GUALALA RIVER WATERSHED COUNCIL

Quality Assurance Project Plan
For
Monitoring Sediment Reduction

Revised Version for Proposition 50

QUALITY ASSURANCE PROJECT PLAN FOR MONITORING SEDIMENT REDUCTION IN THE GUALALA RIVER WATERSHED

Prepared for:
California State Water Resources Control Board
and
California North Coast Regional Water Quality Control Board

By
Kerry Williams, Sotoyome Resource Conservation District
Kathleen Morgan, Gualala River Watershed Council
December 2002

A. PROJECT MANAGEMENT

1. Title Page and Approvals

QUALITY ASSURANCE PLAN FOR MONITORING SEDIMENT REDUCTION IN THE GUALALA RIVER WATERSHED

This Document was compiled by:
Kerry Williams
Sotoyome Resource Conservation District
P.0. Box 11526
Santa Rosa, Ca 95406
(707) 569-1448

with contributions from

Matt O'Connor
O'Connor Environmental, Inc.
P.O. Box 794
Healdsburg, CA 95448

Henry Alden
Gualala Redwoods, Inc.
P. O. Box 197
Gualala, CA 95445

Gualala River Watershed Council
P.O. Box 1369
Gualala, CA 95445

Approvals:

North Coast Regional Water Quality Control Board

By: Peter Otis Date: December 4, 2002
Environmental Planner
Quality Assurance Manager

AA. Revisions Page and Approvals

I. Table 7.1: Total Suspended Solids has been revised 4/1/08 to the following:

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Total Suspended Solids (TSS)	Residue, Non-Filterable (EPA Method 160.2)	mg/l	4	NA	Standard Reference Materials (SRM, CRM, PT) within 95% CI stated by provider of material. If not available then with 80% to 120% of true value	Laboratory duplicate, Blind Field duplicate, or MS/MSD 25% RPD Laboratory duplicate minimum.	80%

II. Section 5, page 21, paragraph 5 has been revised 4/1/08 to the following:

If data do not meet the project's specifications (see Table 7.2 –error tolerance), the following actions will be taken. First, the technical advisors will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. If the problem cannot be corrected by re-training, revision of techniques, or replacement of supplies/equipment, then the technical advisors and the TAC will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, the parameter should be eliminated from the monitoring program.

Approval:

Kathleen Morgan Digitally signed by Kathleen Morgan DN: cn=Kathleen Morgan, o=Gualala River Watershed Council, ou=Coordinator, email=grwc@mcn.org, c=US Date: 2008.04.04 07:59:02 -07'00'

4/1/08

Kathleen Morgan
GRWC CQAO
GRWC Contract Manager

Date

SWRCB QAO — Date

SWRCB Contract Manager — Date

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3. Distribution List

Primary distribution list for the Gualala River Watershed Monitoring Program Quality Assurance Plan:

NAME	AGENCY/ORGANIZATION
Lauren Clyde	North Coast Regional Water Quality Control Board
Bill Cox & Doug Albin	California Department of Fish & Game
Matt O'Connor	O'Connor Environmental, Inc.
Steering Committee	Gualala River Watershed Council
Technical Advisory Committee	Gualala River Watershed Council
Field Team Leaders	Gualala River Watershed Council

Once approved, this Quality Assurance Project Plan (QAPP) will be available to any interested party by requesting a copy from the Sotoyome Resource Conservation District (SRCD) (see address on title page).

4. Project/Task Organization

The members of the Gualala River Watershed Council (GRWC) in partnership with the SRCD are implementing the Gualala River Watershed Monitoring Program. The GRWC is an association of stakeholders in the Gualala River watershed. These stakeholders include any persons and/or entities that live within, own property within, use water from, operate commercial businesses within or are affected by land uses within the Gualala River Watershed. There is also consistent participation by representatives of local, state and federal agencies.

Formation of the GRWC in 1997 was facilitated by the North Coast Regional Water Quality Control Board (NCRWQCB), the California Department of Forestry (CDF), the Redwood Coast Land Conservancy (RCLC) and with ongoing support from the SRCD.

The development of a Gualala River Watershed Monitoring Program with a QAPP is part of the ongoing development of a watershed enhancement plan for the Gualala River watershed. This program is currently being funded by grants from the State Water Resource Control Board (State WRCB) 319(h) program and the California Department of Fish and Game (CDFG) SB271 program.

The GRWC monitoring program is managed by the SRCD with program over site and coordination by the GRWC Steering Committee, and Matt O'Connor, O'Connor Environmental, Inc.

The following personnel and subcontractors will perform sample collection and analysis:

- Trained GRWC citizen volunteers
- Trained GRWC supervising staff

- O'Connor Environmental, Inc.
- Forest Science Project
- Macroinvertebrate Lab

The Sediment Reduction in the Gualala River Watershed Monitoring 319(h) Project is a multi-organization project. Consultants and volunteer citizen monitors and staff from Gualala Redwoods, Inc. (GRI) will work together to monitor and assess natural streams in the Gualala River watershed at monitoring sites selected as outlined in the scope of work for the project. The results of this monitoring shall be reviewed during periodic technical advisory committee (TAC) meetings. In addition, any problems, concerns, and/or proposed amendments to this QAPP will also be reviewed and discussed by the TAC.

The following is a list of key personnel and their project responsibilities.

TASK	KEY PERSONNEL
Contract Manager	Lauren Clyde, North Coast RWQCB
Project Director	Kerry Williams, Sotoyome RCD
Coordinator for Field Teams & TAC	Kathleen Morgan, GRWC
Equipment Supply, Calibration	Nola Craig, DFG Staff, SRCD Staff, GRI Staff, Kathleen Morgan, Matt O'Connor, GRWC volunteers
Field Data Collection	Nola Craig, DFG Staff, SRCD Staff, GRI Staff, Kathleen Morgan, Matt O'Connor, GRWC volunteers
Data Management	Matt O'Connor, Kathleen Morgan, Kerry Williams, SRCD Staff, GRI staff
Quality Assurance/Quality Control	Matt O'Connor, GRWC Team Leaders
Technical Advisors	Matt O'Connor, agency members of TAC

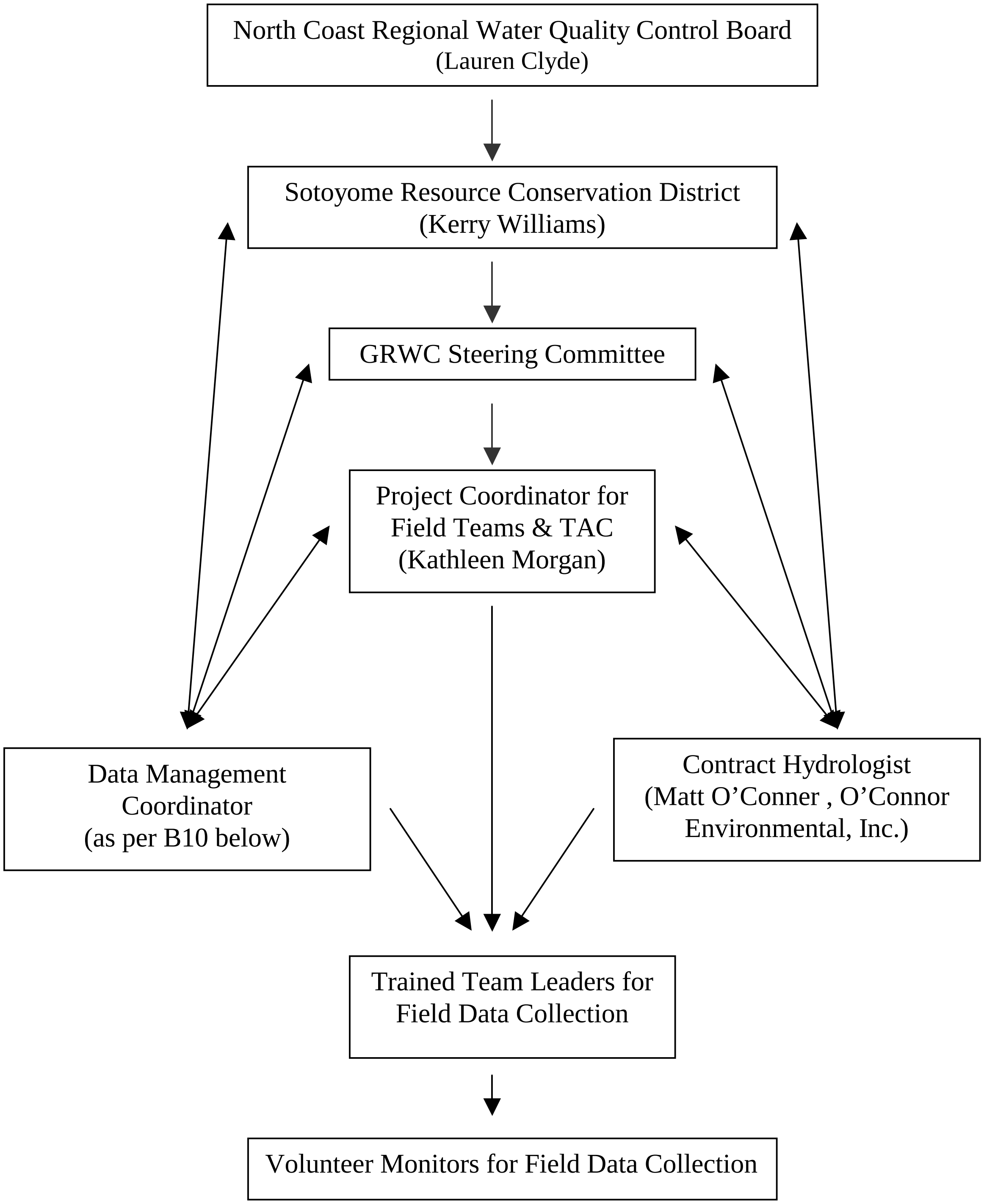
The organizational structure of the GRWC monitoring program is illustrated in Figure A-1.

5. Problem Definition/Background

Land use practices, combined with erosive landscape characteristics have accelerated the rate of erosion and mass wasting, and contributed to sedimentation in the Gualala River and its tributaries. Sedimentation is a result of a variety of natural and anthropogenic factors, including mass wasting, roads, and surface erosion. Sedimentation is believed to be a major contributing factor to the decline of historic runs of salmon and steelhead..

There is insufficient information to adequately assess the status of aquatic resources in the Gualala River watershed. The GRWC was formed in order to address watershed conditions and activities, including water quality concerns within the watershed. There are also small citizen monitoring groups forming to conduct monitoring in the various areas of the watershed and some private landowners have been conducting monitoring for several years. If quality assurance is adequate, valuable information will be provided for watershed management. One of the primary tasks of the GRWC is to design and implement a monitoring program for the watershed. A TAC has been formed to advise on this task.

Figure A-1 Organizational structure of the GRWC monitoring program.



6. Project/Task Description

This project will supplement existing agency information by monitoring streams in the Gualala River watershed. The focus of the project is on physical aquatic habitat and physical and biological water quality measures that will assist in identifying the status of these aquatic resources. Analysis, for the most part, will be conducted in the field with test kits and field instruments.

The objective of this project is to improve water quality through collaboration between public agencies, community groups, and private landowners. The project involves a three-year incremental process to implement non-point source controls, emphasizing on road improvements and to develop a mechanism for further assessments and implementation for reducing sedimentation in the watershed. The assessment and implementation will be aimed at improving water quality by reducing up-slope erosion impacts to the aquatic resources, improving the riparian zone, and enhancing anadromous salmonid habitat in the tributaries and main stem of the Gualala River watershed.

A map of the Gualala River watershed is attached as Appendix A.

The GRWC monitoring groups will be monitoring water quality in Gualala River watershed. Physical and biological parameters are measured; however, not all groups are measuring all parameters. Table 6.1 identifies the type and frequency of the monitoring parameters.

This QAPP addresses data quality objectives for the following parameters:

- Temperature
- Longitudinal Profiles & Benchmarks
- Cross-section Measurements
- Pebble Counts
- Large Woody Debris
- Canopy and Riparian Measurements
- Benthic Macroinvertebrate
- Streamflow, Turbidity and Total Suspended Solids

Table 6.1 Type and Frequency of Monitoring in the Sediment Reduction in the Gualala River Watershed Monitoring Program

Parameter	Maximum Frequency	Time of Year
Temperature	A	Summer
Longitudinal Profiles & Benchmarks	B	Summer
Cross-sections	B	Summer
Pebble Counts	B	Summer
Large Wood Debris	B	Summer
Canopy & Riparian Measurements	B	6/1-8/31
Benthic Macroinvertebrates	B	Fall
Stream Flow, Turbidity & Total Suspended Solids (Optional monitoring element)	C	Winter/Spring

Frequency: A: Annual B: Annual or less frequently depending on objectives C: Seasonal, frequency depending on objectives and flow conditions

7. Quality Objectives and Criteria

Table 7.1 Data Quality Objectives for Conventional Water Quality Parameters

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Temperature	Thermometer (-5 to 50)	^{o}C	-5	0.5 ^{o}C	± 10%	± 10%	80%
Turbidity	Tubes (5 -)	JTUs	< 5	5 JTUs	± 5 JTUs	NA	80%
Total Suspended Solids (TSS)	Refer to page ia for revisions						

NA: not applicable

Table 7.2 Data Quality Objectives for Physical Aquatic Habitat Parameters

Parameter	**Time scale**	**Spatial scale**	**Endpoints/units**	**Tolerated error**	**Supporting documentation**	**Prep by professionals**
Large woody debris survey	1 year maximum and after major events.	Stream reaches of 1000 ft or 20 bankfull widths, whichever is more.	All LWD > 6 in. diameter and > 4 ft length within the bankfull channel; locate position of LWD in the long-profile.	Length +/- 1 ft per 5 ft, Diameter +/- 2 in. per 6 in., Root wad dimensions +/- 1 ft per 2 ft of size. Distance from start point (long profile survey) +/- 3 ft to center point of log.	Notes on how to locate beginning and ending points of reach, associated long-profile data, associated cross-section data.	Measurement techniques, how to handle odd LWD shapes, how to estimate jam volumes when all pieces are not visible.
Longitudinal channel profile	1 year maximum and after major events.	Stream reaches of 1000 ft or 20 bankfull widths, which ever is more. Thalweg elevation minimum of 10 ft intervals.	The most important features to measure are: riffle crests, breaks in slope and deep points of pools. Measure elevation (± 0.02 ft) whenever the channel bed changes slope and at least every 15 ft where the slope is relatively uniform (e.g. a long run, riffle or pool).	Elevation +/- 0.02 ft; distance (± 3 ft) from start point and left right offset (± 4ft). Elevation closure within 0.01 ft for each benchmark, each turning point, and each 500 linear feet of distance.	Notes on how to locate beginning and end points of reach, associated cross-section data, pebble count data, photo-documentation of stream channel and benchmarks.	Surveying techniques, site selection.
Cross-sections	1 year maximum and after major events.	3 per 1000 ft reach are conventional; sites initially selected are likely spawning sites defined as riffles located at pool tails.	Elevation observations at inflections points with at least one intervening point between breaks in slope. The most important features to measure are: breaks in slope, bankfull, wetted width and thalweg. Average spacing between observations equivalent to < 5% of bankfull width.	Elevation closure within 0.01 ft for each benchmark, each turning point, and each 500 linear feet of distance.	Notes on how to locate beginning and ending points of cross-section, associated long-profile data, pebble count data, and photo-documentation of stream channel.	Surveying techniques, site selection.

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Pebble count (Wolman 1954) (as specified for GRWC) Refer to Appendix F	1 year maximum and after major events.	4 per 1000 ft reach are conventional; sites initially selected are likely spawning sites defined as riffles located at pool tails.	100 measurements in a random walk on the riffle surface from upstream to downstream, collecting a pebble diameter at 3 ft intervals (about one stride by the observer). Lateral extent of observation area defined by active bed deposits lacking significant vegetation or leaf litter.	Individual pebbles to +/- 1mm	Location within long profile and associated cross-section stations and reach end point.	Measurement techniques and data recording.
Riparian Canopy Closure	1 year at time of installation of the temperature data logger.	Thermal reaches of a 1000 to 2000 feet above data logger installation site.	Using a spherical densiometer adapted to the Strickler method (1959). From center of channel take measurements at 100 ft. intervals along the thermal reach.	+/- 2 intersections in the field of view	Notes on how to locate beginning and ending points of a thermal reach and center of channel, associated Forest Science protocols.	Measurement technique and data recording.
Riparian Canopy Density	1 year maximum and after major events.	In stream channel and riparian forest stand plots located at 200 ft intervals along monitoring reach.	Using a spherical densiometer, measure the percentage of overhead canopy density at 5 locations along a transect perpendicular to the stream channel: center of channel, at the left and right edge of the bankfull channel, and at 50ft beyond the bankfull channel edge in the riparian zone.	+/- 2 squares in the field of view i.e. +/- < 10%	Notes on how to locate beginning and ending points of reach, associated long-profile data, reference to associated riparian stand inventory plots.	Measurement technique, sampling rules regarding non-standard situations (e.g. what is done if the 50 ft distance ends on a road, or a very steep slope that cannot be negotiated?).

