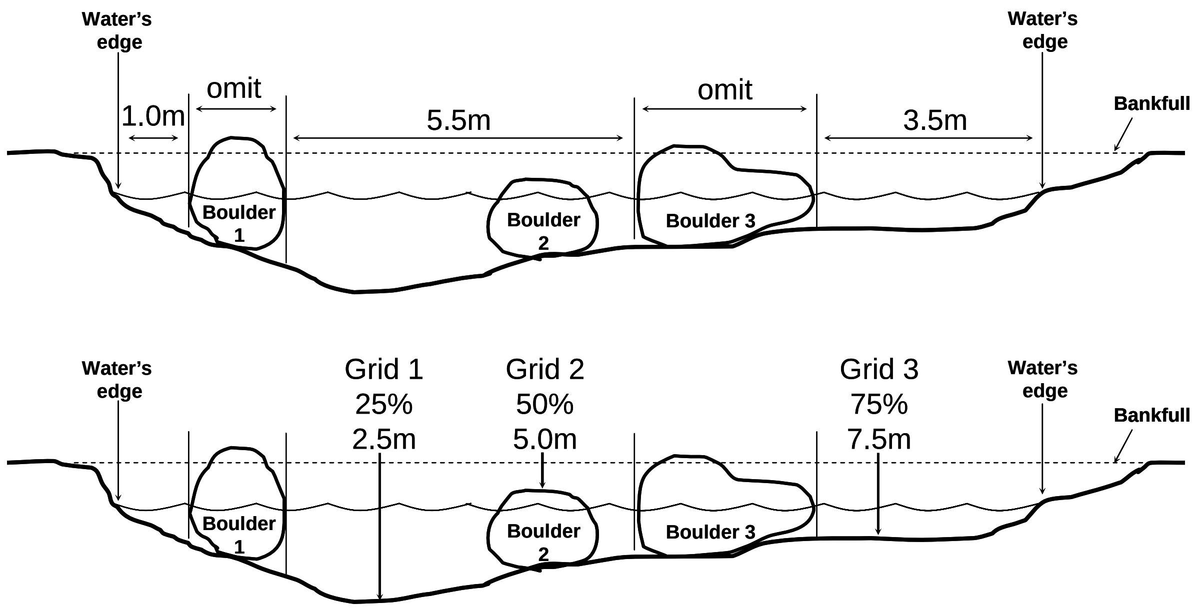

Figure 5. Cross section of pool tail and placement of fines grid. Determine wetted channel width along the pool tail. Omit boulders (and other obstructions) that extend above bankfull elevation (boulders 1 & 3). Boulder 2 extends above the water surface, but not bankfull elevation, so it is NOT omitted. 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 (NOT APPLICABLE FOR 2007 MONITORING)

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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Standard Operating Procedures, Part 2

CALIFORNIA SALMONID STREAM
HABITAT RESTORATION MANUAL

PART III

HABITAT INVENTORY METHODS

PART III. HABITAT INVENTORY METHODS

Following completion of a preliminary watershed overview, a stream habitat inventory should be conducted. The preferred procedures used to accomplish fish habitat inventory include: 1) stream channel typing using the stream classification system developed by D. L. Rosgen (1994); and 2) habitat typing using a variation of the system originally developed by P. A. Bisson, et al. (1982) and later expanded by others. Stream channel typing describes relatively long reaches within a stream using eight morphological characteristics. Habitat typing describes the specific pool, flatwater, and riffle habitats within a stream.

The different habitat types and their boundaries are easily identified once the surveyor gains experience. Changes in stream channel types are more subtle and require a surveyor to recognize changes in substrate, channel entrenchment, gradient, and other morphological characteristics that signal a different channel type.

The field data collected is used for stream analysis and planning. DFG has developed a data entry and summary program to process the field data (Part V). An examination of the results will provide the baseline data necessary to determine if habitat modification may be appropriate. If habitat projects are implemented, baseline data are vital for evaluation and monitoring.

Before deciding whether or not to modify fish habitat in a stream reach, judgements can be made as to the need and range of suitable structures applicable to the stream channel type. Rosgen and Fittante (1986), and Rosgen (1994) developed guidelines for evaluating the suitability of a wide variety of commonly used habitat enhancement designs over a wide range of channel types. (Pages III-8 through III-21, Stream Channel Type Descriptions and Structure Suitability).

HABITAT INVENTORY FIELD PREPARATION

All habitat inventory field work must be conducted by two persons. Wading shoes with non-slip soles are recommended. If hip boots, chest waders, or hiking boots are used, non-slip soles or non-slip cleats must be worn.

Permission to trespass must be obtained before field work begins on private land (Appendix N). The designated agency manager of public land should always be notified before inventory work begins on public land.

Most surveyors use a day pack or a vest to carry their tools and supplies, a coat or rain gear, food, and water. Do not drink any stream water that has not been purified and treated to destroy *Giardia*.

Tools and Supplies Needed for Two Person Crew

- Stream Channel Typing Work Sheet and Habitat Inventory Data Forms
- Pencil(s) and waterproof marker(s)
- Plastic flagging
- Topographic maps (it is best to carry photocopies)
- Camera (film)
- Thermometer
- Watch
- Stadia rod (fiberglass, calibrated in tenths)
- Fiberglass open reel tape 200 ft.
- Optical range finder (optional)
- Hand level
- Flow meter
- Compass
- Hip chain and thread
- Spherical densiometer
- Aluminum clipboard and waterproof notebook
- First aid kit
- Aluminum nails and tags (for marking reference points)
- Cruiser's vest or day pack
- Footwear with non-slip soles

STREAM CLASSIFICATION SYSTEM

This manual uses a modified stream classification system developed by Rosgen (1994). Stream types are characterized by eight morphological features:

1) Channel width
2) Depth
3) Velocity
4) Discharge
5) Channel slope
6) Roughness of channel materials
7) Sediment load
8) Sediment size

Some applications of stream classification data include:

- Determine the suitability of habitat restoration structures.
- Describe specific stream reaches by channel type and sequence within the basin.
- Predict a stream's behavior from its appearance.
- Describe the condition of the stream and its ability to transport the sediment yield from the watershed.
- Provide a consistent and reproducible frame of reference for communication among those working with river systems.

Stream Channel Type Definitions

The following terminology is provided to gain an understanding of the measurable information needed to classify stream types.

Channel type unit length: A stream reach must exhibit the same channel type over a minimum distance of twenty bankfull channel widths to be recognized as an independent stream channel type unit.

Bankfull discharge (Q_{bkf}): The dominant channel forming flow, and has a recurrence interval of 1.5 years.

Bankfull depth (d_{bkf}): The mean depth measured at bankfull discharge.