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Riparian forest stand inventory	1 year maximum and after major events.	Sample of trees and downed logs within a 100 ft long, 21.8 ft wide (20th acre) rectangular plot and understory in a 100th acre sub-plot in riparian forest stands located at 200 ft intervals along monitoring reach.	Measure height and live crown % and distance of the first 3 conifer trees > 5.6 in DBH from the origin of the plot centerline. Estimate DBH and measure distance of all remaining tree species >5.6 in DBH. The diameter of all down logs that intersect the 100 ft centerline of the plot is also measured. A 100th acre lesser vegetation sub-plot is established 15 ft from bankfull. The plot is established and monumented with rebar at the edge of the bankfull channel and the 100 ft end point.	Length/Height +/- 1 ft. Diameter +/- 1 in. Distance from plot start point +/- 1 ft	Notes on how to locate beginning and ending points of plot, adjust 100 ft measurement for slope, associated long-profile data, reference to associated riparian canopy data.	Measurement techniques and sampling rules for non-standard situations (e.g. what is done if the 100 ft distance ends on a road? or a very steep slope that cannot be negotiated?).
Turbidity	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	NTU's, see Table 7.1	See Table 1, +/- 10%	Manufacturer's instruction manuals.	Training of monitoring team leaders; QA/QC on data and instrument logs
Stream Discharge	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	cubic feet per second (cfs)	+/- 10%	US Geologicial Survey WRI Report 00-4036, ver. 1.1 (CD-ROM interactive training manual)	Training of monitoring team leaders; QA/QC on data and instrument logs

Table 7.2 continued…

Parameter	Time scale	Spatial scale	Endpoints/units	Tolerated error	Supporting documentation	Prep by professionals
Total Suspended Solids	Instantaneous during periods of storm runoff	Designated cross-section locations within larger monitoring sites	Sample collected using a depth-integrated sampler; sample represents verticle spatial average concentration of solids in the water column; optimal sample is in or near channel thalweg as flow conditions permit; number of samples likely to be limited by funds available for lab processing; intended for correlation with turbidity data and stream discharge collected at the same site and time	See Table 1, +/- 10%	Manufacturer's instruction manual for use of depth integrated sampler (equivalent to USGS DH-48 sampler)	Training of monitoring team leaders; QA/QC on data and instrument logs

Benchmarks for each parameter are addressed separately

Table 7.3 Data Quality Objectives for Biological Parameters

Parameter	Method/range	Units	Detection Limit	Sensitivity*	Precision	Accuracy	Completeness
Benthic Macro-invertebrates	Calif. Stream Bioassessment Protocol (CDFG)	N/A	Family level	N/A	$\leq$ 5% difference	$\leq$ 5% difference	80%

8. Special Training/Certification

The Gualala River Watershed Coordinator, members of the GRWC, employees of SRCD, employees of Gualala Redwoods, Inc. and volunteers from the community will collect data at selected sites in the watershed and will receive training in techniques used to evaluate general watershed condition. All protocols and example data collection sheets are attached in the Appendices and source documentation is identified in the protocols themselves.

The data will be made available to the public to use for educational and informational purposes. It is hoped that information gained from the ongoing volunteer monitoring program will lead to land management decisions that consider the health of the watershed.

All citizen-monitoring leaders must participate in three hands-on training sessions related to water quality and channel monitoring conducted by either GRWC or a comparable entity and approved by the SRCD and RWCQB. Training sessions will be held in the Gualala River watershed. Certificates of completion will be provided once all training as been completed. The following topics will be covered under this training:

- General hydrology
- Ecology
- Health and Safety
- Quality Assurance and Quality Control (QA/QC) Measures
- Sampling Procedures
- Field Analytical Techniques
- Data recording

The trainer will ensure that volunteer citizen monitoring leaders are reading instruments and recording results correctly. Individual trainees are evaluated by their performance of analytical and sampling techniques, by comparing their results to known values, and to results obtained by trainers and other trainees. Sampling and safety techniques will also be evaluated. The trainer will discuss corrective action measures with the volunteers, and the date by which the action will be taken. The citizen-monitoring leader is responsible for reporting back if any corrective action is taken. Certificates of completion will be provided once all training has been completed.

To be certified for macroinvertebrate bioassessment citizen monitoring leaders must also participate in a three-day training course provided by the CDFG, the Sustainable Lands Stewardship Institute, the American Fisheries Society, or the State WRCB.

9. Documents and Records

All field results will be recorded at the time of completion in the field, using the data sheets (data sheets are included with each individual protocol in the appendices B through H) and field logbooks. Each monitoring group will also keep and record information in the instrument maintenance logs.

Data sheets will be reviewed for outliers and omissions before leaving the sample site at the completion of each data collection. Data sheets will be signed after review by a team-monitoring leader. Data sheets will be turned in to data headquarters within one week of actual data collection. Data headquarters will be either the SRCD office or.(we need to choose another alternate location in Gualala area)The monitoring coordinator's house. Copies of all data sheets will be made immediately upon receipt at data headquarters. Original copies will be stored in an "original binder" and copies will be put into a "working binder." Copies of all information in the field logbooks will be made and inserted into the working copy binder. Entry of all data will be made into a computer database within three months of data collection. computer backup copies will be made on a quarterly basis and will be made and held at data headquarters. All data entry and other tasks involving data sheets will utilize the working binder. The original binder shall be used as a reference only. Field sheets are archived for three years from the time they were collected.

Instrument maintenance logs will also be kept by each citizen-monitoring group for each instrument in use. These include HOBO temperature units. The instrument logs detail the dates of equipment inspection and calibrations, as well as the dates reagents are replaced. The logs will be returned to the team-monitoring leader following each monitoring event, in case a review is necessary. Instrument logs will be turned in with data sheets and photocopies will be placed in the working binder.

A field site log pertaining to the location, including maps, specific directions to locating sample sites in the field, photographs, and site characteristics (including site selection criteria particular to each site) will be maintained at headquarters and updated annually. Within one week after each site visit, copies of the field log will be made and inserted in the working binder. Once field logs are full, the original will be kept at data headquarters along with other original documentation.

The Monitoring Program Coordinator and scientific members of the Technical Advisory Committee will complete an annual audit of data sheets and instrument logs.

B. DATA GENERATION AND AQUISITION

1. Sampling Process Design

Up to 30 sampling sites will be selected as part of this program with the GRWC and TAC participation. The following criteria will be evaluated when choosing sampling locations:

- sample can be taken in main river current or where homogeneous mixing of water occurs (pertains to temperature and turbidity measurements);
- sample is representative of the part of the river of interest which may include sampling related to implementation projects;
- location complements or supplements historical data;
- location represents a stream reach that possesses typical representative value for fish and wildlife or recreational use.

Additional criteria that will help determine the location of sampling sites includes:

- access (convenience in terms of time and effort);
- safety (access and specific site conditions anticipated during periods of field data collection);
- permission to cross private property (access agreement).

The monitoring program, as outlined in task 4 of the 319h contract, requires reference sites to assess the effectiveness of implementation projects. These locations will be chosen upstream and downstream of any potential impact, and upstream and downstream of any secondary discharge or disturbance.

Prior to final site selection, permission to access the stream is obtained from all property owners. If access to the site is a problem, the citizen-monitoring leader will select an alternate site. Safety issues will be included in the Gualala River Watershed Monitoring Manual.

The group leader will review sample sites. Relevant site characteristics will be observed and recorded on the field data forms and logs.

Data pertaining to date and time of sampling and weather conditions will be transcribed to the field data log (described in A9 above). A catalog of site photographs will be maintained as part of the field data log. See tables 6.1, 7.1, 7.2, 7.3.

2. Sampling Methods

Field Observations

Sampling Site Observations

Site condition observations will include pertinent detail about the location of the site, access, special considerations, photos obtained, and sampling point location(s), as well as climatic and hydrologic variables. These observations will be documented in a waterproof field data log as well as on data collection sheets (referred to in A9) to maintain standardization of information, and ensure all variables are recorded. All forms for data collection will be included in the appendices for each individual protocol. The field data pertaining to site conditions will be transcribed to the field data log (see A9).

Automated Sample Collection

Data loggers are effective in collecting physical-chemical measurements on short time intervals over many days without constant staff oversight. Data are stored on internal memory chips and downloaded to a computer in the field or office for further data analysis. The only protocol utilizing automated sample collection in this QAPP is temperature.

Temperature

Temperature loggers manufactured by Onset® Corp., will be programmed to sample at least every 96-minutes. With 8K of internal memory, a full summer of data can be collected. Additionally, the 96-minute sampling interval is the minimum specified in the cooperative effort developed by the Forest Science Project (FSP 1998) to detect daily maxima (Appendix B).

Basic considerations for site selection are presented in the modified protocol. The primary use of the data at this point is for characterizing a stream reach, so placement is in a well-mixed, flowing section of the stream that is representative of a reach.

A thermal reach is a reach with similar (relatively homogenous) riparian and channel conditions for a sufficient distance to allow the stream to reach equilibrium with those conditions. The length of reach required to reach equilibrium will depend on stream size (especially water depth) and morphology (TFW, 1993). A deep, slow moving stream responds more slowly to heat inputs and requires a longer thermal reach, while a shallow, faster moving stream will generally respond faster to changing riparian conditions, indicating a shorter thermal reach. Generally, it takes about 1000 feet of similar riparian and channel conditions to establish equilibrium with those conditions in fish-bearing streams.

Data sheets for calibration, deployment, and site conditions accompany the data for each deployment and are provided in Appendix B. Raw field data is delivered to the Forest Science Project (FSP) for processing and analysis according to FSP protocols. The processed temperature data is then returned to the GRWC in both raw and analyzed form.

Channel Measurements

Stream channels form and are maintained by the interaction of streamflow and sediment regimes in a process that yields consistent average channel shape and size (Dunne and Leopold 1978). A reach is a section of a stream at least 20 times longer than its average channel width (Flosi and Reynolds, 1994) that maintains relatively homogenous channel morphology, flow, and physical, chemical, and biological characteristics.

The width and depth of a channel reflects the discharge and sediment load the channel receives, and must convey, from its drainage area. Channels are formed during peak flow events, and channel dimensions typically reflect hydraulic conditions during bankfull (channel-forming) flows.

Channel form and composition is monitored at low water. The monitoring is done within a section of a stream called a study reach. All locations for study reaches will be selected, reconnoitered with respect to reach criteria described above, and flagged by GRWC Technical Committee Members (TAC) and/or Technical Advisors before the sites are assigned to be surveyed. During reach reconnaissance, locations where cross-sections and bed composition protocols will be implemented are flagged. The study reach will be re-visited on a seasonal schedule consistent with the monitoring objectives. The study reach procedure for channel form monitoring is outlined below and specific information regarding basic surveying techniques is available in Appendix C.

- The study reach is first laid out on the ground
- Bankfull indicators are identified and bankfull width is determined
- Three benchmarks are established
- Three cross-sections are then located and staked
- A longitudinal survey is performed
- Cross-sections are surveyed
- Bed composition protocols are performed
- Large woody debris is surveyed
- Riparian measurements and Canopy Density are recorded
- Water quality tests are run

The following descriptions are summaries of the measurements with reference to specific literature. Specific methods and the actual references for these metrics are presented in the appendices.

Longitudinal (Thalweg) Profiles & Benchmarks

The amount of variability in thalweg along a longitudinal axis in the stream is a good measure of complexity of the wetted stream channel. Pools, logs, boulders, riffles, etc. add complexity to the channel that affect sediment transport, channel form, and fish habitat. Changes in the thalweg profile reflect overall changes in the channel complexity, which are a result of channel-forming forces in the stream. Reduction of complexity occurs with excessive sediment introduction. Increased complexity indicates a recovery from such a condition. Thalweg profiles provide information on existing conditions, but are useful in trend analysis over the long term.

Strictly implemented, a thalweg profile or survey, as mentioned above, measures the streambed elevation along the thalweg of the stream, taking particular care to measure all breaks-in-slope, riffle crests, maximum pool depths, and pool tail-outs. Concurrently, while the tapes, levels, etc., are set up for measuring thalweg profiles, the locations of transects for cross-sections are also usually documented and measured (Madej, and Ozaki, 1996; Ramos, 1996). Since it is impossible to uniformly arrange the longitudinal tape exactly over the thalweg, measurements should be perpendicularly referenced to the centerline tape, and read to within one foot. Ramos suggests that as thalweg measurements intersect the point of a designated cross-section, the thalweg should be measured at the intersection first, and then the cross-section is surveyed before proceeding upstream. In addition to the thalweg elevations, other variables, such as water surface, bar height, substrate size, high water marks, and comments on local channel features such as pools, riffles, runs, and the presence or absence of large woody debris can be recorded. Subsequent analysis of the profile allows the detection of changes in the vertical dimensions of channel features. Depending on the data obtained from the thalweg survey, standard parametric and non-parametric statistical methods can be applied to more fully interpret survey results.

Depending on the study's intent, the reach length surveyed in a thalweg profile may vary from 20 to 50 channel widths. Rather than channel widths, surveys can also be modeled around a specific number of meander segments, generally three to four, within a reach (Madej, and Ozaki, 1996; Trush, 1997; Rosgen, 1996). The important consideration in selecting a specific length for a reach to conduct thalweg profiles is the ability of the study design to answer any questions or hypotheses proposed, whether it is to detect changes over time in channel aggradation or degradation, or to inventory available pool and riffle habitat for salmonids and other insteam biota.

Specific methods and the actual references for Longitudinal Profile surveys are presented in Appendix E.

Cross-sections

Channel cross-section measurements provide valuable information on the shape and dimension of a stream channel and its relationship to the flood plain. Coupled with other measurements, cross-sections measured repeatedly over a period of years provide valuable information on the transport and storage of sediment in the stream channel and inter-annual variation of stream channel geometry. Common parameters can include width/depth ratio, bankfull depth, entrenchment, and flood-prone area. For utility and ease of reference, other parameters, such as scour chain and bank-pin placement (for monitoring bed scour and fill and bank erosion and accretion, respectively), pebble counts, riparian canopy measurements, etc., can also be combined and conducted at cross-section locations.

Monitoring the long-term changes in cross-sectional data can provide insights into channel bed and bank stability, and relationships between sediment transport and discharge (Beschta and Platts 1986). , For example, stream aggradation may be manifested by changes in channel geometry such as decreasing thalweg depth, increasing channel width, and increasing mean bed elevations. Channel incision (i.e. downcutting) may be indicative of a return to more "natural" conditions from previous management and/or impacts of major storms and floods (McDonald, et al., 1991).

A typical study design can have as few as three, or as many as 15-20 cross-sections located in a study reach. A reach has been variously defined as 20-50 bankfull flow widths (Kondolf and Micheli), one thousand meters (Knopp, 1993), or a predetermined length based on the geomorphic characteristics of the watercourse under study. For example, Madej and Ozaki, defined a study area as 26 kilometers long in Redwood Creek from its confluence with the

Pacific Ocean to a slope-determined end point. Within the study area the 26 km stream segment was divided into three interconnected reaches, an upper, middle, and lower reach. A total of 58 cross-sections were nested within the three reaches. The end points of each reach were determined by major breaks in stream gradient.

A cross-sectional profile is developed by measuring points along a tape measure stretched across the stream and recording the distance, and surveying streambed elevations at each specific point along the tape. Streambed characteristics, such as changes in bottom elevations, the position of the field estimated bankfull height, wetted width, breaks in slope, and the deepest points in the particular channel feature being measured are recorded. The end points of the cross-section should extend at least above the estimated bankfull stage and preferably beyond the current floodplain.

Specific methods and the actual references for Longitudinal Profile surveys are presented in Appendix E.

Pebble Counts

One of the most widely used methods of sampling grain size from a streambed is the pebble count technique (Wolman, 1954). It can be used as a simple and rapid stream assessment method that may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams (Potyondy and Hardy, 1994). Pebble counts are routinely used by geomorphologists, hydrologists and others to characterize bed material particle size distributions of wadable, gravel bedded streams. The procedures have been adapted in fisheries studies as a preferred alternative to visually characterizing surface particle sizes commonly used during instream flow studies (Kondolf and Li, 1992). The methodology is best applied in gravel and cobble streams with a single channel and are not applicable to lower gradient, sand-bed dominated channels. A recent, comprehensive review of [Bunte, 2001 #641] measurement of streambed sediment in wadable, gravel bedded streams describes the advantages and constraints of a wide variety of sampling designs.

Pebble counts are conducted by randomly collecting, counting and measuring the intermediate diameter (b-axis) of 100, and up to 200 (Kappesser, 1993) particles from the surface of a given streambed. Bunte and Abt (2001) suggest that accurate characterization of the size distribution of sediment for a given reach requires a sample of 400 measurements. Riffles deemed suitable for spawning salmonids are the preferred location for sampling efforts (Schuett-Hames, et al., 1999). Pebbles are collected along transects at measured points following a predetermined grid pattern, or by walking the streambed and picking up individual pebbles at the toe of a boot along a toe-to-heel, zigzag pattern. Whether the structured grid pattern or the toe-to-heel method is used, all transects should traverse the stream channel from the estimated bankfull to bankfull stage.

After at least 100 pebbles are sampled cumulative size distribution curves can be developed for the D50, median particle size, the diameter at which 50% of the particles are finer, and the D16 and D84, the diameters at which 16% and 84% of the particles are finer. Other analyses that may be applied are the geometric mean diameter: $dg = [(D84)(D16)]^{0.5}$ and the geometric sorting coefficient: $sg = (D84/D16)^{0.5}$ (Kondolf and Li, 1992). As mentioned, it has been shown that shifts toward the lower end of the pebble count cumulative frequency curves may be indicative of significant increases in streambed fines from accelerated natural and or land-use disturbances. Conversely, a progressive coarsening of streambed surface particles may indicate improving conditions from past upstream and/or upslope disturbances.

Specific methods and the actual references for pebble count procedures are presented in Appendix F.

Large Woody Debris

Large Woody Debris (LWD) is known to be an important structural element of stream channels. It improves juvenile Coho salmon and steelhead trout summer rearing habitat by increasing the numbers and depths of pools. Large amounts of LWD also increase winter cover that is critical for salmonid protection from predation and the reduction of water velocity.

Beechie and Sibley (1997) concluded that when the number of LWD pieces (>8 inches in diameter) reached about 122 pieces /1,000 Ft., pool formation is less sensitive to further increases in LWD loading. Similarly, Martin (1999) found that the effectiveness of LWD for forming pools in alluvial channels was diminished when the LWD load exceeded a threshold of approximately 137 pieces. LWD loading (m^3 of LWD per 100 m of channel length) in surveyed stream reaches in northern California have been compiled and may provide another useful basis for assessment of LWD abundance [O'Connor Environmental, 2000 #687].www.fire.ca.gov/bof/pdfs/garcia_LWD_final.pdf

To monitor large woody debris we use an inventory method developed in partnership by GRI and the GRWC after reviewing other accepted techniques. It is designed to allow sorting and recompiling of data to answer different questions over time. A measurement is made of every piece that breaks the plane of the bankfull line and is at least 6” in diameter on the small end and 4’ long.