Bankfull width (W_{bkf}): The channel width at bankfull discharge. This stage is delineated by the presence of a floodplain at the elevation of incipient flooding and indicated by deposits of fine sediments such as sand or silt at the active scour mark, break in stream bank slope, and/or perennial vegetation limit (Figure III-1).

Flood-prone area: Any flat, or nearly flat lowland that borders a stream and is covered by its waters at flood stage (Figure III-1). This is determined at twice the maximum bankfull depth.

Flood-prone width (W_{FP}): The stream width at a discharge level defined as twice the maximum bankfull depth.

Wetted width: The width of the wetted stream at the time of the survey. Wetted width is generally less than bankfull width. Wetted width is also referred to as "low flow channel".

Stream Type Delineation Criteria

The Rosgen delineation criteria includes general description, width/depth ratio, water surface slope/gradient, dominant particle size, entrenchment and sinuosity.

General description: A general description of the channel geometry, gradient, bank stability, substrate, pool or riffle occurrence, etc.

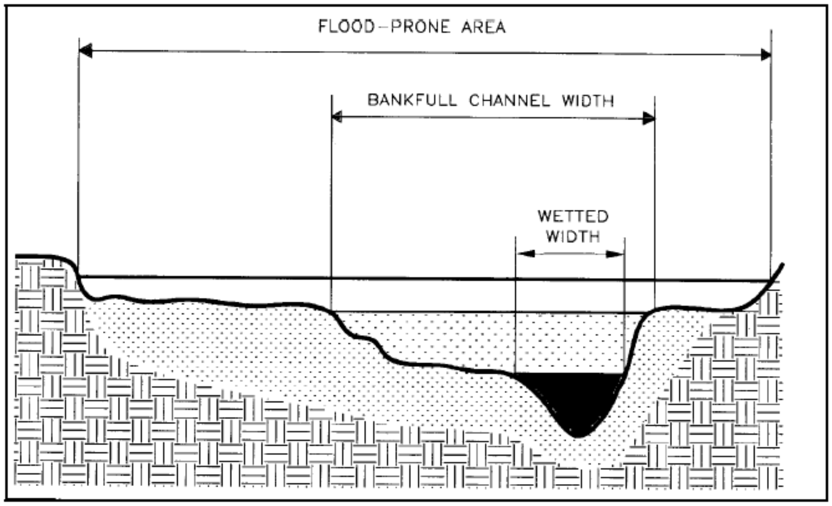

Figure III-1. Channel cross section.

Width/depth ratio: The ratio of the bankfull width (W_{bkf}) to the bankfull mean depth (d_{bkf}). The categories are:

1) Low ($W_{bkf}/d_{bkf} < 12$)
2) Moderate to High (W_{bkf}/d_{bkf} 12 - 40)
3) Very High ($W_{bkf}/d_{bkf} > 40$)

Water surface slope/gradient: The slope of the water surface is measured over a distance of at least 20 bankfull channel widths at velocity crossovers.

Dominant substrate: The most common particle found on the bed of the stream measured at the velocity crossover. The particles are classified by their maximum diameter.

PARTICLE SIZE:	INCHES
Boulder	> 10"
Cobble	2.5-10"
Gravel	0.08-2.5"
Sand	< 0.08"
Silt/clay	N/A
Bedrock	N/A

Entrenchment: The ratio between flood-prone width (W_{FP}) and bankfull width (W_{bkf}). There are three categories (Figure III-2):

1) Entrenched (W_{FP} /W_{bkf} <1.4)
2) Moderately entrenched (W_{FP} /W_{bkf} 1.4 to 2.2)
3) Slightly entrenched (W_{FP} /W_{bkf} >2.2)

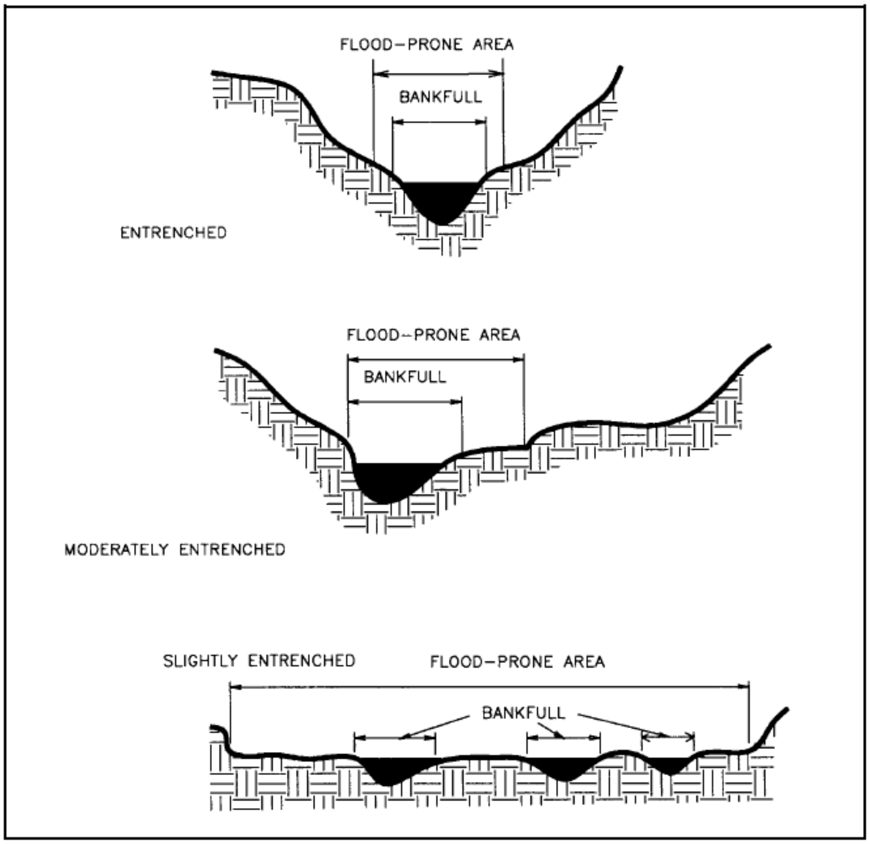

Figure III-2. Entrenchment.