Specific methods and references for monitoring LWD are presented in Appendix G.

Riparian Measurements and Canopy

Riparian, or streamside forest, provides habitat for many types of wildlife, shades the creek keeping water temperatures cool for salmon and trout, and protects creek banks. When a tree is undercut and falls into the creek it becomes the large wood, and essential element for fish habitat. There are several features of riparian forest that indicate its value as habitat and as part of the stream system. The density and diversity of plant species, the width of the riparian corridor beyond the edge of the creek scour channel, the size of the trees in the corridor and the occurrence of dead trees, vines, downed wood and other features, all describe the habitat value of the forest for birds, mammals, reptiles, amphibians and salmonids.

The density of the streamside tree canopy creating shade over the creek, and the availability of large trees along the banks to become wood in the stream are features of the riparian forest, which relate to salmon and trout habitat in the creek channel. The extent of creeks in the watershed with dense riparian corridor indicates where water temperatures are likely to be low. By assessing the riparian area the current conditions of the riparian areas will be documented and these current conditions can be compared throughout the watershed. The objective of the riparian assessment is to understand and identify areas in need of restoration and enhancement. In addition, monitoring over time will provide the opportunity to investigate the relationship between riparian stand conditions and LWD recruitment to stream channels and effect on aquatic habitat.

The riparian surveys use the Forest Projection System (FPS) developed by Dr. Jim Arney of Forest Biometrics. Riparian forest stands will be inventoried by identifying a sample of trees by species within 20^{th} acre plots at 200 ft intervals along the established monitoring reaches. The 20^{th} acre fixed plots are run up-hill from bank-full to 100 feet and are 21.8' wide. Measurements of live trees, snags, down-logs and understory vegetation are documented.

Canopy density is measured using a spherical densiometer to record the riparian vegetation shading the creek. The measurements are taken in conjunction with the riparian surveys. Measurements are taken at five points at the established riparian plot sites: center of channel, bank-full (right & left), and 50 ft. inland from the bankfull point. Four readings per location are made first facing upstream, left bank, downstream, and right bank then the results are averaged to provide an estimate of canopy cover for that point.

Specific methods and the actual references for canopy and riparian monitoring procedures are presented in Appendix H.

Biological Sample Collection

Freshwater benthic macro invertebrates include worms, snails, clams, crustaceans, aquatic beetles, the nymph form of mayflies, stoneflies, dragonflies and damselflies and larval form of caddisflies and true flies. They are a minimum of 0.5 mm in length and live primarily on instream boulder, cobble or gravel substrate. They are most easily categorized into feeding guilds, species that obtain a common food source in a similar manner. The most common feeding guilds are shredders, filter-collectors, collect-gatherers, scrapers-grazers, and predators.

The physical structure of rivers and streams are measured by stream order, which is related to watershed size. Stream order influences the assemblage of benthic macro invertebrates. The Gualala River mainstem is a fourth order stream, all other tributaries within the basin are of smaller order. The predominant feeding guilds in fourth order streams are scrapers, which consume the algal growth associated with a more open canopy cover and collectors utilizing the high amount of fine particulate organic matter, which has drifted downstream. Shredders, which process leaf litter and other forest debris, and collectors, which further process shredder excrement, usually dominate first and second order streams.

Macroinvertebrate samples will be obtained using the methodology outlined in the *California Stream Bioassessment Procedure* (CDFG 1999). Sampling sites will be selected according to guidance provided in those protocols as well as knowledge of the watershed and land uses upstream of the site.

Other interesting, descriptive, or unusual biota will be noted in the field log at the time of sampling to provide additional qualitative information on the relative health of the water body.

Stream Discharge, Turbidity, and Total Suspended Solids

The measurements and data analysis presented below describe a limited monitoring program utilizing field observations and measurements collected by monitoring personnel that could be used to quantitatively characterize the magnitude of the measured parameters. Although the protocol provides for the collection of quantitative data, the interpretation of the data is limited by high sample variance and small sample size. A statistically robust data set that could potentially be used to assess trends or cause-effect relationships between water quality and land management would require at minimum a continuous data record that could be produced only by automated samplers, supplemented by a field monitoring program comparable to that presented here. It would be possible for committed field personnel to produce a valuable data set using this monitoring protocol, however, the investment of time and effort would be high.

Simultaneous measurements of stream discharge (instantaneous rate of flow in units of cubic feet per second), water turbidity, and total suspended solids in the water column form a discrete component of the monitoring program that can be conducted during periods of storm runoff from October through the end of the rainy season. Monitoring sites will require installation of a monumented cross-section, a staff plate allowing observation of water surface elevation surveyed in the cross-section, and must be relatively accessible and safe for sampling during periods of runoff.

The field protocol includes observations of time and stream stage, collection of a depth integrated water sample for subsequent lab analysis of suspended solids, collection of a surface grab sample for field measurement of turbidity, and measurement of stream discharge (requires at least 0.5 hours of wading and measurement of stream velocity with a current meter). Supplemental data on flow velocity at the water surface will be collected using a float test. The relationship between stream discharge and surface velocity will be used to improve the accuracy of estimated stream discharge during periods when in-stream measurements are not possible or unsafe. Following the discharge measurement, a second set of stage and water samples are collected. Observations of stage, turbidity, and suspended solids immediately before and following discharge measurements are intended to account for variability of conditions in the short-term, including potentially rapid changes in stream stage and discharge.

The surface grab sample for field measured turbidity should be taken as near the channel thalweg as possible, and must be collected from a location where flow is well-mixed. The same criteria apply to the depth integrated sample. Samples for turbidity will be processed immediately in the field. Samples for suspended solids will be labeled and refrigerated and will be transported to a contract laboratory as soon as possible, normally within 72 hours. Chain of custody forms will be maintained for these samples.

Stream discharge measurements typically require measurement of stream velocity at a minimum of 10 points, and preferable 20, in the cross-section. These measurements necessarily include periods of storm runoff. Safety considerations are paramount, and it is anticipated that there will be periods of flow when field personnel will determine that in-stream measurements are not sufficiently safe. In recognition of this reality of field work in streams, supplemental observations of surface velocity are included in the monitoring protocol.

Specific methods and the actual references for canopy and riparian monitoring procedures are presented in Appendix I.

Photo Documentation

Photos of the downstream end of the reach are taken to document location of benchmarks used to relocate and resurvey the reach. In addition, instream photo monitoring using photos taken both upstream and downstream from station zero, at each cross-section station, and at end of the reach is conducted to record general channel conditions and assist in interpretation of channel change over time. No formal analysis of photos is conducted. Specific methods are included in the monitoring procedure where photo documentation is part of the methodology (i.e. longitudinal profiles, cross-sections).

3. Sample Handling and Custody

Field teams will collect data with a team leader supervising. All data sheets and instrument logs will be turned into the team leader who will check the data for quality and completeness. As noted above, chain of custody will be documented for water samples collected for laboratory processing, withshipment to laboratory based on the protocols for the individual metrics. Chain of custody (COC) forms will be maintained for all samples.

4. Analytical Methods

The parameters being measured as part of this QAPP are physical in nature and do not involve analytical methods, with the exception of turbidity and total suspended solids. Turbidity measurements will be collected using a field instrument approved for this purpose by the California Regional Water Quality Control Board, North Coast region (RWQCB). Total suspended solids would be determined using EPA Method 160.2. Additional information regarding these methods is provided in Appendix I.

5. Quality Control Requirements

Each of the parameters being used in this QAPP has an associated Quality Control, which is addressed in the Appendices.

Field data sheets will be checked and signed in the field by the monitoring leader. For laboratory samples the monitoring team leader will discard any results where holding times have been exceeded, sample identification information is incorrect, samples were inappropriately handled, or calibration information (recorded in the instrument logs) is missing or inadequate. Following each event, the team leader will collect the field notebooks and data sheets. All notebooks and data sheets will then be copied and stored in a site-specific binder. The binder and the original data will be stored in a specied location.

Independent laboratories will report their results to the monitoring leader. The leader will verify sample identification information, review the chain-of-custody forms, and identify the data appropriately in the database.

Data sheets and data files will be reviewed quarterly by the technical advisors to determine if the data meet the Quality Assurance Project Plan objectives. They will identify outliers, spurious results or omissions to the citizen-monitoring leader. They will also evaluate compliance with the data quality objectives. They will suggest corrective action that will be implemented by the citizen-monitoring leader. Problems with data quality and corrective action will be reported in final reports.

If data do not meet the project’s specifications (see Table 7.2 –error tolerance), the following actions will be taken. First, the technical advisors will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. If the problem cannot be corrected by re-training, revision of techniques, or replacement of supplies/equipment, then the technical advisors and the TAC will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, the parameter should be eliminated from the monitoring program.

6. Instrument/Equipment Testing, Inspection and Acceptance Maintenance

All sampling equipment will be inspected for broken or missing parts, and will be tested to ensure proper operation. Inspection of equipment will occur as a pre-sampling check prior to use or as indicated by an exceeded QC limit. Maintenance will be performed in accordance with manufacturers recommendations or more frequently if problems are identified by QC checks.

Testing, inspection, and calibration for each specific piece of equipment are addressed in the Appendices. The following is a list of equipment that will be needed for the parameters being measured in this QAPP:

- ✓ Onset Hobo Temperature Data Loggers
- ✓ Non-Mercury Thermometers (NIST certified)
- ✓ Engineers Level, tripod, Stadia rod, 8” carpenter level
- ✓ Compass
- ✓ Clinometer
- ✓ Densiometer
- ✓ Calculator
- ✓ Camera
- ✓ 200’ Fiberglass 2-sided tape, 150” Fiberglass tape, Spenser tape, 25’steel tapes, clear metric rulers
- ✓ (optional) Turbidometer, field unit (issued by RWQCB to GRWC)

Additional equipment that will be used but will not require any testing, QA/QC related inspection or maintenance will include:

- ✓ Fence Posts
- ✓ D-shaped kick net (0.5 mesh)
- ✓ Lag Bolts & Driver
- ✓ 3’ Rebar
- ✓ Flagging
- ✓ Rudd Paint
- ✓ Aluminum & Code Tags
- ✓ Sledge Hammer
- ✓ Fence Post Pounder
- ✓ Clippers & Machete

7. Instrument/Equipment Calibration and Frequency

The equipment calibration and frequency is addressed for each protocol where equipment needs to be calibrated. This includes the calibration of the data loggers discussed in the temperature protocol (Appendix B) and the calibration of the turbidometer used in the optional water quality protocol (Appendix I).

8. Inspection/Acceptance of Supplies and Consumables

The inspection of supplies and consumables for the macroinvertebrate sampling are outlined in California Stream Bioassessment Procedure. Inspection of equipment will occur as a pre-sampling check prior to use or as indicated by an exceeded QC limit. Maintenance will be performed in accordance with manufacturers recommendations or more frequently if problems are identified by QC checks.

9. Non-direct Measurements

N/A to project

10. Data Management

Refer to A9 above for discussion regarding handling of data sheets and instrument logs. The designated data management coordinator will review the field sheets and enter the data deemed acceptable by the citizen monitoring leader(s) and the technical advisors. Data will be entered into a spreadsheet or a database using a format that is approved by the RWQCB. The data coordinator will review electronic data, compare to the original data sheets and correct entry errors. After performing data checks, and ensuring that data quality objectives have been met, data analysis will be performed. Summary statistics will be generated annually.

Raw Data

Raw data will be provided to the State WRCB and RWQCB in electronic form at least once every year so that it can be included in the 305(b) report and referenced for other watershed improvement projects and/or studies. Appropriate quality assurance information can be provided upon request. This should occur when the data files are updated and backed up (see A9 above). Refer to B2, B3 and B5 for additional discussion regarding data quality control processes.

Analysis

Temperature

Raw temperature data will be processed according to the methods outlined in the FSP protocols. A core set of metrics will be calculated from the data on a seasonal basis. These will include:

- daily minimum
- daily maximum
- daily average
- seven-day moving average of the daily mean
- seven-day moving average of the daily maximum

Yearly summary statistics calculated from the daily and weekly data will be produced for each site for each year. Yearly site-specific statistics of the seasonal maximum for the Maximum Weekly Average Temperature (MWAT) and the seasonal Maximum (Max) will be produced in chart form for each Super Planning Watershed (NCWAP Synthesis Report, 2002).

Longitudinal (Thalweg) Profiles & Benchmarks

Subsequent analysis of the channel profile may reveal subtle changes in channel morphology resulting from small scale shifts in bed sediment associated with low-magnitude annual floods and will document major changes in the stream bed that may result from high-magnitude floods that occur relatively infrequently. A core set of metrics will be calculated from the thalweg elevation data on an annual basis. These will include:

- channel slope

- a plot of the thalweg profile and associated summary data used to evaluate:
  - local changes in bed conditions, including location and depth of pools
  - changes in channel elevation relative to base year elevation
- Variation Index (Madej, 1999), a metric developed in northern California to evaluate channel response to and recovery from bed aggradation.

Summary statistics for slope, the thalweg profile and channel elevation are calculated by using an Excel database developed for Gualala Redwoods, Inc. The Variation Index is a means to quantifying variability in a longitudinal channel profile and is calculated by using the Longpro database developed by the USGS and Redwood National Park.

Cross-sections

Analysis of the cross-sectional profile may reveal changes in streambed elevation, bank stability, bankfull width/depth ratio, and channel scour and/or fill (aggradation/degradation). A core set of metrics will be calculated on an annual basis. These will include:

- bankfull width/depth ratio
- a cross-sectional profile plot to evaluate changes in streambed elevation and bank stability.
- changes in channel elevation relative to base year elevation
- channel scour and/or fill (Madej, 1999)

Summary statistics for bank-full width/depth ratio are calculated by using the CDF&G protocol. The cross-sectional profile plot and the channel elevation change are calculated by using an Excel database developed by Gualala Redwoods, Inc. Channel scour and/or fill is calculated by using the Winscour database developed by the USGS and Redwood National Park

Pebble Counts

It has been shown that shifts toward the lower end of the pebble count cumulative frequency curves may be indicative of significant increases in streambed fines from accelerated natural and or land-use disturbances. Conversely, a progressive coarsening of streambed surface particles may indicate improving conditions from past upstream and/or upslope disturbances. A core set of metrics will be calculated on an annual basis. These will include:

- d50, median particle size, the diameter at which 50% of the particles are finer
- d16, the diameter at which 16% of the particles are finer
- d84, the diameter at which 84% of the particles are finer

Summary statistics for the particle size diameters will be provided for individual sites and averaged by study reach. Other analyses that may be applied on a site-specific basis are the geometric mean diameter, $dg = [(D84)(D16)]^{0.5}$, and the geometric sorting coefficient, $sg = (D84/D16)^{0.5}$ (Kondolf and Li, 1992).

Large Woody Debris

Beechie and Sibley (1997) concluded that when the number of LWD pieces (>8 inches in diameter) reached about 122 pieces /1,000 Ft., pool formation is less sensitive to further increases in LWD loading. Similarly, Martin (1999) found that the effectiveness of LWD for forming pools in alluvial channels was diminished when the LWD load exceeded a threshold of approximately 137 pieces.

Calculating the size, position and number of LWD pieces within a survey reach will allow monitoring of natural LWD recruitment and assist in planning and monitoring future LWD restoration plans. A core set of metrics will be calculated from the data on an annual basis. These will include:

- cubic feet of LWD per 1,000 feet (also determined in units of m^3/100 m)
- number of LWD pieces per 1,000 feet

Yearly summary statistics are reported by monitoring study reach. A comparison of LWD load in each sample reach to the frequency distribution for regional values may be provided.

Riparian Measurements and Canopy

Subsequent analysis of riparian data allows the calculation of the riparian habitat within the study reaches. A core set of metrics will be calculated from the riparian surveys and canopy data on an annual basis. These will include:

- canopy density at center of channel, bank-full and 50' into the riparian zone
- riparian composition
- basal area
- tree height

Summary statistics for canopy density, riparian composition and basal area are averages for the study reach sites. Tree height is calculated by averaging the height of the 100 tallest trees per acre.

Turbidity

If and when turbidity data are collected, simultaneous measurement of stream discharge must occur. The turbidity data would be summarized in tabular format, including collection time and date, location of sample site, and stream discharge. In addition, for each sample station, a scatter plot showing turbidity as a function of stream discharge will be presented, and a linear regression analysis will be performed using stream discharge as the independent variable and turbidity as the dependent variable. If a relatively large data set is collected, it is expected that turbidity will be correlated with discharge.

Stream Discharge

In addition to the data report above, stream discharge observations will also be computed in terms of discharge per unit watershed area for comparison to continuous gauge data collected at the North Fork, Wheatfield, and South Fork gauges. If a relatively large data set is collected, it is expected that discharge will be correlated with one of the continuous gauges, and that a predictive relationship using linear regression can be developed whereby the continuous gauge data can be used to estimate discharge in smaller tributary watersheds based on drainage area.

Total Suspended Solids

These data are collected to determine the extent to which turbidity is correlated with suspended sediment transport. To the extent that these parameters are correlated at a monitoring site, turbidity data can be interpreted as an estimator for sediment load. Where available, total suspended solids will be reported in the summary table along with turbidity and discharge data. In addition, for each sample station, a scatter plot showing total suspended solids as a function of turbidity will be presented, and a linear regression analysis will be performed using turbidity as the independent variable and total suspended solids as the dependent variable. If a relatively large data set is collected, it is expected that total suspended solids will be correlated with turbidity. For individual sampling stations, a predictive relationship will be developed using linear regression which relates total suspended solids to turbidity. It is anticipated that the number and frequency of collection of samples for analysis of total suspended solids will decrease over time, once the predictive relationship is established.

Biological Sample Collection

Benthic macro invertebrate biotic condition is commonly measured by species richness, species composition, and tolerance/intolerance metrics. Species richness and composition tend to decrease in response to habitat disturbance. Harrington (2000) developed the Russian River Index of Biological Integrity, which includes six metrics:

- taxa richness
- percent dominant taxa
- EPT taxa
- modified EPT taxa
- Shannon diversity
- tolerance value

These six metrics will be integrated into a single score, which is compared to determine biotic condition categories: excellent (30-24), good (23-18), fair (17-12), and poor (11-6).