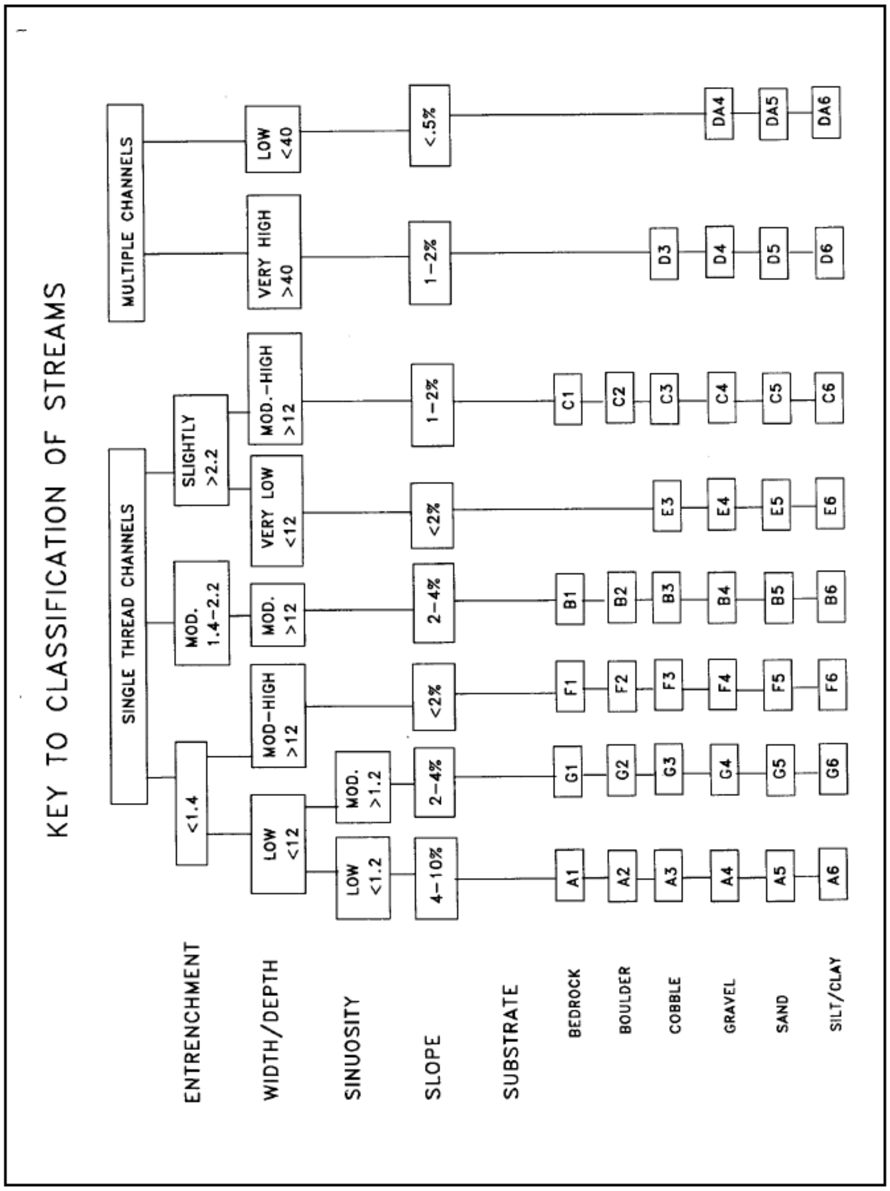

Figure III-5. Key to classification of streams.

STREAM CHANNEL TYPE WORK SHEET

A Stream Channel Type Work Sheet is filled out at the beginning of the survey and each time the channel type changes. Significant changes in stream gradient, flood plain width, width/depth ratio, sinuosity or substrate size all indicate possible changes in channel type. The habitat unit number corresponding with the beginning and ending of each new channel type should be recorded on the Stream Channel Type Work Sheet and accompanying topographical field map. Field measurements for stream types are conducted at velocity crossover areas. Water surface slope measurements are taken between two points that are at least 20 bankfull channel widths apart. Velocity crossover areas occur where stream velocity changes from slower flatwater or pool velocities to the swifter riffle velocities. These crossover areas are typically found where the thalweg of the stream crosses from one side of the channel to the other (Figure III-6). Further, stream types should be determined at points where the channel geometry is not affected by outside influences. Outside influences include road embankments, riprap, landslides, tributaries, etc.

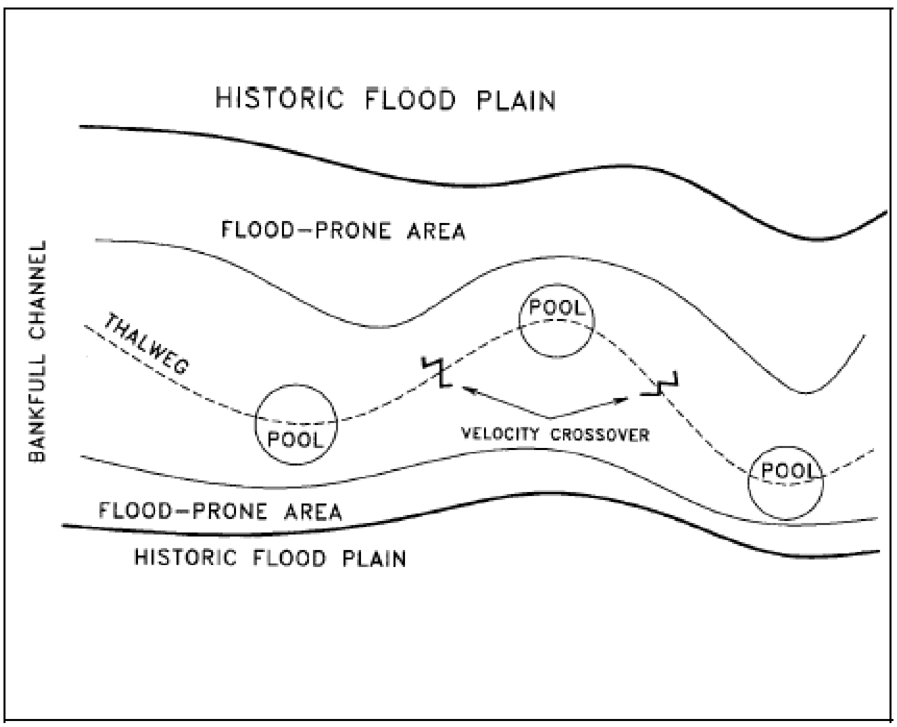

Figure III-6. Velocity crossover areas.

Instructions for Completing the Stream Channel Type Work Sheet

A channel type unit length must extend over a distance at least twenty times the average bankfull width.

1) **Form No.** - Print in the form number. Number the forms sequentially beginning with "01" on the first page,"02" on the second, and so on.

2) **Channel Type** - Enter the channel type code from the completed work sheet.

3) **Channel Change Location** - Enter the habitat unit # where the channel change occurred from the corresponding Habitat Inventory Data Form.

4) **Cross-Section Location** - Enter the habitat unit number at the location of the cross section.

5) **Date** - Enter the day's date: mm/dd/yy.

6) **Stream** - Print in the stream name.

7) **T-R-S** - Enter the township, range and section of the stream confluence. This information can be obtained from a USGS quadrangle.

8) **Surveyors** - Enter the names of the surveyors.