C. ASSESSMENT AND OVERSIGHT ELEMENTS

1. Assessment and Response Actions

Review of all field and data activities is the responsibility of the monitoring leader, with the assistance of the TAC. The monitoring leader, or a technical advisor will accompany volunteers on the 1st and 2nd sampling trips. If possible, volunteers in need of performance improvement will be retrained. All volunteers must attend a refresher course offered annually by the GRWC, SRCD or other recognized agency or entity. If errors in sampling technique are consistently identified, retraining may be scheduled more frequently.

Within the first three months of the monitoring project, State WRCB staff, or its designee, will evaluate field and laboratory performance and provide a report to the citizen-monitoring group. All field and laboratory activities, and records may be reviewed by state and EPA quality assurance officers as requested. If corrective action is required, State WRCB and the Regional WQCB staff will work with the SRCD and monitoring group to implement improvements.

2. Reports

The technical advisors will review draft reports to ensure the accuracy of data analysis and data interpretation. Raw data will be made available to data users per their request. The individual citizen monitoring organizations will report their data to their constituents after quality assurance has been reviewed and approved by their technical advisors. Every effort will be made to submit data and/or a report to the State and/or Regional Board staff in a fashion timely for their data uses, e.g. 305(b) report or special watershed reports.

D. DATA VALIDATION AND USABILITY ELEMENTS

1. Data Review, Validation and Verification

Data sheets will be reviewed quarterly by the technical advisors to determine if the data meet the Quality Assurance Project Plan objectives. They will identify outliers, spurious results or omissions to the monitoring team leaders. They will also evaluate compliance with the data quality objectives. They will suggest corrective action that will be implemented by the citizen-monitoring leader. Problems with the data quality and corrective action will be reported in final reports.

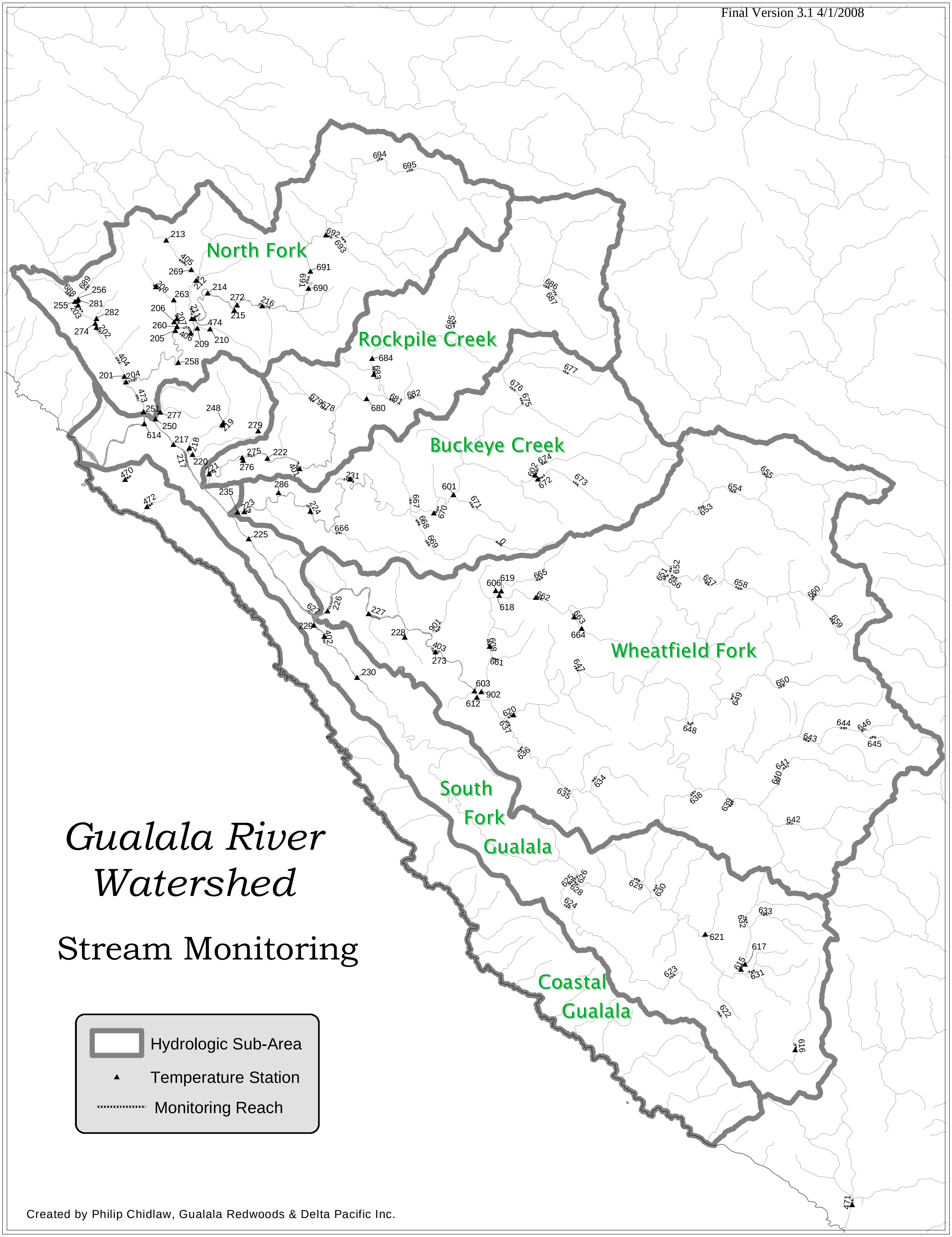
2. Validation and Verification Methods

As part of the standard field protocols, any sample readings out of the expected range will be reported to the monitoring team leader. A second sample will be taken as soon as possible to verify the condition. It is the responsibility of the team monitoring leader to re-train volunteers until performance is acceptable.

3. Reconciliation with User Requirements

All references are contained in the appendices.

Appendix


Final Version 3.1 4/1/2008
North Fork
Rockpile Creek
Buckeye Creek
Wheatfield Fork
South Fork Gualala
Coastal Gualala
Gualala River Watershed
Stream Monitoring
Hydrologic Sub-Area
Temperature Station
Monitoring Reach
Created by Philip Chidlaw, Gualala Redwoods & Delta Pacific Inc.

Appendix B
Water Temperature Monitoring

Introduction

Background
This protocol has been adapted in large part from the Forest Science Project's Protocol (FSP 1998). Stream temperature is one of the most important environmental factors affecting aquatic ecosystems. The vast majority of aquatic organisms are poikilothermic--their body temperatures and hence their metabolic demands are determined by temperature. Temperature has a significant effect on cold-water fish, both from a physiological and behavioral standpoint. Below is a brief list of the physiological and behavioral processes affected by temperature (Spence et al., 1996):

- Metabolism
- Food requirements, appetite, and digestion rates
- Growth rates
- Developmental rates of embryos and alevins
- Timing of life-history events, including adult migrations, fry emergence, and smoltification
- Competitor and predator-prey interactions
- Disease-host and parasite-host relationships

This protocol sets forth a sampling approach that will provide consistent data that can be used to address stream temperature issues at broad regional scales, i.e., watershed, basins, and regions.

Scope and Application
The field methods described in this protocol are for obtaining representative stream temperatures from perennial streams for regional monitoring. The field methods are specifically applicable for the deployment of continuous monitoring temperature sensors (e.g., Hobo Temps, Temp Mentors, Stowaways, etc.) for the purpose of identifying diurnal changes in temperature, seasonal changes in thermal regime as well as seasonal changes. Possible interferences in the accurate and precise measurement of stream temperature include: 1) exposure of the sensor to ambient air, 2) improper calibration procedures, including date and time settings, 3) improper placement of the sensor in the stream, 4) low battery, 5) inherent malfunctions in the sensor or data logger, and 6) vandalism.

Summary of Method
All continuous stream temperature monitoring sensors should be calibrated against a National Institute of Standards and Technology (NIST) traceable thermometer. Sensors not meeting precision and accuracy data quality objectives should not be used. Sensors should be placed in a well-mixed zone, e.g., at the end of a riffle or cascade. Monitoring location should represent average conditions — not pockets of cold water refugia or isolated hot spots. Location of sampling points should either avoid or account for confounding factors that influence stream temperatures such as:

- confluence of tributaries
- groundwater inflows
- channel morphology (particularly conditions that create isolated pools or segments)
- springs, wetlands, water withdrawals, effluent discharges, and other hydrologic factors
- beaver ponds and other impoundments

The sensor should be placed toward the thread or thalweg of the channel. Keep in mind that flow will decrease throughout the summer resulting in an exposed sensor. The thermistor portion of the device should not be in contact with the bottom substrate or other substrate that may serve as a heat sink (e.g., bridge abutment or boulder). Secure the sensor unit to the bottom of the channel with aircraft cable, surgical tubing, rebar, or diver's weights. The sensor should be set to record temperatures at sampling intervals that should not exceed 1.6 hours (96 minutes).

Equipment and Supplies

Calibration and Standardization
Prior to deployment of sensors, calibration of each sensor must be performed. The following is a list of equipment and supplies for calibration:

- NIST traceable thermometer - resolution of 0.2ºC or better, an accuracy of ±0.2ºC or better.
- controlled-temperature water bath, or water-filled thermos
- ice chest
- laboratory notebook
- ice

Field Measurements
There are several useful materials and pieces of equipment that should be taken to the field to install or service temperature sensors. These include:

- securing material such as zip ties, bailing wire, aircraft cable, surgical rubber tubing, locks, rebar, cinder blocks, large rocks with drilled holes, diver's weights
- GPS w/extra batteries
- surveyors marking tape or flagging
- sledge hammer (e.g., two-pound)
- wire cutters and/or pocket knife

- thermistor equipment items (silicone rings, submersible cases, silicone grease, silica packets)
- portable computer or interface for data downloading and launching
- backup batteries and thermistors
- timepiece/watch
- Rite-in-the-Rain field book w/ extra field sheets
- NIST-traceable auditing thermometer
- waders
- camera and film
- brush removal equipment (e.g., safety axe)
- maps and aerial photos
- first aid kit
- spray paint, rags and clean up cloths
- metal stakes or spikes, rebar

Pre- and Post-Deployment Calibration and Standardization

A. A NIST-traceable thermometer must be used to test the accuracy and precision of the temperature sensors. The NIST-traceable thermometer should be calibrated annually, with at least two calibration points between 10ºC (50ºF) and 25ºC (77ºF). Calibrations should be performed using a thermally stable mass of water, such as a controlled-temperature water bath, or water-filled thermos or ice chest. The stable temperature of the insulated water mass allows direct comparison of the unit’s readout with that of the NIST-traceable thermometer. Accuracy of the NIST-traceable thermometer must be within ±0.5ºC.

B. Prior to use, all continuous monitoring devices should be calibrated at room temperature (~25ºC, 77ºF) and in an ice water bath to insure that they are operating within the accuracy over the manufacture’s specified temperature range. Calibrate all continuous monitoring devices with a NIST-traceable laboratory thermometer at two temperatures, room temperature (i.e., ~77ºF, 25ºC) and near the freezing point of water as follows:

When calibrating and prior to deployment, set all units to the same current date and synchronize all devices using an accurate watch/clock that will be used to time the recording intervals of the reference thermometer. Call for the correct time.

Set the record interval of each thermograph to a short period, six to 30 seconds.
Record the date, sensor serial number, data logger serial number, and analyst’s name in a laboratory notebook. Table 1 is an example of a format that can be used for data collection. The same sensor and same data logger should be deployed in the field as they were paired together during calibration.

Place the reference thermometer and the continuous monitoring devices in a five-gallon pail filled with about three gallons of water that has reached room temperature overnight or in a controlled-temperature water bath that has reached room temperature (~77ºF, 25ºC). Make sure the casings of all continuous monitoring devices are completely submerged. Stir the water, just prior to, and during the calibration period to prevent any thermal stratification.

After allowing 10 to 20 minutes for the continuous monitoring devices to stabilize, begin recording data for a 10-minute interval. Record the time, the reference thermometer temperature, and the continuous monitoring device temperatures measured at the predetermined sampling frequency (e.g., 6 second, 10 second) used during the 10-minute interval. After all readings are completed, calculate the difference between the reference thermometer and each of the continuous monitoring devices for each reading and calculate the mean difference. Record the data using a format similar to that shown in Table 1.

Table 1. Example of Calibration Data Collection Table

4/12/98	**Sensor Serial Number = 10043 Data logger S.N. = 2S256S**	**Analyst: Joe Celsius**	**Reference Thermometer No. 412**
Time (sec)	**NIST Thermometer Reading (ºC)**	**Device Reading (ºC)**	**Difference (ºC)**
0	25.0	24.8	-0.2
10	25.1	25.0	-0.1
20	25.0	24.9	-0.1
30	25.2	25.0	-0.2
40	25.0	24.6	-0.4
Etc.			
		Mean = 24.9 S.D. = 0.16	Mean Diff. = -0.16

C. Any continuous monitoring devices not operating within their specified accuracy range should be thoroughly scrutinized. If a particular device returns readings that are outside of the manufacturer’s accuracy limits, but is still precise, then a correction factor (addition and/or multiplication) can be applied to the data. Precision should be within 0.2 standard deviations (S.D.) of the mean. Acceptable precision should be observed over the range of temperatures that will be experienced in the field. The correction factor, when applied over the calibration range, should give temperature values that are within the accuracy limits of the device. If units are inaccurate and imprecise they should not be used.

D. Using the same water bath, add enough ice to nearly fill the bucket and bring the temperature down to nearly freezing. Stir the ice bath to achieve and maintain a constant water temperature. Place the reference thermometer and the continuous monitoring devices in the water bath or five gallon pail. Again, make sure that the casings are completely submerged.

E. Repeat steps 2B-D with ice water bath.

F. Also confirm that thermograph batteries have sufficient charges for the entire monitoring period (will the length of the upcoming field season fit into the life expectancy of the unit's lithium batteries?).

G. Calibration (post-deployment calibration) should also be repeated when sensors are retrieved at the end of the sampling season. Repeat steps 2A-F.

Quality Assurance and Quality Control

Laboratory
Precision and accuracy should be 0.2 SD and ±0.5ºC, respectively for each continuous monitoring device.

Monitoring equipment with detachable sensors must be marked in order to match the sensor with the data logger. This allows instrument and sensor to be calibrated and tested prior to deployment, and also makes malfunctions easier to diagnose and correct. A logbook must be kept that documents each unit's serial number, calibration date, test results, and the reference thermometer used (Table 1).

Field
In addition to laboratory quality control checks, temperature monitoring equipment should be audited during the field season if possible. A field audit is a comparison between the field sensor and a hand-held NIST-traceable reference thermometer. The purpose of a field audit is to ensure the accuracy of the data and provide an occasion for corrective action, if needed. A minimum of two field temperature audits should be taken during the sampling period — one after deployment when the instrument has reached thermal equilibrium with the environment, and ideally one prior to recovery of the device from the field. Reference thermometers used for field audits must meet the same specifications as those used for laboratory calibrations: accuracy of ±0.5ºC, resolution of 0.1ºC. Exercise caution with mercury thermometers in the field.

A field audit is performed as follows:

Place the reference thermometer in close proximity to the continuous monitoring device.

Record the reference thermometer temperature and the sensor temperature in a field notebook. A stable reading is usually obtained within 10 thermal response units or time constants. For example, a reference thermometer with a ten-second time constant should give a stable reading in 100 seconds.

Post-processing audit accuracy must be within ±0.5ºC .

> Response time (time constant) is the time required by a sensor to reach 63.2% of a step change in temperature under a specific set of conditions. Response time values should be provided by the manufacturer. Five time constants are required for the sensor to stabilize at 100% of the step change value. Ten time constants are recommended to ensure that the reference thermometer has reached equilibrium with the stream temperature.

Data loggers typically set date and time based on the set-up computer's clock. It is important that field personnel synchronize their watches to the computer clock's time. Prior to the field audit, the computer clock should be set to the correct date and time by calling for the correct Pacific time.

Procedures

Water temperatures vary through time and space. The temporal and spatial aspects of deploying stream temperature monitoring devices is discussed in the following sections.

Temporal Considerations of Sensor Deployment

Sampling Window
Launch sensors to capture the hottest period of the field season, which will vary with watershed location. Coastal streams in Humboldt and Del Norte Counties require deployment at least during July, August, and September; whereas Mendocino County and more inland streams may require longer recording periods (June-October) (FFFC, 1996). For consistency it is recommended that the sampling window be from June 1 to October 1. This sampling window will ensure that the highest temperatures during the summer will be captured in the data set.

Sampling Frequency
The time interval between successive temperature readings can be adjusted from every few seconds, to every few hours, to every few days, for most continuous monitoring devices. Table 2 shows some of the typical sampling frequencies and the number of days the device can be left in the field prior to data downloading. In most monitoring activities, the primary objective is to determine the highest temperatures attained during the year. Thus, one of the deciding factors in setting the sampling frequency on a device will be to ensure that the daily maximum temperature is not missed.

The more frequent the monitoring, the more precisely the duration of daily maximum temperature can be characterized. The disadvantage of frequent data collection is reduced number of days of data storage and increased number of data points to be analyzed. Some agencies and other groups have found that an 80-minute sampling interval still captures the daily maximum stream temperatures for sites (OCSRI, 1996). If a less frequent sampling interval is desired, then a pilot study must be performed with monitoring at 30-minute intervals over a one to two week period during the hottest time of the year to determine how rapidly stream temperatures change. Pilot study information can provide information on the time interval most appropriate for capturing the daily maximum.