9) **Quad** - Enter the name(s) of the 7.5-minute USGS topographic map(s).

10) **Latitude** - Enter the stream's latitude in degrees, minutes, and seconds from the Watershed Overview Work Sheet. These positions can be obtained using a Global Positioning System (GPS) receiver, a GIS computer program, or a latitude and longitude calculator (Coordinator brand). (Appendix M).

11) **Longitude** - Enter the stream's longitude in degrees, minutes, and seconds from the Watershed Overview Work Sheet. These positions can be obtained using a Global Positioning System (GPS) receiver, a GIS computer program, or a latitude and longitude calculator (Coordinator brand). (Appendix M).

12) **Determination of Number of Channels** - Determine if the channel type reach is dominated by either a single thread or multiple channel(s) at bankfull discharge.

13) **Bankfull Width (W_{bkf})** - Measure the width of the stream at bankfull discharge (Q_{bkf}). is measured by stretching a level tape from one bank to the other, perpendicular to the stream and at the Q_{bkf} line of demarcation on each bank. Q_{bkf} is determined by changes in substrate composition, bank slope, and perennial vegetation caused by frequent scouring flows.

14) **Transect Recording Box** - This form is used to record depths and substrate composition from 20 stations equally spaced along a fiberglass measuring tape stretched across the channel at bankfull width. The distances at which measurements are made are recorded in the recording box's top row titled "Dist.". Measurements are taken along the tape line starting at zero at each predetermined distance point. Depths are the distance from the tape to the channel substrate below, and are recorded in the middle row titled "Depth." Twenty substrate samples are collected at the equidistant sample points along the distance of the tape by selecting the substrate particle first touched by the stadia rod. The code number for the corresponding substrate sampled is then recorded in the row titled "Sub."

15) **Dominant Substrate Determination** - When all 20 substrate samples have been collected, the number of samples of each substrate size are added and the totals are recorded in the summary section. The substrate most frequently sampled is the dominant substrate type.

16) **Entrenchment Determination** - (Figure III-7)

Step One: **Flood-Prone Width Elevation** - Multiply the deepest bankfull depth recorded in the Transect Recording Box by two.

Step Two: **Flood-Prone Width (W_{FP})** - Establish a level plane at an elevation twice the maximum bankfull depth and measure the distance between the points where the plane intersects the stream banks.

Step Three: **Entrenchment Determination** - Divide the flood prone width by the bankfull width to determine the entrenchment of the channel.

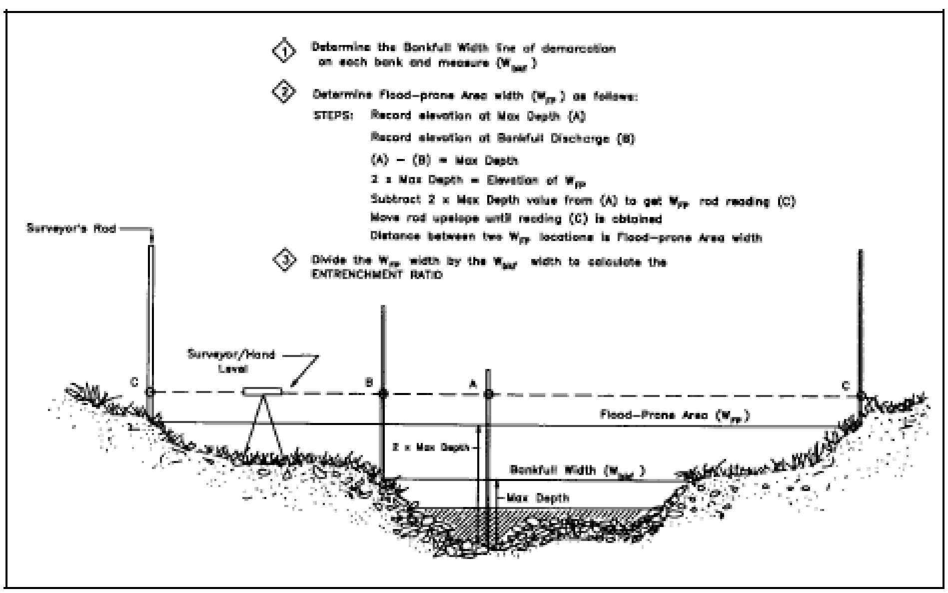

Figure III-7. Entrenchment determination.

17) **Width/Depth Determination** -

Step One: **Mean Bankfull Depth (d_{bkf})** - Divide the sum of depths from the transect recording box by the number of depths measured.

Step Two: **Width/Depth Determination** - Divide the bankfull width by mean bankfull depth to determine the width/depth ratio.

18) **Sinuosity** - Determine the ratio between stream length and valley length. These lengths can be calculated from 7.5-minute USGS topographic maps or aerial photographs using a map wheel. Sinuosity ratio is only used to distinguish A from G channel types.

19) **Water Surface Slope Determination** - To determine stream gradient, establish two survey stations along the stream at least twenty bankfull widths apart, and located at velocity crossover locations. Station elevations are set at the level of the water surface on either side of the stream. A sight level is used to determine the difference in elevation between the stadia rods. The horizontal distance between the stations is measured along the thalweg of the stream. The elevation difference is divided by the horizontal distance and multiplied by 100 to express water surface slope in percentile.

HABITAT TYPING

The habitat typing procedure presented is a standardized methodology that physically describes 100 percent of the wetted channel. It is a composite of systems principally developed or modified by other investigators and compiled in part by Trinity Fisheries Consulting on contract to DFG.

Habitat types are described according to location, orientation, and water flow. The attributes distinguishing the various habitat types include over-all channel gradient, velocity, depth, substrate, and the channel features responsible for the unit's formation.

A basin-level habitat inventory is designed to produce a thorough description of the physical fish habitat. Basin-level habitat classification is on the scale of a stream's naturally occurring pool-riffle-run units. The length of a habitat unit depends on stream size and order. For basin-level habitat inventory, homogeneous areas of habitat that are equal or greater in length than one wetted channel width are recognized as distinct habitat units. During basin-level habitat typing, full sampling of each habitat unit requires recording all characteristics of each habitat unit as per the "Instructions for completing the Habitat Inventory Data Form" (Part III). After DFG analysis of over 200 stream habitat inventory data sets, it was determined that similar stream descriptive detail could be accomplished with a sampling level of approximately 10 percent (Appendix O).

The information provided by habitat and channel typing, and biological information collected during spawning surveys and/or juvenile rearing surveys aids in determining if critical habitat needs of a target species are lacking, and if there are areas where improvements can be made.