Table 2. Typical Sampling Frequencies and Storage Capacity of a Hobo® Data Logger Used for Stream Temperature Monitoring

2K Memory / 1,800 Meas.	8K Memory / 7,944 Meas.	32K Memory / 32,520 Meas.	Sample Frequency
37.5 days	165 days	677 days	30 min
45 days	198 days	813 days	36 min
60 days	264 days	1084 days	48 min
75 days	331 days	1355 days	1 Hr
90 days	397 days	1626 days	1.2 Hr
120 days	529 days	2165 days	1.6 Hr
150 days	662 days	2710 days	2 Hr
180 days	799 days	3270 days	2.4 Hr
240 days	1050 days	4300 days	3.2 Hr
360 days	1590 days	6540 days	4.8 Hr

Note: BoxCar and LogBook software's launch menu allows the user to choose from 42 intervals ranging from 0.5 seconds to 4.8 hours. The table shows the most likely settings that may be used for stream temperature monitoring. Mention of trade names does not denote endorsement by the Fish, Farm, and Forests Community Forum, the Forest Science Project, or any of their cooperators.

Selection of appropriate sites for monitoring is dependent upon the purpose and monitoring questions being asked. There are two scales of consideration for the appropriate monitoring site: selection of a sample point or location in the stream which provides representative data and the broader strategy of selecting sites that can provide useful information to answer the questions being asked.

Data Downloading

It is preferable to have the data cover the entire monitoring without interruptions. However, if data must be downloaded during the monitoring period due to insufficient data logger memory, record the date and time the sensor was removed from the stream and the date and time when it was returned to the stream. Some models may allow for downloading of data without interruption or removal of the sensor from the stream. Be sure to return the sensor to the same approximate location and depth after downloading. During a field visit for data downloading or auditing, record in the field notebook whether the sensor was exposed to the air due to low flow, discontinued flow, or vandalism. This information will be valuable for verification and validation of the data in the office.

Mid-Season Field Audit/Calibration Check

If data downloading is performed in mid-season, an opportunity for a mid-season field audit and calibration check presents itself. See Field Section for mid-season field audit and calibration procedures.

Spatial Considerations of Sensor Deployment

Stream Sample Point Location
The simplest and most specific scale is a sampling point on a stream. Here, the focus is on sample collection methods that will reduce variability and maximize representativeness.

Monitoring must record daily maxima at locations which represent average conditions - - not pockets of cold water refugia or isolated hot spots. Measurements should be made using a sampling protocol appropriate to indicate impact to beneficial uses (OCSRI, 1996). Thus, location of sampling locations should be done in a manner that is representative of the waterbody or stream segment of interest. In order to collect representative temperature data, sampling site selection must minimize the influence of confounding factors, unless the factor is a variable of interest. Some confounding factors include:

- confluence of tributaries
- groundwater inflows
- channel morphology (particularly conditions that create isolated pools or segments)
- springs, wetlands, water withdrawals, effluent discharges, and other hydrologic factors
- beaver ponds and other impoundments

Site Installation
Unless study design dictates differently, all sensors should be placed in the thalweg of riffles to insure a complete mixing of the water and to maintain sufficient water depth for the duration of the sampling window. Alternatively, if riffles are too shallow place the sensor in a pool or glide that exhibits well-mixed conditions. Do not place the sensor in a deep pool that may stratify during the summer, unless this is the objective of your study. This measure insures that sensors are not selectively placed in cooler areas such as stratified pools, springs, or seeps or in warm, stagnant locations (hot spots) that would misrepresent a stream reach's temperature signature. A hand-held thermometer can be used to document sufficient mixing by making frequent measurements horizontally and vertically across the stream cross-section. If stream temperatures are relatively homogenous (±1-2 C) throughout the cross-section during summer low-flow conditions, then sufficient mixing exists.

Monitoring devices should be installed such that the temperature sensor is completely submerged, but not in contact with the bottom. Place the sensor near the bottom of the stream by attaching it to a rock, large piece of woody debris, or a stake. Use zip ties, surgical tubing, or aircraft cable to attach the sensor to the bottom substrate. Rebar or diver's weights can be used if no suitable fastening substrate is available. For non-wadeable streams, the sensor should be placed one meter below the surface, but not in contact with a large thermal mass, such as a bridge abutment or boulder (ODF, 1994). If the monitoring site is not in a heavily visited area, mark the location of the sensor by attaching flagging marked with the gauge number or site ID number to nearby vegetation.

Precautions against vandalism, theft, and accidental disturbance should be considered when installing equipment. In areas frequented by the public, it is advisable to secure or camouflage equipment. Visible tethers are not recommended because they attract attention. When equipment cannot be protected from disturbance, an alternative monitoring site should be considered. For external data loggers that are not waterproof, place them above the mean high water line to prevent loss during a freshet. Some data loggers must be housed in a waterproof metal or plastic box that should be locked and chained to a tree. Data logger boxes and cables should be covered with rocks, moss, and wood to hide equipment.

Install the sensor in a shaded location; shade can be provided by canopy cover or some other feature such as large woody debris. If no shaded locations are available, then it may be necessary to construct a shade cover for the sensor (e.g., using a section of large diameter plastic pipe.) The intention for this measure is to avoid direct solar warming of the sensor. The intent is not to suggest that sensors should be placed only in shaded thermal reaches.

Sensors should be located at the downstream end of a thermal reach, so as to characterize the entire thermal reach, as opposed to local conditions. Protocols for characterizing thermal refugia can be found in FFFC (1996).

The number of thermograph units deployed will vary with 1) drainage area of the watershed, 2) numbers and sizes of inflow tributaries or other transitions in riparian condition, 3) changes in elevation, and 4) proximity to coastal fog zone. In all circumstances, a continuous monitoring device should be located as far downstream as surface water flows during the summer. In watersheds with multiple sensors locate them in a lower/upper or lower/middle/upper distribution.

Mark all monitoring site locations on a USGS 1:24,000 topographic map, aerial photo, or GIS map. Clearly show the location of the site with respect to other tributaries entering the stream, e.g., above or below the confluence. Record measured distance to a uniquely distinguishable map feature (i.e., road crossing, specific tributary, etc.) Draw a diagram of the monitoring area. Include details such as: harvest unit boundaries, sensor location and thermal reach length, tributaries with summer flow, description of riparian stand characteristics for each bank, areas where portions of the stream flow become subsurface, beaver pond complexes, roads near the stream, other disturbances to the channel or riparian vegetation (heavy grazing, gold dredging, gravel mining, water withdrawals).

Record the serial number of each sensor/data logger combination at each monitoring site. Make an effort to deploy the same sensor/data logger combination at the same site each year.

Once a sensor/data logger combination has been deployed at a site, do not move the equipment to another location. Adjustments in sensor location may be necessary if the initial location ran dry, and the sensor must be moved to the active, flowing channel. This will necessitate a unique site_id for spatial statistical analysis. Make notes of such relocations in the field notebook.

If sensors are used to collect long-term baseline or trend data in specific watersheds, establish fixed-location monitoring stations so that data sets will be comparable.

Site-Specific Data Collection

Other site-specific data should be collected at the time of sensor deployment or retrieval. These additional attributes will greatly assist in post-stratification and interpretation of status and trends in stream temperatures.

Length of Thermal Reach or Stream Segment

The thermal reach extends 300-600 meters above the site, depending on stream size (TFW, 1993). With a hip chain or measuring tape, measure the length of thermal reach or stream segment (in feet). If the stream has more than one channel, measure along the channel that carries most of the summer flow.

Canopy Closure

Use a spherical densiometer at evenly spaced intervals to determine average canopy closure for the thermal reach above the monitoring site. Take canopy closure measurements at 50-meter intervals along the thermal reach. If the percent canopy cover varies by more than 20% between measurements, then take additional measurements at 25-meter intervals to more accurately determine the average percent canopy closure for the reach. In order to save time, it may be advantageous to determine canopy closure at 25-meter intervals from the start, thus avoiding the need to back-track in cases where the variability exceeds 20%. In addition to calculating the average canopy closure, keep a record in a field notebook of the percent canopy closure at each sampling interval and note the locations on a map or sketch of the reach to document how the shade level varies through the reach. At each 25- or 50-meter interval, stand in the center of the channel and measure canopy closure four times: facing upstream, downstream, right bank, and left bank. Average these four values to obtain canopy closure for the location.

Elevation

Determine the elevation at the midpoint of the thermal reach from a USGS topographic map, or altimeter and record on data sheet to nearest feet.

Average Bankfull Width and Depth

Bankfull width and depth refer to the width and average depth at bankfull flow. These dimensions are related to discharge at the channel-forming flow, and can be used to characterize the relative size of the stream channel. This characterization will be useful for later post-stratification and assessment of stream temperature data. In addition, the ratio of bankfull width to depth (width:depth ratio) of a stream channel provides information on channel morphology. Width:depth ratio is related to bankfull discharge, sediment load, and resistance to bank erosion (Richards, 1982). For example, channels with large amounts of bedload and sandy, cohesionless banks are typically wide and shallow, while channels with suspended sediment loads and silty erosion-resistant banks are usually deep and narrow. Changes in width:depth ratio indicate morphologic adjustments in response to alteration of one of the controlling factors (Schumm, 1977).

Refer to Channel Form Monitoring Appendix E for step-by-step procedures for estimating bankfull width and depth.

Average Wetted Width
Measure the wetted channel width at the location where the sensor is placed. This measurement should be collected at the time of deployment and at the time of retrieval. Change in wetted width over the field season will provide information on the change in flow during the monitoring period. Follow the method outlined in Flosi (1998).

Habitat Type
Record the habitat type in which the sensor was placed. Use the following codes for the habitat types:

- **Riffle** Shallow reaches with swiftly flowing, turbulent water
- **run** Relatively uniform flowing reaches with little surface agitation
- **spool** Shallow pools less than 2 feet in depth with good flow (no thermal strata)
- **mpool** Mid-sized pools 2 to 4 feet in depth with good flow (no thermal strata)
- **dpool** Deep pools greater than 4 feet in depth or pools suspected of maintaining thermal strata (possible thermal strata)

Stream Class
Record the stream classification as defined by the California Forest Practice Rules.

1 - ***Class I Watercourse:*** Domestic supplies, including springs, on site and/or within 100 feet downstream of the operations area and/or 2) Fish always or seasonally present onsite, includes habitat to sustain fish migration and spawning.

2 - ***Class II Watercourse:*** a) Fish always or seasonally present offsite within 1000 feet downstream and/or 2) Aquatic habitat for nonfish aquatic species. 3) Excludes Class III waters that are tributary to Class I waters.

3 - ***Class III Watercourse:*** No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.

4 - ***Class IV Watercourse:*** Man-made watercourses, usually downstream, established domestic, agricultural, hydroelectric supply or other beneficial use.

For Class I watercourses make a concerted effort to collect fish presence/absence and/or abundance data in the same thermal reaches or stream segments where stream temperature data is being gathered. Conduct fish surveys during the period when stream temperatures are highest (July-August).

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Data Field Form

To assist in the collection and organization the site-specific information a field data form has been adapted from the Forest Science Project form. The form can be found below. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

GRWC Stream Temperature Field Data Form

Station ID:	**File Name:**
Stream Name:	
X Coordinate:	**Y Coordinate:**
Projection (UTM Zone 10 NAD 27 preferred):	
Basin Name:	**USGS Quadrangle:**
Describe Placement:	
Surveyor:	**Organization:**
Device ID (serial #):	**Device Type:**
Calibration Date:	
Installation:	***Removal:***
Date Launched:	**Date Retrieved:**
Time:	**Time:**
Air Temperature ©:	**Air Temperature ©:**
Water Temperature ©:	**Water Temperature ©:**
Depth at Instument:	**Depth at Instrument:**
Depth of Instrument:	**Depth of Instrument:**
Maximum Depth:	**Maximum Depth:**
Wetted Width:	**Wetted Width:**
Wetted Length:	**Wetted Length:**

Habitat Type (circle one):

Riffle	shallow reaches with swiftly flowing, turbulent water
Run	relatively uniform flowing reaches with little surface agitation
Spool	shallow pool less than 2 feet in depth with good water flow
Mpool	mid-sized pool 2 to 4 feet in depth with good water flow
Dpool	deep pools greater than 4 feet in depth or pools suspect of maintaining thermal strata
Mpool	mid-sized pool 2 to 4 feet in depth with good water flow

Thermal Reach Information:	Diagram or Photo
Bankfull Width:	
Bankfull Depth:	
Reach Length:	
Mean Canopy Closure:	
Average Channel Gradient:	
Average Channel Aspect:	
Channel Type (Flossi et al., 1998):	
Stream Class (I,II, etc.):	
Elevation:	
Drainage area:	
Comments:	

Appendix C
SURVEYING BASICS

Introduction

Topographic surveying is an essential tool in watershed monitoring. A basic field survey establishes the horizontal and/or vertical location of a series of points in relation to a starting point (called a benchmark). Repeated surveys of the stream channel, in each study reach, are used to document changes over time in the shape of the streambed. Changes in the sediment supply affect the shape of the streambed. The shape of the streambed, in turn, affects the amount of bedload material that the stream can carry.

Sediment levels are an important factor in determining the quality of salmon habitat. Salmon spawn on gravel beds in the stream. High levels of sediment prevent the circulation of oxygen and inhibit the ability of salmon eggs to develop into fry.

Protocol Summary

The objectives of the survey include measuring the bankfull width of the stream, the slope of the streambed and the size of bed material. By making annual survey measurements, over a number of years, it is possible to assess changes in the amount of material stored in the bed of the stream, this information will indicate trend in the amount of bedload that is being delivered to the study reach.

Figure 1. Automatic Level

The cross-section survey, in conjunction with identifying bankfull indicators, allows the direct measurement of the bankfull width. The longitudinal survey measures the channel slope. The longitudinal survey also shows the shape of the streambed along the direction of flow.

A survey of the stream channel is accomplished by using a surveying tool called an *automatic level* (see Figure 1). The automatic level is carefully set up to establish a horizontal reference plane. The horizontal reference plane allows the relative elevation of different features on the streambed to be measured. Distances from the horizontal reference plane are measured down to the surface of the ground using the *survey rod*. The Survey Protocol (*page 2*) describes, in detail, the steps to be followed in setting up the tripod and the automatic level. It describes how to use the automatic level (Figure 1) and the survey rod to measure elevation.

Surveying requires at least two people. The *Instrument Person* operates the automatic level and records the measurements in the level logbook. The *Rod Person*, selects sites and holds

the survey rod at the site while the Instrument Person is reading it. The protocol explains how to calibrate the instrument using a point of known elevation called a *benchmark*.
The general procedure for surveying is to first set up the instrument. Once the instrument is level, the rod is placed on a point with a known elevation called a benchmark. The instrument person looks through the telescope on the level and reads the number on the rod. The reading (backsight) is added to the elevation of the benchmark to give the elevation of the instrument crosshairs. The rod is then placed on a point whose elevation is to be determined. The reading (foresight) is subtracted from the elevation of the instrument to get the elevation of the new point.
Distances between points are measured with a tape measure or are measured optically with the level and the rod. Careful notes, including sketch maps, are taken to help interpret the survey information.

Surveying Protocols

Directions for Instrument Person

- Step 1: Setting Up the Tripod.
  1. Extend the legs of the tripod until the top of the tripod is level with your chin.
  2. Push one of the legs firmly into the ground. Spread the tripod legs 3’ to 4’ apart. Push the other two legs into the ground.
  3. Level the top of the tripod by raising or lowering the legs.
     Note: Leveling the instrument will be easier if the tripod head is on a nearly horizontal plane.
  4. After the head is level check that the leg adjusting screws are tight and the legs are firmly set in the ground.

- Step 2: Setting Up the Level.
  1. Place the instrument on the tripod.
  2. Screw the level snugly (finger-tight) to the head of the tripod.
     Note: Do not over-tighten the screw.
  3. Move the level screws in pairs to bring the bubble into the target circle on the level vial.
  4. Rotate the scope 90^0 degrees and re-level.
  5. Repeat until the bubble stays in the target circle throughout a 360^0-degree rotation. This procedure brings the instrument into the range where the self-leveling pendulum prism can operate.
  6. Turn the telescope to bring the rod into the field of vision.

- Step 3: Reading the Rod

The numbers on the face of the rod show the distance measured from the ground in feet. The scale can be read to the one hundredths of a foot. Whole numbers of feet are marked off on the scale on the left of the rod by the longer line with an angled end. For example, see the number 3.00 in Figure 2. The number of feet is read at the top of this line and is indicated by the large red numbers. Tenths-of-feet are also marked by a line with an angled end. For example, see the number 2.90 in Figure 2. The black numbers indicates the number of tenths-of-feet.

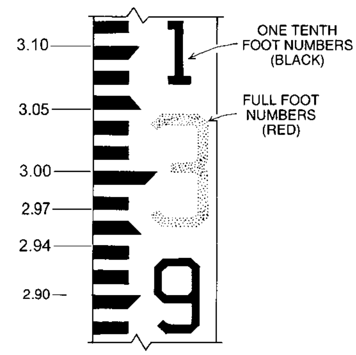


Figure 2. Face of the survey rod

Each black line and each white space on the scale is exactly one hundredths of a foot. The top of each black line, between the angled tenth-of-a-foot lines, mark off 2/100th's of a foot. Even number hundredths of a foot can be read at the top of the lines. Odd number hundredths of a foot are read at the bottom.

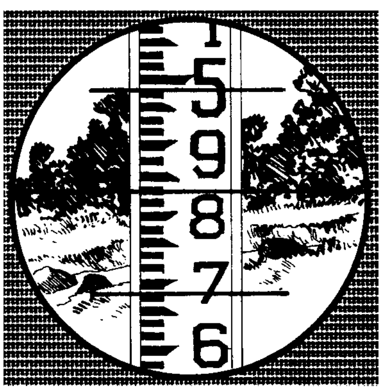


Figure 3. Reading the rod. The elevation is read at the middle line. The upper and lower lines are called stadia.

Point the telescope towards the rod. The center crosshairs should cross the face of the rod (Figure 3). Turn the focus knob until the rod can be clearly seen. Adjust the eyepiece to darken or lighten the cross hairs. I f the rod is leaning to the side, ask the rod person to move the top of the rod until it is vertical. The rod person should try to keep the rod vertical along your line-of-sight. The center crosshair gives the elevation. Do not use the upper or lower lines for elevation. The upper and lower lines are called stadia. Using the stadia lines to measure distance will be described later.