There are four levels of classification used to describe physical fish habitat. Each higher level in the sequence includes more descriptive categories of habitat types (Figure III-8). Level I categorizes habitat into riffles or pools. Level II categorizes riffles into riffle or flatwater habitat types, for a total of three types (riffle, pool, and flatwater). Level III further differentiates riffle types on the basis of water surface gradient (riffle or cascade), and pool types according to their location in the stream channel (main channel, lateral scour, or backwater). At Level IV, pools are categorized by the cause of formation (obstruction, blockage, constriction, or merging flows); riffles are categorized by gradient; and cascades by gradient and substrate type; and flatwaters are categorized by depth and velocity. Level IV habitat types are the 24 habitat types listed on page III-30 and diagramed on pages III-31 through III-42.

Prior to conducting an inventory, the level of data collection necessary to meet the needs of the investigation should be established. Habitat typing at Level IV will provide the greatest detail and the most complete description of existing habitat. This data can later be aggregated into broader levels of habitat classification if detail is found to be excessive.

Instream Shelter

Instream shelter within each habitat unit can be rated according to a standard system. This rating system is a field procedure for habitat inventories which utilizes objective field measurements. It is intended to rate, for each habitat unit, complexity of shelter that serves as instream habitat or that creates areas of diverse velocities which are focal points for salmonids. In this rating system, instream shelter is composed of those elements within a stream channel that provide protection from predation for salmonids, areas of reduced water velocities in which fish can rest and conserve energy, and separation between territorial units to reduce density related competition. This rating does not consider factors related to changes in discharge, such as water depth.

Instream Shelter Complexity. A value rating can be assigned to instream shelter complexity. This rating is a relative measure of the quantity and composition of the instream shelter.

Value	Instream Shelter Complexity Value Examples:
0	• No shelter.
1	• One to five boulders. • Bare undercut bank or bedrock ledge. • Single piece of large wood (>12" diameter and 6' long) defined as large woody debris (LWD).
2	• One or two pieces of LWD associated with any amount of small wood (<12" diameter) defined as small woody debris (SWD). • Six or more boulders per 50 feet. • Stable undercut bank with root mass, and less than 12" undercut. • A single root wad lacking complexity. • Branches in or near the water. • Limited submersed vegetative fish cover. • Bubble curtain.
3	Combinations of (must have at least two cover types): • LWD/boulders/root wads. • Three or more pieces of LWD combined with SWD. • Three or more boulders combined with LWD/SWD. • Bubble curtain combined with LWD or boulders. • Stable undercut bank with greater than 12" undercut, associated with root mass or LWD. • Extensive submersed vegetative fish cover.

Instream Shelter Percent Covered. Instream shelter percent covered is a measure of the area of a habitat unit occupied by instream shelter. The area is estimated from an overhead view.

Instructions for Completing the Habitat Inventory Data Form

1) **Form No.** - Print in the form number. Number the forms sequentially beginning with "01" on the first page and "02" on the second and so on.

2) **Date** - Enter the day's date: mm/dd/yy.

3) **Stream Name** - Print in the stream name.

4) **Legal** - Enter the township, range and section of the stream confluence or from where you started the survey from the USGS quadrangle.

5) **Surveyors** - Enter the names of the surveyors.

6) **Lat** - Enter the latitude taken from the 7.5-minute USGS quadrangle at the confluence of the stream (Part II- Instructions for Completing Watershed Overview Work Sheet).

7) **Long** - Enter the longitude taken from the 7.5-minute USGS quadrangle at the confluence of the stream (Part II- Instructions for Completing Watershed Overview Work Sheet).

8) **Quad** - Enter the name of the 7.5-minute USGS quadrangle on which the confluence of the stream appears.

9) **Channel Type** - Record the channel type determined from completing the Stream Channel Type Work Sheet (Part III). Record in the comments the habitat unit number in which the channel type change occurs in.

10) **Reach** - Enter the reach number beginning with 1 for the lowermost channel type in the basin. Each stream channel type change proceeding upstream will be designated by a new stream reach number.

11) **Flow Measurement** - Record the flow at the beginning and the end of the survey, at the same location. Record in cubic feet/second.

12) **Time** - At the beginning of each page enter the time in military time (24-hour clock).

13) **Water Temperature** - At the beginning of each page record the water temperature to the nearest degree Fahrenheit. Water temperatures are taken in the middle of the habitat unit, within one foot of the water surface.

14) **Air Temperature** - At the beginning of each page record the air temperature to the nearest degree Fahrenheit. Air temperatures are taken in the middle of the habitat unit.

15) **Page Length** - Sum of the mean length for the page.

16) **Total Length** - Sum of all the page lengths through the current page.

17) **Habitat Unit Number** - Enter the habitat unit number. Record these numbers in sequential order, beginning with "001" at the survey start. When numbering side channels begin with the number of the unit where the split or divide begins; use a new column and entirely fill it out for each subsequent side channel unit, and number the units sequentially adding a ".1", ".2", etc. as appropriate to describe the exact position of the side channel units. Example of a side channel with two habitat units:

Habitat Unit Number	005	006	006.1	006.2	007
Habitat Unit Type	5.3	1.1			4.2
Side Channel Type			1.1	3.2	

18) **Habitat Unit Type** - Determine the type of habitat unit and enter the appropriate habitat type number code. If the unit is dry, use 7.0 for the habitat unit type. If a stream length is contained within a culvert, use 8.0 for the habitat unit type. If the length of stream was not surveyed due to lack of access, use 9.0 for the habitat type. If the length of stream was not surveyed due to a marsh, use 9.1 for the habitat unit type. Record all pertinent information in the comments.

19) **Side Channel Type** - Determine the type of habitat unit and enter the appropriate habitat type number code.

20) **Mean Length** - Enter the thalweg length of the habitat unit, in feet.

21) **Mean Width** - Measure two or more wetted channel widths within the habitat unit. Calculate and enter the mean width for the habitat unit, in feet.

22) **Mean Depth** - Take several random depth measurements across the unit with a stadia rod. Calculate and enter the mean depth, in feet.

23) **Maximum Depth** - Enter the measured maximum depth for each habitat unit, in feet.

24) **Depth Pool Tail Crest** - Measure the maximum thalweg depth at the pool tail crest, in feet. This measurement is taken only in pool habitat units and is used to determine the pool's residual volume.

25) **Pool Tail Embeddedness** - Percent cobble embeddedness is determined at pool tail-outs where spawning is likely to occur. Sample at least five small cobbles (2.5" to 5.0") in diameter and estimate the amount of the stone buried in the sediment. This is done by removing the cobble from the streambed and observing the line between the "shiny" buried portion and the duller exposed portion. Estimate the percent of the lower shiny portion using the corresponding number for the 25% ranges. Average the samples for a mean cobble embeddedness rating. Additionally, a value of 5 is assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size, having a bedrock tail-out, or other considerations:

1 = 0 to 25%
2 = 26 to 50%
3 = 51 to 75%
4 = 76 to 100%
5 = unsuitable for spawning

26) **Pool Tail Substrate** - Enter the letter code (A through G) for the dominant substrate composition of the tail-out for all pools.