Directions for the Rod Person

The rod person decides where to set the rod, which is the most vital part of the survey.

The level is attached to the back of the rod. Use the bubble on the level to adjust and maintain the rod so that it is vertical. Stand behind the rod so that the rod can be held vertical and the level can be read. Holding the rod vertical is essential. If the rod leans forward or backwards the reading will be larger than the true value, see Figure 4.

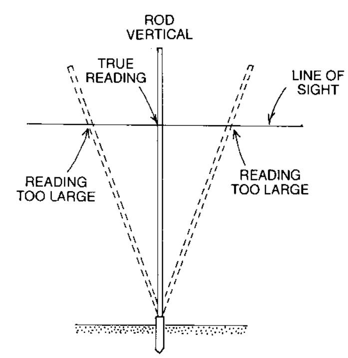


Figure 4. Keep the rod vertical.

When changing the length of the rod it is essential that each section be fully extended and properly secured. When a section of the rod is fully extended a locking button should pop into place.

Measuring Distance

Measuring with Tape

- Tapes marked in feet that can be read to the hundredth of a foot can be used to measure distance. Always make sure that the tape for the horizontal distance is the same standard as your stadia rod.
- When measuring horizontal distance stretch the tape tight before making the reading.
- Do not use a tape to measure the horizontal distance if the tape cannot be stretched out on a horizontal line between the points.

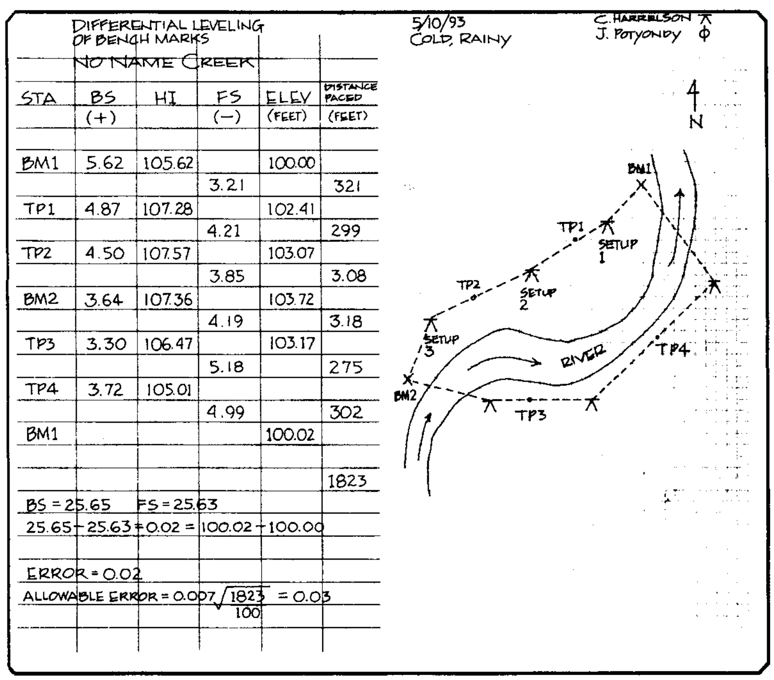
Measuring distance with surveying level

Use the level and the survey rod to estimate distances where stretching a tape would be difficult. To do this read the *stadia,* the short crosshairs above and below the central crosshair on the survey rod.

- Set up the level at one end of the distance to be measured. Place the Survey Rod at the other point.
- Read the rod at the upper and the lower stadia line.
- Subtract the lower stadia reading from the upper stadia reading
- Multiply the difference by 100 to get the distance from the instrument to the rod.

Differential Level Survey

A differential level survey is used to measure the relative elevation of points that are quite far apart. For example, a differential level survey can be used to determine the true elevation of your benchmark if a point of known true elevation is several hundred feet from your site. It consists of making a series of instrument setups along a route that ends back where it began. The route of the survey is called a *traverse.* From each instrument setup, the rod is taken to a point of known elevation to establish the *instrument height.* The instrument height is used to calculate the elevation of new points after the rod is read on the new point. Temporary reference points, called *turning points,* are


DIFFERENTIAL LEVELING
OF BENCH MARKS
NO NAME CREEK

5/10/93
COLD, RAINY

C. HARRELSON
J. POTYONDY

STA	BS (+)	HI	FS (−)	ELEV (FEET)	DISTANCE PACED (FEET)
BM1	5.62	105.62		100.00	
			3.21		321
TP1	4.87	107.28		102.41	
			4.21		299
TP2	4.50	107.57		103.07	
			3.85		3.08
BM2	3.64	107.36		103.72	
			4.19		3.18
TP3	3.30	106.47		103.17	
			5.18		275
TP4	3.72	105.01			
			4.99		302
BM1				100.02	
					1823

BS = 25.65 FS = 25.63
25.65 − 25.63 = 0.02 = 100.02 − 100.00

ERROR = 0.02
ALLOWABLE ERROR = $0.007\sqrt{\frac{1823}{100}} = 0.03$

Figure 5. Field notes from a differential survey. The purpose of the survey is to find the elevation of BM-2 relative to BM-1. The traverse starts at BM-1. Returning to BM-1 closes the survey.

established before the instrument is moved to a new location. The details of the process are described below.

- The first reading (a reading is also called a *shot*) is to the benchmark. In Figure 5, the benchmark is BM-1. The elevation of the benchmark is known or assumed, see Figure 6. If the elevation of the benchmark is assumed it is strongly recommended that you survey from your benchmark to a benchmark with known elevation.
- Place the rod on the benchmark.
- Get the rod vertical.
- Read the scale where the crosshair crosses the rod face.
- Record the reading in the field book as a *backsight*. In the notes, *backsight* is abbreviated as BS.

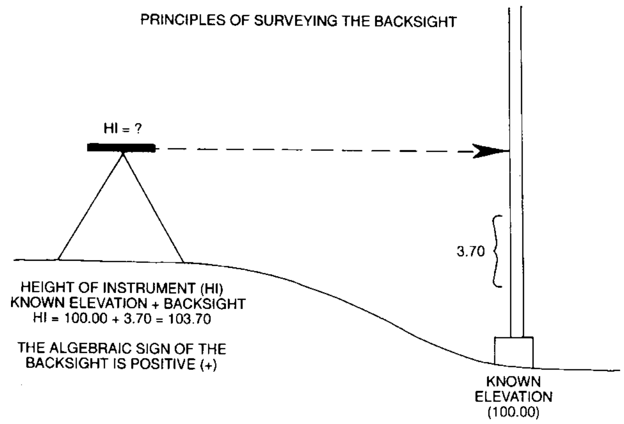


Figure 6. Shooting the backsight to find the instrument height.

- The shot to the benchmark is called a backsight. The backsight reading is added to the elevation of the benchmark to calculate the *instrument height*, see Figure 6. The instrument height is the elevation of the instrument crosshair.
- The notes shown in Figure 5 give an example of a differential survey. The elevation of BM-1 is given as 100.00 feet. The backsight to BM-1 is 5.62 feet. Thus, the height of the instrument, for the first setup, is 105.62 feet.
- Use a tape, the stadia method, or pacing to measure the distance from the instrument to the benchmark. Record the distance in the field book. The total distance covered by the survey is used to calculate the allowable error of the survey. This will be explained below.
- In Figure 5, the distance was determined by pacing. The distance between BM-1 and TP-1 is shown as 321 feet.
- The rod person should drive a stake in the ground as a temporary reference known as a turning point, TP. The TP should be in the direction of the survey and about the same distance from the instrument as the benchmark. The stake should be solidly in the ground so that it does not shift.
- The rod is then placed on the TP and the instrument person reads the elevation and records it as a foresight, see Figure 7.
- For example, in Figure 5, the foresight, FS, of TP-1 is 3.21.
- The foresight of TP-1 is subtracted from the instrument height to determine the elevation of TP-1.

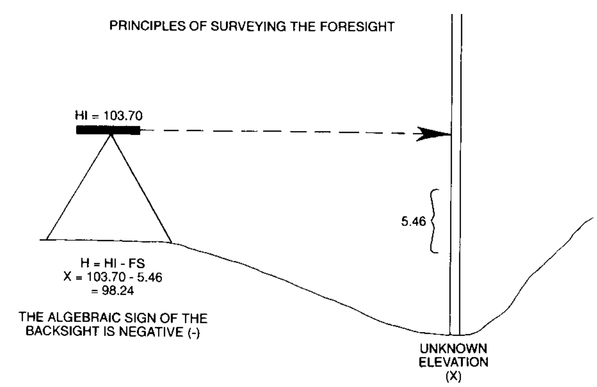


Figure 7. Shooting a foresight. The instrument height is already known.

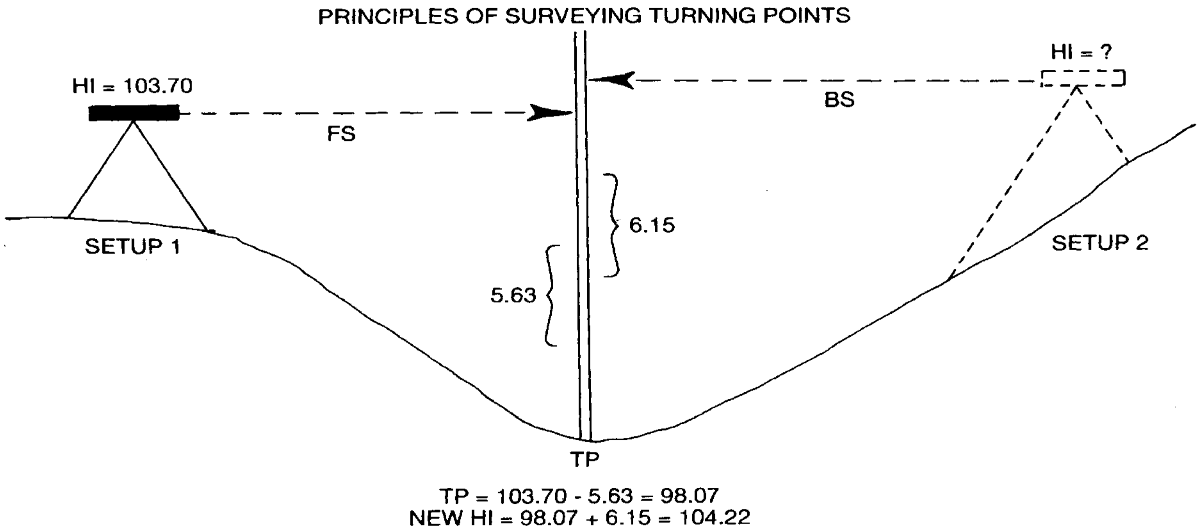


Figure 8. Using *turning points* to move the instrument.

- For example, in Figure 5, the foresight of TP-1 (3.21) is subtracted from the instrument height (105.62) to calculate the elevation of TP-1 (102.41).
- The instrument is then moved to the other side of TP-1.
- The rod is then placed on TP-1 and the rod is read as a backsight, after the instrument has been setup and leveled. The backsight is added to the elevation of TP-1 to calculate the instrument height. For example, the backsight to TP-1 from setup 2 is 4.87 feet. The backsight (4.87) is added to the elevation of TP-1 (102.41) to calculate the instrument height (107.28) at setup 2.
- The process outlined in steps 1-8 is repeated until the traverse is closed by shooting the original benchmark as a foresight. See the map in Figure 5.
- After you have closed the survey, the elevation of the benchmark at the end of the survey is compared to its original value. This process is known as closing the survey. The difference between the calculated elevation of the benchmark and its original value is the error.

  The acceptable amount of error depends on the total distance of the differential level survey. One equation to estimate the acceptable error is:

$$Acceptable\ \ Error \leq 0.007\sqrt{(total\ \text{distance})/100}$$

Where the *total distance* is the sum of the distances between the instrument stations in the differential level survey loop. For example, in Figure 7, the total distance of the differential level survey is 1,823 feet and the acceptable error is 0.03 feet.

A differential level survey can be performed as part of a longitudinal survey or cross-section survey. These types of surveys are described in other protocols. The purpose of the longitudinal and cross-section surveys is to gather elevation and distance data for selected points along the stream channel.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Appendix D
Field Equipment

Introduction
There are a variety of different types of equipment and instrumentation available to help take field measurements. Below is a description of the equipment we will be using for in-stream monitoring program. Please carefully read the instructions describing the use of each. For quality and measurement control each surveying team will have to fill out the attached instrument form.

Tapes
We have two types of tapes: lineal tapes that measure distance, and Spenser diameter tapes for measuring tree diameter.

Lineal Tapes
We have several lengths of tapes. The longest tapes are 200 ft. tapes, fiberglass and marked in tenths of feet. These tapes are used for the longitudinal profiles and cross-sections. The tapes that are marked in inches (usually reel tapes) are used for the riparian plots.

Spenser diameter tapes
Spenser tapes are two sided tapes. One side is calibrated so that when the tape is wrapped around the circumference of a tree, the tape is actually showing the diameter of the tree [so it is adjusted by a factor of π because C (circumference) = π (diameter)]. This side of the tape is printed in red ink. The other side is a lineal tape. A common error is to read the lineal side of the tape instead of the diameter side. Be sure to check your reading of the tape to make sure the number you have called out for diameter actually makes sense.

Diameter is almost always measured at breast height (DBH). DBH is the point on the tree trunk that is 4.5 feet from the ground. An easy way to measure DBH in the field is to pre-measure where 4.5 ft. is located on your body, then you will be able to easily estimate this height.

Pacing
In many field situations, pacing (or counting your steps) is the preferred method of measuring distance, where very precise distance measurements are not necessary. With practice, pacing can be quite accurate. However, it is usually not so accurate in the mountains of the Pacific Northwest, where slopes are steep, slipping is common, and large logs often interfere with straight-line travel. Nevertheless, pacing is a standard method used for rough separations of distance.

Start with a lineal tape and lay out a straight-line course of at least 300 feet. A pace is defined as two steps, so if you start walking with your right foot, the spot where your left foot lands is equivalent to one pace. Pace to the end of the calibrated line and total the number of paces you took. Repeat the process several times. The average number of paces, divided into the length of the line, is your pace length. Some people find that pace length in meters is preferable, others like the English units of feet (which are a little more precise as the unit is smaller). Pick your favorite, but know the conversion factor between them (feet X 3.3 = meters, meters/3.3 = feet).

Once you know your pace, you can follow simple compass courses on flat ground with relative ease.

Clinometers

A clinometer is a handy device for determining slope (in percent) and for measuring tree height. The standard Suunto brand will be employed. It has a dial containing two scales: percent on the left, and degrees on the right. As one sights the clinometer with one eye and leaves the other eye open, objects are lined up with the horizontal line in the dial, and a degree or percent then can be read off the dial. In case there is confusion about the dial, turn the clinometer up vertically and the scales are defined on the left and right side of the dial. We employ the percent scale to denote slope steepness, and the angle scale for an estimate of tree height.

Slope Determinations

In order to determine slope steepness, sight the clinometer directly upslope or downslope on an object that is at eye height in either direction. The reading on the clinometer is the percent slope (left scale) or slope angle (right scale). In the upslope direction, the reading will be (+), while in a downslope direction it will read (-). Often, an upslope and downslope measurement will be averaged to determine average slope steepness, but the direction of the reading (+ or -) is not included.

Tree Height Determinations

The determination of tree height uses the angle scale on the clinometer.

You must be a known distance of 66 ft away from the tree. Sight the clinometer at the base of the tree and then the top of the tree. On flat ground, you are generally sighting from zero to the top of the tree, but "zero" is really eye height, so your eye level must be added to the height.

If you have to take readings on slopes. Try to move laterally (across slope) for tree height measurements - your horizontal distance will be more accurately measured.

On a slope you will generally be either below or above the base of the tree. Generally the position above the tree is more accurate than being below the tree. If above the tree base but below the top, you must add both sightings together. If below the tree base, you must take a sighting to the top of the tree, and subtract from it the sighting to the bottom of the tree: (for example, 100 to top, 30 to bottom = 70 ft. reading). If above both the tree base and the top of the tree, usually you'll have to move your position.

Spherical Densiometers

The spherical densiometer can be used as a hand held instrument to estimate relative vegetative canopy closure or canopy density caused by vegetation. Vegetation canopy closure is the area of the sky over the selected stream channel that is bracketed by vegetation (regardless of density). Canopy density is the amount of the sky blocked within the closure by vegetation. Canopy closure can be constant throughout the season if fast growing vegetation is not dominant, but density can change drastically if canopy vegetation is deciduous.

Canopy density is measured in conjunction with the riparian plot surveys and canopy closure is measured when installing temperature data loggers.

Operation of the Spherical Densiometer to Estimate Canopy Density

The spherical densiometer should be held 12-18 inches in front of your body and at elbow height, so that the operator’s head is not visible in the mirror (and will not be counted as canopy cover!). Make sure the level bubble is level. In each square of the grid, assume that there are four dots, representing the center of quarter-square subdivisions of each of the grids. In the following instructions, it is assumed that you are under a forest canopy where openings are less common than canopy. Systematically count the number of dots NOT occupied by canopy (where you can see sky at that dot). Multiply the total count by 1.04 to obtain the percent of overhead area not occupied by canopy, as there are only 96 dots to count. The difference between this and 100 is the canopy cover in percent. Make four readings per location – start by facing upstream then turn in a clockwise fashion taking a reading every 90 degrees – and average them to provide an estimate of canopy cover from that point.

Obviously, this instrument is not useful for measuring understory tree, shrub, or herb cover.

Operation of the Spherical Densiometer to Estimate Canopy Closure

These instructions are for using a convex spherical densiometer that has adapted to the modifications developed by Strickler (1959). Strickler uses only 17 of the line intersects as observation points by taping a right angle on the mirror surface (Figure D-1).

Stand in the middle of the stream channel facing upstream. The densiometer is held in the hand, in front of the body at waist level, with the arm from the hand to the elbow parallel to the water surface. The convex densiometer is held away from the observer’s body with the apex of the V pointed towards the observer. The observer’s eye reflection should be seen along the margin of the original grid (Figure D-1). Level the densiometer using the bubble indicator and maintain the level and standard eye positions while recording. The grid between the V formed by the tape encloses 17 observation points. Each point has a value of 1.5 percent when four different readings are made. The number of points <u>surrounded by vegetation</u> are counted when measuring canopy closure.