27) **Shelter Value** - Enter the number code (0 to 3) that corresponds to the dominant structural shelter type that exists in the unit (Part III- Instream Shelter Complexity).

28) **Percent Unit Covered** - Enter the percentage of the unit occupied by the structural shelter. Classify 100 percent of the shelter by the types indicated on the form. Note: bubble curtain includes white water.

29) **Substrate Composition** - Enter a "1" for the dominant substrate and a "2" for the co-dominant substrate. Note: changes in the dominant and co-dominant substrate may indicate that the channel type has changed.

30) **Percent Exposed Substrate** - Enter the estimated percentage of the bottom substrate of the unit that is exposed above the water surface.

31) **Percent Total Canopy** - Enter the percentage of the stream area that is influenced by the tree canopy. The canopy is measured using a spherical densiometer at the center of each habitat unit (Appendix M).

32) **Percent Broadleaf Trees** - Estimate the percent of the total canopy consisting of broadleaf trees.

33) **Percent Evergreen Trees** - Estimate the percent of the total canopy consisting of evergreen trees.

34) **Right Bank Composition** - Observed at the bankfull discharge level. Enter the number (1 through 4) for the right bank composition type corresponding to the list located on the lower left hand side of the form. Enter one number only. The right bank is the right side of the stream when facing downstream.

35) **Right Bank Dominant Vegetation** - Enter the number (5 through 9) for the right bank dominant vegetation type, from bankfull to 20 feet upslope, corresponding to the list located on the lower left hand side of the form. Enter one number only.

36) **Percent Right Bank Vegetated** - Estimate the total percentage of the right bank covered with vegetation from bankfull discharge level to 20 feet upslope.

37) **Left Bank Composition** - Observed at the bankfull discharge level. Enter the number (1 through 4) for the left bank composition type corresponding to the list located on the lower left hand side of the form. Enter one number only. The left bank is the left side of the stream when facing downstream.

38) **Left Bank Dominant Vegetation** - Enter the number (5 through 9) for the left bank dominant composition type, from bankfull to 20 feet upslope, corresponding to the list located on the lower left hand side of the form. Enter one number only.

39) **Percent Left Bank Vegetated** - Estimate the total percentage of the left bank covered with vegetation from bankfull discharge level to 20 feet upslope.

40) **Comments** - Add comments which are important to that habitat unit such as: 1) the location of tributaries and the water temperature within that tributary, bridges, culverts or diversions; 2) the presence of landslides or barriers; or 3) a change in channel type, etc.

HABITAT INVENTORY DATA FORM Form # ___of____

Date ___/___/___ Stream Name ______________________________________ T____R____S____
Surveyors ______________________________________Lat.___________ Lon.______________
Quad.____Channel Type____ Reach #___Flow_____
Time _______ Water Temp _______ Air Temp ________Page Length_____Total Length_____
****

Habitat Unit Number										
Habitat Unit Type										
Side Channel Type										
Mean Length										
Mean Width										
Mean Depth										
Maximum Depth										
Depth Pool Tail Crest										
Pool Tail Embeddedness										
Pool Tail Substrate										
SHELTER RATING										
Shelter Value										
%Unit Covered										
% undercut bank										
% swd (d<12")										
% lwd (d>12")										
% root mass										
% terr. vegetation										
% aqua. vegetation										
% bubble curtain										
% boulders (d>10")										
% bedrock ledges										

SUBSTRATE COMPOSITION (Select the two most dominant compositions)

A) Silt/Clay										
B) Sand (<0.08")										
C) Gravel (0.08-2.5")										
D) Sm. Cobble (2.5-5")										
E) Lg. Cobble (5-10")										
F) Boulder (>10")										
G) Bedrock										
% Exposed Substrate										
PERCENT TOTAL CANOPY										
% Broadleaf Trees										
% Coniferous Trees										

BANK COMPOSITION & VEGETATION (See bank and vegetation composition types below

Rt. Bank Composition										
Rt. Bank Dominant Veg.										
% Rt. Bank Vegetated										
Lt. Bank Composition										
Lt. Bank Dominant Veg										
% Lt. Bank Vegetated										

BANK COMPOSITION TYPE
1) Bedrock
2) Boulder
3) Cobble/Gravel
4) Silt/Clay/Sand

VEGETATION TYPES
5) Grass
6) Brush
7) Deciduous Trees
8) Coniferous Trees
9) No Vegetation

************************COMMENTS*********************

LARGE WOODY DEBRIS (LWD) STREAM AND RIPARIAN INVENTORY

Background

The importance of large woody debris (LWD) in the development of a stream's morphology and biological productivity has been well documented over the last twenty years. It strongly influences stream habitat characteristics and biotic composition. Bilby (1984) and Rainville et al. (1985) found that in nearly 80 percent of the pools surveyed in small streams, LWD was the structural agent forming the pool or associated with the pool. The influence that LWD has on the diversity of juvenile salmonid populations, with particular emphasis on the impact of timber harvest activities on that diversity, has been documented by Reeves et al. (1993). Fish populations are benefitted by both the cover and habitat diversity created by LWD and by the substrate environment for benthic invertebrates that serve as food (Sedell et al. 1984, Sedell et al. 1988, and Bisson et al. 1987).

Relatively large pieces of woody debris in streams influence the physical form of the channel, movement of sediment, retention of gravel, and composition of the biological community (Bilby and Ward, 1989). The relationship between size of individual LWD and its effects on channel morphology are influenced by a number of variables such as stream-flow energy, sinuosity, bank composition, and channel width. Bilby and Ward (1989) and Likens and Bilby (1982) describe LWD and its relationship to pool formation, gravel retention, channel orientation, and channel width. Once LWD enters the stream, their orientation and spacing may be more significant than their volume in influencing channel morphology and aquatic habitats (Platts et al. 1987).

LWD in this methodology is defined as a piece of wood having a minimum diameter of twelve inches and a minimum length of six feet. Root wads must meet the minimum diameter criteria at the base of the trunk but need not be at least six feet long. Four diameter ranges and two length ranges were selected to categorize LWD sizes in this inventory method:

Diameter Category		Length Category	
1.	1 - 2 feet	1.	6 to 20 feet
2.	2 - 3 feet	2.	over 20 feet
3.	3 - 4 feet		
4.	> 4 feet		

Each size category is further divided into four type categories according to condition or status of the LWD as follows:

1. Dead and down (D/D)
2. Dead and standing (D/S)
3. Perched (on the bank and soon to be in the stream channel area)
4. Live:
   a. coniferous; b. deciduous

The range of coverage of this LWD inventory includes two distinct zones: 1) the "instream zone," defined as the stream channel within bankfull discharge demarcations; and 2) the "recruitment zone," defined as that area beyond the instream zone encompassing the floodplain and an additional 50-foot wide strip measured uphill, along the slope from the outer edge of the floodplain. The recruitment zone, as defined for this LWD survey, represents about 70 percent of the LWD recruitment potential to the stream (McDade, et al., 1990; and Forest Ecosystem Management, 1993).