Measurements are taken in four quadrants while standing on the same point (facing upstream, right bank, downstream, left bank).

The points counted for each reading are totaled and multiplied by 1.5 to obtain the percentage of canopy closure.

If all possible observation points are counted, the total value will be 102 percent (68 x 1.5 = 102). Although this error is small and not considered important for comparisons of relative values, the following correction factor can be applied to determine the correct percentile:

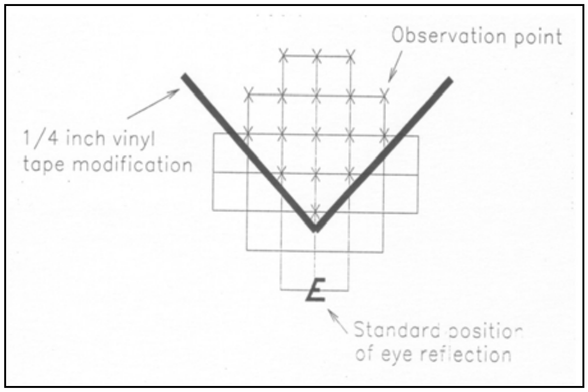


Figure D-1: Modified grid of spherical densiometer.

Calculated Value	Subtract from Calculated Value
Less than 30	0
30 to 60	-1
Over 60	-2

Example: (8+11+7+12)(1.5) = 57% subtract 1% = 56% closure

The Compass

Compasses come in many types. The examples below use the Silva Ranger Type 15 compass. This may or may not be the type of compass you have in the field. The Silva Ranger has some adjustments not seen in other compasses. While the principles of compass use are standard, their application to a particular compass type may be unique. This compass is graduated in 2 degree (^{o}) increments of azimuth from 0^o to 360^o. North is 0^o, east is 90^o, south is 180^o, west is 270^o and north again is 360^o (0^o). The compass has three basic parts. The Magnetic Needle is attracted by the magnetic North Pole of the earth. The red end points north and the white end south. The Graduated Dial turns and can be set to any desired bearing. The bearing is set to read in degrees. The Base Plate with Sighting Mirror is the housing of the compass and serves to point out the line of travel.

Beware of iron or steel objects if they are close to the compass. They will throw off the readings of the compass.

Map and Field Bearings

If you are working from a bearing on a map, it is referenced to true north and is called a true bearing. This is not the same as working from uncorrected bearings in the field, such as the location of a mountaintop in the distance that you take a compass bearing on. Sections A, B, C, D, and E below are based on working from “map to terrain” and deal with true bearings. Sections F and G are uncorrected bearings and are based on working from terrain to map.

Section A. How to use the compass to point out desired directions

First, the dial must be set to the desired degree reading. If this is known, simply turn the dial so that the correct reading appears at the index pointer. Second, without changing the dial setting, the entire compass must be positioned so that the orienting arrow lines up with the magnetic needle and the red end of the needle lies within the two orienting points. When these two conditions are fulfilled, the desired direction is indicated by the sighting line. Always keep the compass level so that the needle can move freely.

Section B. Using the compass without the sight.

When the dial is set as described in Section A, you can use the compass either with or without the aid of the sight. In situations where fast action is important, open the cover wide and make sure the orienting arrow and magnetic needle are lined up. The sighting line extends straight from the index pointer across the sight. Fix your sight on a distant object and head for it.

Section C. Using the compass with the sight.

For situations where accuracy counts, use the sight. The dial is set as in Section A. Hold the compass at eye level and adjust the cover to slightly less than a 90^o opening, so the mirror reflects a top view of the compass dial. While looking in the mirror, move your sighting eye sideways until you see the sighting line intersect one of the two luminous points. Without changing the relationship between compass and eye, pivot yourself and compass together until you see in the mirror that the orienting arrow is lined up with the magnetic needle and the red end of the needle is between the orienting points. Your direction or objective will now lie straight beyond the sight on the upper edge of the cover.

Section D. How to obtain your bearing from a map.

In Section A, one of the two basic conditions for using the compass is to set the dial at the desired degree setting. If this degree, or bearing, is not known, it can be easily determined from a map. First, lay the compass on the map so either the inch scale or millimeter scale is exactly on (or parallel with) the line on the map you wish to travel, AND the hinged cover points in the direction you wish to travel. Then, while holding the compass in position on the map, turn the dial so the meridian lines of the compass are exactly parallel with any meridian (north-south) line on the map, AND the letter “N” on the top of the dial is toward North on the map (not turned down toward South). You may now remove the compass from the map. In these two steps your compass was set for the degree reading to your destinations and this reading may now be used as the index pointer. In fact, while performing these two steps you automatically fulfilled the first basic condition mentioned in Section A, and you may directly proceed to use the compass as per Section B or C.

Section E. How to Take a Bearing.

A “bearing” means the direction or the degree reading from one object to another. One of those objects is usually YOU. To “take” a bearing means to determine the direction from one object to another.

A. From a map, bearings are taken as described in Section D. The “bearing” is the degree reading indicated at the index pointer.

B. Out in the terrain, bearings can be taken by reversing the steps described in Sections B and C. For example, if you are using the compass without the sight, open the cover wide and hold it level and waist high in front of you. The sight and sighting line should be pointing directly ahead of you. The sighting line acts as a pointer. Pivot yourself and your compass around together until the sighting line points straight to the object on which you are taking the bearing. Without changing the position of the compass, carefully turn the dial until the orienting arrow and the magnetic needle are lined up and with the red end of the needle lying between the two orienting points. The “bearing” to your objects is now the degree reading indicated at the index pointer.

C. In a similar manner, bearings can be taken by using the sight. In this case, hold the compass at eye level and adjust the cover so the top of the dial is seen in the mirror. Face toward your object and sight across the compass sight. Look in the mirror and adjust the position of the compass so that the sighting line intersects one of the luminous points. While you simultaneously see your object across the sight, and the sighting line across one of the luminous points, turn the dial so that the orienting arrow is line up with the needle, red end being between the orienting points. The “bearing” to your object is now the degree reading indicated at the index pointer.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual*, Third Edition.

Appendix E
CHANNEL FORM MONITORING

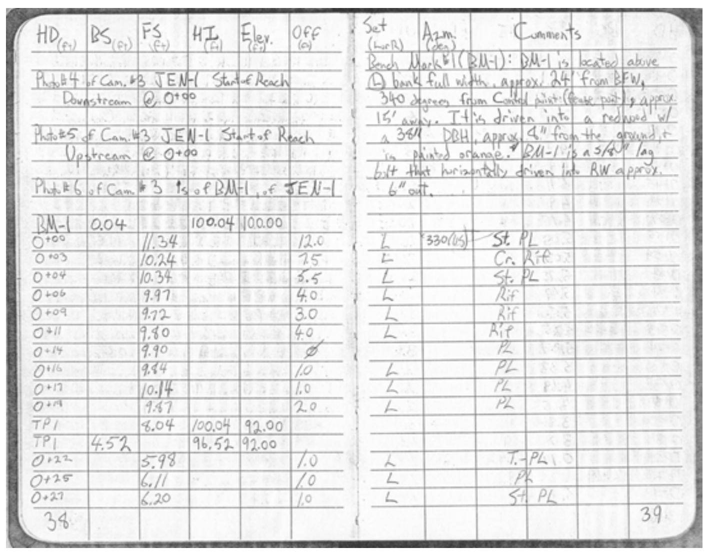
Getting started

Before the fieldwork starts surveyors need to organize their notebooks, forms and equipment. Verify with the GRWC that all the property owners along the study reach have given permission for the monitoring. In addition, make sure that proper notice is given to the property owners before starting the fieldwork.

Directions for Organizing the Level Notebook

Set up the level notebook for the site. Use a *Rite-in-the-Rain* (or equivalent brand) All-Weather Level Notebook. These books are about 5"x 7" and each page has six columns. Laid flat, they photocopy onto 8-1/2" x 11" sheet for standard filling.

- Step 1: Number all the pages in your notebook.
  Note: Leave the first page blank for the Table of Contents, which will be filled in after the survey is finished.
- Step 2: Introductory page. Go to the second page and prepare an introductory page with the site name and number, project description, date and weather, names and tasks of crew.
  Note: This information will be repeated in a new introductory page each day before you start surveying.



HD (ft)	BS (ft)	FS (ft)	HI (ft)	Elev. (ft)	Off (ft)	Set (L or R)	Azm. (deg)	Comments
Photo #4 of Cam. #3 JEN-1 Start of Reach Downstream @ 0+00								
Photo #5 of Cam. #3 JEN-1 Start of Reach Upstream @ 0+00								
Photo #6 of Cam. #3 1s of BM-1, of JEN-1								
BM-1	0.04		100.04	100.00				
0+00		11.34			12.0	L	330(DS)	St. PL
0+03		10.24			7.5	L		Cr. Rif
0+04		10.34			5.5	L		St. PL
0+06		9.97			4.0	L		Rif
0+09		9.72			3.0	L		Rif
0+11		9.80			4.0	L		Rif
0+14		9.90			Ø			PL
0+16		9.84			1.0	L		PL
0+17		10.14			1.0	L		PL
0+19		9.87			2.0	L		PL
TP1		8.04	100.04	92.00				
TP1	4.52		96.52	92.00				
0+22		5.98			1.0	L		T.-PL
0+25		6.11			1.0	L		PL
0+27		6.20			1.0	L		St PL

Bench Mark #1 (BM-1): BM-1 is located above (L) bank full width, approx. 24' from BFW, 340 degrees from Control point (Gauge post) & approx. 15' away. It is driven into a redwood w/ a 34" DBH, approx. 4" from the ground, it is painted orange. BM-1 is a 5/8" lag bolt that horizontally driven into RW approx. 6" out.

38 39

Figure 9: Sample page from Level Notebook

- Step 3: Label the notebook columns, see Figure 2.
  - The first column is labeled **HD** for *Horizontal Distance*.
    The HD is the distance along the thalweg where the elevation readings are taken.
  - The second column is labeled **BS** for *Backsight*.
    The BS is the actual vertical distance from the point of known elevation to a horizontal line projected by the instrument. There is only one BS for each setup of the instrument and it will always be your first reading after setup.
  - The third column is labeled **FS** for *Foresight.*
    The FS is a rod reading taken on any point to determine its elevation.

- The fourth column is labeled **HI** for *Height of the Instrument.*
  The HI is computed by adding the backsight reading to the benchmark elevation or the elevation on which the backsight was taken. HI=Elev +BS
- The fifth column is labeled **Elev**ation.
  The point at which elevations are known or determined are either benchmarks or turning points. To determine the elevation of all other points use Elev=HI-FS.
- The sixth & seventh column is labeled **Offset** for the *horizontal distance offset*.
  The offset is the distance from the HD tape to the actual rod placement site in the thalweg. It is rounded to the nearest foot. Which side of the tape the offset is on is also noted by listing left or right bank.
- The eighth column is labeled **AZM** for the *azimuth* of the *horizontal distance* tape.
  The azimuth of the horizontal distance tape is taken looking upstream and always when there is a change in the direction of the tape.
- The last four columns are labeled **Comment**.
  This is where the surveyors record the type of habitat being surveyed (i.e. pool, riffle, run). In addition, surveyors should record other factors such as fish or amphibian presence, types of vegetation or unusual features.

Be neat and orderly so that the data you record can be easily read. Note all pertinent details in your descriptions. Over the years, the field book will be used to re-locate the benchmark and various survey stakes or markers. The field book will also be the source of data used to analyze the changes in stream shape with time.

Directions for Organizing the Supplemental Forms

Set up a binder or covered clipboard that contains the following documents and supplemental data forms copied onto *Rite-in-the-Rain* paper:

Figure 10: Surveying Equipment

- ❑ A topographical map
- ❑ Copies of old field notes and data forms
- ❑ Copies of all the landowner access agreements
- ❑ Equipment Form
- ❑ Pebble Count Forms (2 sheets)
- ❑ Large Woody Debris Forms (5)
- ❑ Canopy Forms (1)
- ❑ Riparian Plot Forms (12 sheets)

Directions for Organizing the Equipment

Make sure all your equipment has been properly calibrated and is in good working order, see Figure 10. Fill out the Equipment List Form (page 12) making sure you include all the serial numbers. Check your equipment against the following list:

- ❑ Engineer’s Level
- ❑ Tripod
- ❑ Stadia Rod
- ❑ Bullet Level
- ❑ Compass
- ❑ Calculator
- ❑ 11 Fence Posts
- ❑ 10 Lag Bolts & Driver

- ❑ 200’ Fiberglass Tape
- ❑ 150’ Fiberglass Tape
- ❑ Spencer Tape
- ❑ 25’ Steel Tape
- ❑ Clear Metric Ruler
- ❑ Clinometer
- ❑ Densiometer
- ❑ 24 pieces of 3’ Rebar
- ❑ Flagging
- ❑ Rudd paint
- ❑ Aluminum & Code Tags
- ❑ Sledge Hammer
- ❑ Fence Post Pounder
- ❑ Clippers & Machete

Identifying Bankfull

A stream is said to be at bankfull when the water is at the top of the bank and just about to overflow, see Figure 4. The flow at bankfull (bankfull discharge) is the flow that, over time, shapes the channel. The bankfull width is measured by locating indicators of the bankfull level on opposite banks of the channel and measuring the horizontal distance between the points.

Bankfull Indicators (Leopold, 1994).

1. The point bar is the sloping surface that extends into the channel from the bank on the inside bend of a curve in the channel. The top of the point bar is usually at the level of the floodplain. Floodplains generally result from the extension of point bars as the river moves laterally by erosion and deposition through time. The top of a point bar is the lowest possible level of bankfull.
2. The bankfull level is usually marked by a change in vegetation. For example, the change from bare gravel bar to forbs, herbs and grass. Willows can occur well below bankfull. Usually large mature alders do not occur below bankfull. The type of lichens or moss may change at the bankfull level.
3. A topographic break usually occurs at bankfull. The ground may change from a slope bar to a near vertical bank. The change in topography may be subtle.
4. The bankfull level is often marked by a change in size of material on the bed. The change can be from fine to coarse or from coarse to fine.
5. Deposits of flood debris are unreliable and should be used only as a confirmation of other indicators. Debris deposits often indicate the level of the last large flood and may not indicate the bankfull level. Debris in willow branches may have been deposited when the branches were bent over by the force of the floodwater.

Directions for Locating Bankfull Indicators

Use the following procedure to flag bankfull indicators on both sides of the stream. The most consistent indicators on both sides of the channel will indicate the bankfull level. Designate one color of flagging for bankfull indicators. An easy method to flag the bankfull indicators is to put a nail through a piece of flagging and push the nail into the ground

- Step 1: Flag the top of any point bars in the marked reach.
- Step 2: Look for the lower limit of perennial vegetation or a change in vegetation type or density. Flag several of these points on both banks.

  Note: Remember that after extended periods of drought, perennial plants may invade the channel.
- Step 3: Flag the lower limit of moss or lichens on the banks or rocks.

- Step 4: Flag the lowest mature alders on both sides of the channel.
- Step 5: Look for and flag changes in the slope of the bank.

  Note: A change from a near vertical to a horizontal surface is the best indicator of the floodplain and bankfull level. Many streambanks have multiple changes in slope so be careful. A slope break may also indicate a terrace. A terrace is an old floodplain that has been abandoned by a downcutting stream. A terrace usually has perennial vegetation and definite soil structure.

- Step 6: Flag changes in bank materials.

  Note: Typically, a change from coarse to fine material on the surface of the bank indicates the bankfull level. However, the change can also be from fine to coarse. Changes in bank slope are often associated with a change in the size of the bank material.
- Step 7: Look for undercut banks covered by dense root mat from perennial vegetation. Feel up beneath the root mat and estimate the upper extent of the undercut. A spike or pin-flag may be inserted horizontally through the root mass and located by touch at the upper extent of the undercut. This will probably be slightly lower than bankfull.

  Note: Undercut banks are often the best indicators in steep or confined streams that lack a floodplain.
- Step 8: Note any inundation water lines. These may be marked by sediment or lichen. Stain lines are often left by frequent low flows so bankfull is at or above the *highest* stain line.
- Step 9: Wade to the center of channel to view bankfull on both banks. Note features such as bars, boulders, root wads that may effect the water surface elevation or direct the current.
- Step 10: Discuss the significance of individual indicators. Assess the indicators and determine bankfull.
- Step 11: Remove flagging that does not designate bankfull.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the flagging used to mark the bed-material regions. Pick up any trash you may have dropped.

Establish the Benchmarks

When the study reach is established a primary benchmark is selected and its location documented. The survey level is set up where the benchmark and the stream channel are visible. The elevation of the benchmark is shot and recorded. In subsequent years, the benchmark is used as the vertical (elevation) reference for the survey.

A benchmark is a permanent mark near the area to be surveyed that can be located every year. The benchmark serves as the vertical or elevation reference point for the study reach. The elevation may be assumed (100 ft. is normally used) or tied into a project datum or mean sea level.

- For long-term permanent sites three benchmarks are established near the beginning of the study reach. Each cross-section associated with a longitudinal profile must have a benchmark installed on the left and right bank.
- The benchmarks are located outside of the channel, above bankfull and if possible above the floodplain but within line of sight of the reach start point.
- One of the benchmarks should be located on the opposite bank from the other two. This will allow recovery in case of a bank failure.
- The two recommended methods for establishing benchmarks are:
  1. Lag bolt monument – screw a 6-inch lag bolt into the base of a large, healthy tree so the stadia rod can be set on its head and be visible and leveled (no over-hanging branches, etc.). Select a healthy tree (typically a conifer) 14'' in diameter or larger, with roots that are protected from stream erosion, and not subject to windthrow.
  2. Fence post monument – drive an 8' fence post vertically to within 2' of the ground surface. Fence posts need to be installed above bank-full.

Before starting to survey always review the material in the Surveying Basics, Appendix C.