According to McDade et al. (1990), more than 70 percent of woody debris originates within 20 meters of the channel. He looked at the LWD recruitability of riparian vegetation as a function of distance from the stream. His study revealed that over 83 percent of the deciduous LWD and 53 percent of coniferous LWD originates within 10 meters of the stream channel. All hardwood LWD was delivered from within 25 meters, and only 13 percent of the conifers had a source distance greater than 25 meters. Also of interest, there was no significant difference ($P>0.05$) between source distance on steep and gentle side slopes, nor between source distance and stream order.

Andrus et al. (1993) studied recruitment rates based on modeling results of different riparian protection zones and stream sizes over time periods of up to 200 years to simulate long-term recruitment potential for LWD. There was a significantly greater percentage of pieces that should move toward the stream on steep slopes than on gentle slopes. For this reason we defined a "perched" condition category to describe pieces positioned for "imminent" delivery to the stream via near-stream landslides and stream bank failures common to the North Coast of California and generally along unstable or active stream channels.

LWD INVENTORY METHODOLOGY

The inventory includes equipment preparation, stream selection, access permission, stream channel typing, surveyor training, and the actual survey inventory.

Equipment list:

- Clinometer
- 7.5-minute USGS quadrangles of the stream
- Hip chain and refills
- Diameter tape, 50 feet
- LWD Inventory Forms and Stream Channel Type Work Sheets (Part III)
- Waders or hip boots
- Clipboard
- Optional:
    - 100-foot optical distance finder
    - Tree fork
    - *Timber Cruising Fieldbook* (Dilworth, 1981)

Stream selection

This methodology is best suited to first through third-order streams. If streams selected for LWD inventory have been previously stream channel typed, determine the limits and lengths of individual stream channel-type reaches to define LWD inventory reaches.

Training

Persons conducting the inventory must be familiar with stream channel typing methods, proper use of equipment listed above and recording forms presented below. Training in the field should include the following inventory procedure and daily sight calibration by each surveyor of LWD and live tree diameters and lengths.

At the beginning of each day, prior to categorizing and recording LWD, field personnel should select several pieces of LWD for sight calibration. Diameter ranges should be estimated and then verified by measuring with a diameter tape. Also, calibrate sight estimates of 6, 20, and 50 feet with length measurement verifications. Standing tree diameter is determined at breast height (54") above the ground measured from the upslope side of the tree. Diameter of downed logs is the largest diameter anywhere along the log.

Inventory Procedure

In general, the inventory is conducted by two people while walking in the stream channel, proceeding upstream. The LWD Inventory Form is designed so the stream bank entry columns must be oriented to the corresponding stream bank while facing upstream. Right and left banks are defined by convention as one looks downstream. When facing upstream the "right bank" is on the individual's left. One surveyor observes LWD, estimates sizes, and tallies LWD on one bank and LWD within the stream channel, while the other observer tallies the opposite bank. The second person can also estimate instream LWD if surveyor comparison is desired.

Recommended LWD inventory protocol requires that the stream first be stratified into reaches by stream channel types using Rosgen's methodology (Part III). Stream channel types may be determined from previous survey data, or surveyed prior to the LWD inventory. Be sure to attach copies of stream channel typing work sheets to the corresponding LWD Inventory Forms. Stream channel classification measurements within an area that is typical of the stream channel type must be determined. Avoid channel typing measurements near mouths of streams, within stream channel type transition areas, and near artificial or unusual features (e.g., bridges, slides, revetments).

Stream channel typing is important to determine start and stop distances of each stream channel type reach in order to calculate total length of each inventory reach. Begin numbering reaches with "1" as the reach nearest the stream mouth. As different stream channel types are encountered, number corresponding inventory reaches consecutively as the inventory proceeds upstream.

To begin the inventory, consider the stream segmented into 200-foot sections. Number the first six sections consecutively beginning with No. 1 as the downstream most 200-foot section. Next, toss a die to randomly select one of the first six 200-foot segments as Sample Area 1. This segment will become the first LWD inventory sample section in the stream. One LWD Inventory Form is required for each 200-foot sample section. After conducting the survey in this initial sample segment, proceed upstream 800 feet from the upper end of Sample Area 1 and inventory the next 200 feet as Sample Area 2. Sample Area 3 begins 800 feet upstream from the upper end of Sample Area 2, and so on. Stated another way, with the stream segmented into

200-foot sections, this procedure involves using a random start within the first six sections and then systematically sampling every fifth 200-foot section. Continue the LWD inventory in this manner until the stream channel type changes. Be certain to note on the LWD Inventory Forms the distance measurements of where channel types change and a new inventory reach begins. When a new reach begins, the pattern of sampling every fifth 200-feet section can proceed uninterrupted (i.e., it is not necessary to repeat the random start procedure at each stream channel type change).

Beginning at the downstream end of the first 200-foot section, Sample Area 1, observe and tally, in the appropriate boxes on the LWD Inventory Form, all LWD pieces or live trees within the sample area with diameters $\geq$ 1 foot and lengths $\geq$ 6 feet, and root wads with a trunk diameter $\geq$ 1 foot.

During the survey in each 200-foot sample area, each of the surveyors will, periodically, ask the other to measure the diameter and length of the last estimated tree or LWD, and to measure the 50 foot estimated bank distance, and 6 and 20 foot tree length distances for accuracy and calibration purposes. Results of each measured estimate will be recorded on the calibration form. This ongoing calibration effort serves to keep the surveyors' estimates more accurate, and also provides the basis for analyzing the data for standard error.

To eliminate the problem of an insufficient number of samples that would represent LWD conditions in short streams or reaches, it is recommended that stream reaches less than 1,000 feet in length be surveyed throughout their entire length.

Downed large wood which is out of sight on terrace benches, usually has little chance of entering the stream. Therefore, if a piece of LWD cannot be observed from within the stream by a surveyor, it is not tallied. Also, well-rooted tree stumps located back on high bank terraces are not tallied because they have little or no potential for recruitment to the stream.

Root wads are differentiated from stumps in not being secure in the ground. Stumps are fully rooted in the ground and are at distances far enough from the stream that there is little or no potential of them being uprooted and entering the instream zone. Root wads have a high potential for reaching the stream channel. Root wads classified as dead/down are anchored in the ground by less than 25 percent of their root system, or are already "loose" and free to be moved, or are already in the channel. Root wads classified as dead/standing are anchored in the ground by at least 25 percent of their root system and have a good likelihood of being moved from the recruitment zone (bank) to the stream channel, or may already be in the stream channel. Root wads classified as "perched" are on the bank, and their movement into the stream channel is imminent. There is no classification for "live" root wads. If a root wad is sprouting, it is classified as a live tree and categorized based on diameter of the sprouting stem.

LWD INVENTORY FORM KEY

1) **Stream** - Stream name.

2) **Sample__of__** - Indicate Sample No. of total 200-foot sample sections surveyed for each reach. Each sampled section is numbered consecutively proceeding upstream.

3) **Reach No.** - Number reaches consecutively beginning from the stream mouth. The reach number changes when the stream channel type changes (i.e., each reach is a distinct stream channel type).

4) **Date** - Date of survey (mm/dd/yy).

5) **Drainage** - River system.

6) **USGS Quad(s)** - Name(s) of 7.5-minute USGS topographic quadrangles.

7) **Reference Point** - Stream mouth or fixed landmark (bridge, tributary).

8) **Feet from Ref. Pt.** - Start: Distance from landmark at survey start.
Stop: Distance from landmark at survey end.

9) **Total Reach** - Total length in feet of inventoried reach, includes sampled and unsampled sections. Each reach is a distinct channel type.

10) **Latitude** - Latitude of stream confluence point.

11) **Longitude** - Longitude of stream confluence point.

12) **T__R__S__** - Township, range, and section of stream confluence.

13) **Surveyors** - Names of individuals conducting the inventory.

14) **Channel Characteristics** - Attach completed Stream Channel Type Work Sheet.

15) **Discharge Q** - Discharge in cfs at time of survey.

16) **Gradient** - Water surface slope in percent.

17) **Stream Channel Type** - From Stream Channel Type Work Sheet.

18) **Percent Substrate in Boulders** - Percent of the substrate in boulders in two size classes (does not = 100%). Size classes are 1-3 feet diameter, and greater than 3 feet diameter, measured at smallest diameter.

19) **Air Temp** - Air temperature in degrees Fahrenheit.

20) **Water Temp** - Water temperature in degrees Fahrenheit.

21) **Right Bank** - The stream's right bank, facing downstream, measured from bankfull discharge demarcation [bankfull width (W_{bkf})] to a point 50 feet upslope from the edge of the floodplain.

22) **Stream** - The channel area within bankfull width (W_{bkf}).

23) **Left Bank** - The stream's left bank, facing downstream, measured from bankfull discharge (Q_{bkf}) demarcation to a point 50 feet upslope from the edge of the floodplain.

24) **Slope** - Average percent slope of the right and/or left bank within the surveyed reach.

25) **Dom. Veg.** - The dominant live vegetation <u>less</u> than 1 foot in diameter within the entire survey reach is recorded by type and percentage: Code: 1 = Deciduous; 2 = Coniferous. The percent of the dominant type is noted as a decimal %. For example, an observation of deciduous vegetation estimated to compose 70% of the small (<1' diameter) vegetation should be recorded as: 1.70.

26) **D/D** - Number of dead and down pieces.

27) **D/S** - Number of dead and standing stems.

28) **Per** - Number of perched pieces for imminent delivery to stream.

29) **Live** - Number of live trees in two classes, coniferous and deciduous.

30) **Size Classes** - Range in upper part of box = diameter.
Range in lower part of box = length.

Example: the first row is: 1 - 2d x 6 - 20, which indicates the diameter category of 1 - 2 feet and a length of 6 - 20 feet.

31) **Root** - Root wads are a separate size class. They must meet the minimum diameter at the base of the trunk but are not required to meet the minimum 6 feet length criteria.

32) **Comments** - Note indicators of old forest systems (i.e., large stumps). Note presence of fish restoration structures, and if they were tallied. Note suppressed trees if present. Include fish and wildlife observations. Use back side of form if needed.

LWD INVENTORY FORM

Stream:________________________________ **Sample** _____of_____ **Reach No.**______

Date___/___/____ **Drainage:**_______________________ **USGS Quad:**_______________

Reference Point:____________________________________**Sample Length (Ft)**_______

Reach Location (Feet From Ref.Pt) Start _______ **Stop** ______ **Total** _________

Lat __ __ __ **N** **Long**___ __ __ **W (Reach start or Ref.Pt.)** **T** ___ **R** ___ **S**___

Surveyors:____

CHANNEL CHARACTERISTICS (Attach Channel Typing Form)

Discharge Q ________cfs Gradient _______ % Channel Type:__________

Percent Substrate in Boulders: (1'- 3') _______%; (>3') _______%

Air Temp _______ Water Temp _______

	Right Bank % Slope ________ Dom. Veg.________					Stream Dom. Veg.________				Left Bank % Slope ________ Dom. Veg.________				
	D/D	D/S	Per	Live C	Live D	Dead/ Down	D/S	Live C	Live D	D/D	D/S	Per	Live C	Live D
1-2d 6-20														
Root														
1-2d >20'														
2-3d 6-20														
Root														
2-3d >20'														
3-4d 6-20														
Root														
3-4d >20'														
>4d 6-20														
Root														
>4d >20'														

Note any LDAs (log jams), estimate size LxWxH and no. pieces. Note if gravel is retained upstream. Tally live conifer "C" and deciduous "D" trees separately. Tally root wads by diameter of "trunk". Include root wads <6' total length.

Comments:

ESTIMATE CALIBRATION FORM

Stream Name________________________________ Date____________

Surveyors__________________________________

Reach No._____

	Right Bank		Stream				Left Bank	
Sam ple	EST DIA.	TRUE DIA.	EST DIA.	TRUE DIA.	EST LENG.	TRUE LENG.	EST DIA.	TRUE DIA.
%								
Dis								

Reach No.____

	Right Bank		Stream				Left Bank	
Sam ple	EST DIA.	TRUE DIA.	EST DIA.	TRUE DIA.	EST LENG.	TRUE LENG.	EST DIA.	TRUE DIA.
%								
Dis								

Calibration Form Key

Stream Name: Enter name of stream
Date: Enter date of survey (mm/dd/yy)
Surveyors: Enter name of persons conducting the survey
Reach No.: The number that corresponds with the Reach No. on the LWD Survey Form.
Sample: The number corresponding with the Sample No. on the LWD Survey Form.
EST DIA.: Enter the estimated diameter.
TRUE DIA.: Enter the measured diameter.
EST LENG.: Enter the estimated length.
TRUE LENG.: Enter the measured length.
% Enter the average percent difference between estimate and true.
Dist.: Enter the 50-foot distance estimate and measurement.

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