Directions for Installing Benchmarks

- Step 1: Install the access marker for the study reach.
  Install a fence post marker at the nearest road access point. Tag with station ID (stream name & site #).
- Step 2: Install the benchmarks.
  Install 3 benchmarks using lag bolts screwed into the base of trees or fence posts. Number the benchmarks and tag (use aluminum tags) with station ID (stream name and site #), and benchmark #.

  > *Note: All benchmarks need to be installed outside of bankfull, in stable ground. At least one benchmark should be installed on the opposite bank. All benchmarks need to have a clear line of sight to the reach start point. Benchmark #1 should be the primary benchmark with the most secure location and the best line of sight to the study reach start point.*
- Step 3: Document the primary benchmark position.
  Stand at the access marker and with your compass find the azimuth and estimate the distance from the access marker to the primary benchmark (benchmark #1). Record the azimuth in your level notebook.
- Step 4: Document the secondary benchmarks positions.

Stand at the primary benchmark (benchmark #1), find the azimuth and estimate the distance to both secondary benchmarks (benchmarks #2 and #3), record in your level notebook under site description.

- Step 5: Photo Documentation.
  From the access marker take a photo of the primary benchmark (benchmark #1).
  From the primary benchmark take photos of the secondary benchmarks (benchmarks #2 & #3). Log the photo numbers with a description of the photos (i.e. Photo #1 = BM1 taken from access marker) in your level notebook.
- Step 6: Mapping.
  In your level notebook describe in detail the location of your benchmarks, access marker and study reach start. Draw a site map of the area.

Reviewing the Study Reach

After finding bank-full at the start of the study reach, installing or finding the existing access markers and benchmarks, your next step is to walk the study reach from beginning to end. As you walk up the reach, observe the following:

- Location of benchmarks
- Bankfull and the active channel
- Location of all cross-sections
- Location of logjams
- Location of the reach end points
- Roads and topographic features

Documents from past surveys will help you identify the beginning and end of the reach and cross-section benchmarks. If the study reach has not been previously surveyed then you need to look for flagging that delineates the reach segments. Also note access points to the nearest road. As you work your way up the study reach you may find it helpful to find new access points along the way.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Longitudinal (Thalweg) Profiles

Repeated longitudinal profile surveys of the stream channel are done to document changes in channel form and hydraulic variables. After the benchmark elevation is calculated, the rod person moves to the downstream end of the study reach and the thalweg is profiled. Riffles, runs and pools are defined and the elevations measured.

The survey is conducted in conjunction with the benchmarks, the cross-sections, the pebble counts and the Large Woody Debris surveys. All five surveys are linked by either elevation or horizontal distance.

Before starting to survey always review the material in the Surveying Basics, Appendix C.

Directions for Laying out the Horizontal Distance

- Step 1: Monument the start of the study reach.
  Install fence posts outside of bankfull on the left and right banks in a line, which is perpendicular to the flow. Starting at left bank lay a tape between the fence posts.
- Step 2: Find the starting point for the horizontal distance (HD).
  Find the center of the channel in the lay line between the two fence posts marking the start of the study reach. *This is your starting point for the HD.* Stake by using a temporary piece of rebar.
  > *Note: This is your starting point for the longitudinal profile. You will attach the zero (0+00) end of your thalweg tape to this stake.*
- Step 3: Document the HD starting point.
  Record the distance from the left bank fence post to the HD starting point.
  Then stand at the primary benchmark. Take a bearing to the HD starting point, record.
  Measure and record the distance from the primary benchmark to the HD starting point.
  > *Note: Record all distances and azimuths in your level notebook under the description of the site. The measurements will assist future surveyors to find the exact starting point of your survey.*
- Step 4: Laying the horizontal distance tape.
  Attach the zero ft end of a 200’ fiberglass tape to the HD starting point stake. Walk up-stream near the thalweg and lay the tape in as straight a line as possible. Stake any curves in the tape. Stake the 200 ft end.
  > *Note: The tape may be layed up to 20’ from the thalweg. Any curve in the tape needs to be staked to an angle.*
- Step 5: Flagging for riparian plots.
  Flag left and right bankfull at the HD starting point for the riparian plot surveys. You will continue to flag bankfull every 200’ when you start a new segment.
  > *Note: <u>Always</u> record on flagging: stream name, site #, distance, date, purpose, crew.*
- Step 6: Photo documentation.
  Stand in middle of channel at the HD starting point. Take photos of the stream channel; first looking downstream then upstream. Record photo numbers in your level notebook.
  > *Note: Photo documentation is repeated at all cross-sections and the end point (1000’)*

Directions for Performing the Longitudinal Profile Survey

- Step 1: Setup the engineer's level.
  Setup the level at a location where both the benchmark and the downstream end of the study reach are visible. The line-of-sight of the level must be higher than the benchmark.
  Note: To set up the level follow the instructions in Surveying Basics in Appendix C. Choose the location to minimize the number of times the level will have to be moved. Moving the level adds time and potential error to the survey.
- Step 2: Surveying the benchmarks.
  1. Turn the telescope to view the primary benchmark. The rod person places the rod on top of the benchmark. The rod is held vertically by using a level.
     Note: Stand so that you can control the rod and see the level.
  2. The instrument person reads the elevation on the rod and records it as a backsight. After recording the backsight elevation, re-check the rod reading.
     Note: The elevation of the primary benchmark will be set at 100'. See Figure 6 in the Surveying Basics section.
  3. Calculate the instrument height by adding the elevation of the benchmark to the backsight (HI=Elev + BS).
  4. Turn the telescope to the secondary benchmarks and repeat the process.
     Note: Elevations of the secondary benchmarks are not recorded in the BS column but in the site description area.
- Step 3: Surveying the thalweg.
  1. The rod person stands at the HD starting point looking up-stream. Take the azimuth and distance (in this case the distance would be 0+00) of the first straight section of the HD tape. The instrument person records the azimuth in the AZM column at the distance the azimuth is taken.
     Note: The distance and the azimuth of the HD tape are always recorded at each angle change throughout the longitudinal profile.
  2. The rod person moves to the thalweg at the HD starting point, tells the instrument person the horizontal distance (in this case it would be 0+00) and then levels the rod.
  3. The instrument person always waits until the rod person says "level" then reads the elevation and records it as a foresight.
  4. The rod person then tells the instrument person the offset of the stadia rod from the tape.
     Note: The offset is rounded to the nearest foot and needs to be recorded as to which side of the HD tape; left or right bank.
  5. Calculate the elevation of the thalweg at the start point by subtracting the foresight from the instrument height (Elev=HI-FS).
  6. The rod person moves upstream to the next survey point in the thalweg.
     - First take the azimuth if the HD tape has changed angles.
     - Second take the horizontal distance
     - Third place and level the rod in the thalweg
     - Fourth take the elevation
     - Fifth take the offset

     Note: The most important thalweg features to measure are; riffle crests, breaks in slope, and the deep points of pools.
     Always measure the beginning, middle and end of any feature.

Measure the elevation whenever the channel bed changes slope. Where the slope is relatively uniform (e.g. a long run, riffle or pool) measurements can be farther apart but not more than 15'.

- Step 4: Follow the above procedure until the instrument person can no longer see the stadia rod. The line of sight may be blocked by vegetation or the stream may curve.
  Note: Vegetation can be moved by using bungee cords to tie it back.

Directions for Moving the Instrument (Turning Points)

- Step 1: Finding a stable foresight elevation.
  Pick a point for a foresight that is stable.
  Note: A boulder, a nail hammered into a piece of large wood or a stake are all good choices.
- Step 2: Recording a Turning Point (TP) foresight.
  In the HD column write TP1 instead of the horizontal distance. Record the elevation in the foresight (FS) column.
  Note: For accuracy, repeat the turning point foresight by removing the rod and then replace it in the same spot, verify elevation.
- Step 3: Moving the engineer's level.
  Setup the level at a location where both the TP and the thalweg of the study reach are visible. The line-of-sight of the level must be higher than the TP.
  Note: To set up the level follow the instructions in Surveying Basics in Appendix C. Choose the location to minimize the number of times the level will have to be moved. Moving the level adds time and potential error to the survey.
- Step 4: Recording a Turning Point (TP) backsight
  Place the rod in the exact spot the TP1 foresight was taken. In the HD column write TP1 instead of the horizontal distance. Record the elevation in the backsight (BS) column.
  Note: For accuracy, repeat the turning point backsight by removing the rod and then replace it in the same spot, verify elevation.
- Step 5: Continue surveying the thalweg along the horizontal distance tape.
  Note: Follow the above steps every time the engineer's level is moved.

Directions for Closing the Survey

- Step 1: Ending the thalweg survey.
  Always end the survey at the designated ending point. Continue surveying up to the end of the designated reach if your last tape lay was short of the ending point.
- Step 2: Differential Survey.
  After you have reached the end of the horizontal distance for the longitudinal survey, you must run a differential survey back to the benchmark. The elevation of the benchmark at the end of the survey is compared to its original value. This process is known as closing the survey. Closing the survey is accomplished by executing a number of turning points from the end of the longitudinal survey back to the primary benchmark. The difference between the calculated elevation of the benchmark and its original value is the error.
  Note: To close the survey you want to use the shortest way back to the beginning (primary benchmark). It is sometimes easiest to use a road or trail that parallels the stream.

For more information consult the Differential Level Survey section in Surveying Basics, Appendix C.

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Cross-section Survey

Permanent cross-sections are essential for monitoring the stream channel. Additionally, the cross-sections sites provide established locations for pebble counts and photo surveys.
Each of our study reaches has three monumented cross-sections and they are surveyed in conjunction with the longitudinal survey. The cross-sections are placed at pool tail crests to document salmonid spawning habitat. Stakes are placed on opposite streambanks to mark each end of the cross-section. The line connecting the stakes should be at right angles to the stream flow. Distance along the cross-section is referenced to the stake on the left bank (facing downstream).

The rod is read on top of the left bank stake. The rod is then placed on the ground next to the stake and read. The rod person then places the rod on a series of points across the channel. The distance is recorded and the rod is read at every *break in slope*. A break in slope is the point where the angle of the ground surface changes (for example, at the top of a bank there is a distinct change in the slope of the ground surface).

The rod and distance should also be read at every significant channel feature such as the top of bank, bankfull indicators, bottom of the bank, edge of water and the thalweg (deepest point in channel).

Before starting to survey always review the material in Surveying Basics, Appendix C.

Directions for Performing a Cross-section Survey

- Step 1: Monument the cross-section.
  Install fence posts outside of bankfull on the left and right banks in a line that is perpendicular to the flow.
- Step 2: Delineate the cross-section data.
  In your level notebook draw a line below your last entry for the thalweg survey. Note that this is the start of a cross-section and the cross-section number.
- Step 3: Measuring the cross-section.
  Starting at left bank lay a tape between the fence posts. Stretch the tape from the left bank stake to the right bank stake. Read and record the horizontal distance between the stakes.
  Note: Leave the tape stretched to guide the rod person as she/he moves from point to point along the cross-section.
- Step 4: Surveying the cross-section.
  1. Start the survey at the left bank stake. Place the rod on top of the left bank stake and record the elevation as a foresight. The HD will be zero and under comments you will note that this elevation is at the top of the left bank stake.

2. Place the rod vertically on the ground next to the stake. Read the rod and record the value as a foresight. The cross-section distance of this elevation is also zero. Note in the comment section that this elevation is the base of the left bank stake.
   Note: All elevations for the cross-section will be foresights unless you need to move the instrument.
3. Then proceed to the next break in slope or the next channel feature, such as the bankfull stage or wetted width.
   Note: The elevations of all breaks in slope, bankfull stage, wetted width and the thalweg need to documented by identifying those elevations in the comment section.
   The maximum spacing between elevations cannot be greater than 5% of bankfull width.

- Step 5: Ending the cross-section survey.
  Continue shooting the elevation and recording the distance at each point along the cross-section. Finish the cross-section by taking the elevation at the base of the right bank stake and then on top of the right bank stake.
  Note: If the tape is too high for the rod person to read the instrument person can read the distance from the instrument to the rod using the stadia lines (see the Basic Surveying protocol). If the distance between the rod and the instrument is measured, make sure that it is recorded as such. It will be necessary to convert the distance from, "the distance from the instrument" to, "the distance from the left bank stake".
  Occasionally you will have to move the instrument to complete the cross-section survey. This may happen if an obstacle such as a large tree limb is blocking your line of sight. Do your turning points before and after you move the instrument. Follow the instructions in Surveying Basics, Appendix C.
- Step 6: Photo documentation.
  Stand in middle of channel at cross-section. Take photos of the stream channel; first looking downstream then upstream. Record photo numbers in your level notebook.
  Note: Photo documentation is repeated at all cross-sections and the start point (0+00') and end point (10+00')

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., ***A View of the River***, 1994, Harvard University Press, Cambridge, MA.

GRWC Monitoring Equipment List

Station: ______________________ Date: _______________

Crew: _______________________

Equipment	Serial Number
Surveying Book	
200' Fiberglass Tape	
150' Fiberglass Tape	
Carpenters 25' Steel Tape	
Spencer Tape	
Metric Ruler	
Engineers Level	
Tripod for Engineer Level	
Bullet Level	
Stadia Rod	
Stadia Rod Level	
Compass	
Densiometer	
Clinometer	
Camera	
Fence Post Hammer	
Maul	
Electric Drill	
Ratchet	
Machete and/or Clippers	
Other:	

Appendix F
Pebble Counts

Introduction

The composition of the streambed (substrate) is an important factor in how streams behave. Observations tell us that steep mountain streams with beds of boulders and cobbles act differently from low gradient streams with beds of sand or silt. This difference can be documented with a quantitative description of bed material.

The most efficient basic technique is the Wolman Pebble Count (1954). Pebble counts can be made using grids, transects, or random step-toe procedure. We use a step-toe procedure here. Pebble counts are conducted at the three cross-sections in the study reach.

Starting at bankfull, the riffle is traversed and every three feet the surveyor randomly selects a pebble. The pebble is measured at the intermediate axis. It is important for the surveyor to avert their eyes and pick up the first particle touched by their index finger at the toe of your wader. This continues in a zigzag pattern transecting the stream until 100 pebbles are measured.

Pebble counts are easier if you have two surveyors. One to act as the observer who will wade the stream and measure the pebbles and the other as data recorder who remains on the bank.

Directions for Performing a Pebble Count

- Step 1: Start the transect.
  1. Select the closest riffle downstream from the cross-section.
  2. Record the Horizontal Distances (HD) of the downstream and upstream ends of the riffle.
  3. Select a random starting point (perhaps by tossing a pebble) at one of the bankfull elevations.
  4. Averting your gaze, pick up the first particle touched by the tip of your index finger at the toe of your wader.
- Step 2: Measure the intermediate axis (Figure F-1).
  Measure (with the metric ruler) the intermediate axis (neither the longest nor the shortest of the three mutually perpendicular sides of each particle picked up)
  Note: To measure embedded particles or those too large to be moved in place, measure the smaller of the two exposed axis.
- Step 3: Call out the measurement.

To make sure the recorder has heard the correct measurement have the note taker repeat back the information for confirmation.

- Step 4: Take one step across the channel in the direction of the opposite bank and repeat the process.
- Step 5: Traverse across the stream perpendicular to flow. Continue your traverse of the cross-section until you reach an indicator of bank-full stage on the opposite bank so that all areas between bank-full elevations are representatively sampled. Move up and down the stream in a zigzag fashion.
- Step 5: Continue to pick up particles until you have 100 measurements.

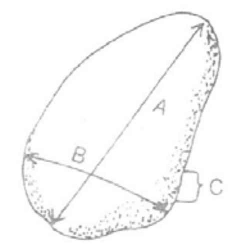


Figure F-1: Pebble Axis

Equipment and Forms List for 1,000 ft. Reach

- ❑ Clear plastic metric ruler (meters)
- ❑ 2 sheets of Pebble Count Forms (4 forms)
- ❑ Clipboard
- ❑ Pencils

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., *A View of the River,* 1994, Harvard University Press, Cambridge, MA.

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found below. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

Station: ______________ Date: __________ Crew: __________

Distance: __________ Cross-section number: __________

Pebble Count

1____	26____	51____	76____
2____	27____	52____	77____
3____	28____	53____	78____
4____	29____	54____	79____
5____	30____	55____	80____
6____	31____	56____	81____
7____	32____	57____	82____
8____	33____	58____	83____
9____	34____	59____	84____
10____	35____	60____	85____
11____	36____	61____	86____
12____	37____	62____	87____
13____	38____	63____	88____
14____	39____	64____	89____
15____	40____	65____	90____
16____	41____	66____	91____
17____	42____	67____	92____
18____	43____	68____	93____
19____	44____	69____	94____
20____	45____	70____	95____
21____	46____	71____	96____
22____	47____	72____	97____
23____	48____	73____	98____
24____	49____	74____	99____
25____	50____	75____	100____

Station: ______________ Date: __________ Crew: __________

Distance: __________ Cross-section number: __________

Pebble Count

1____	26____	51____	76____
2____	27____	52____	77____
3____	28____	53____	78____
4____	29____	54____	79____
5____	30____	55____	80____
6____	31____	56____	81____
7____	32____	57____	82____
8____	33____	58____	83____
9____	34____	59____	84____
10____	35____	60____	85____
11____	36____	61____	86____
12____	37____	62____	87____
13____	38____	63____	88____
14____	39____	64____	89____
15____	40____	65____	90____
16____	41____	66____	91____
17____	42____	67____	92____
18____	43____	68____	93____
19____	44____	69____	94____
20____	45____	70____	95____
21____	46____	71____	96____
22____	47____	72____	97____
23____	48____	73____	98____
24____	49____	74____	99____
25____	50____	75____	100____

Appendix G
Large Woody Debris Survey

Introduction

Large Woody Debris (LWD) is known to be an important structural element of stream channels. It improves juvenile Coho salmon and steelhead trout summer rearing habitat by increasing the numbers and depths of pools. Large amounts of LWD also increase winter cover that is critical for salmonid protection from predation and high water velocity.

All wood pieces greater that 6” in diameter and 4’ long that are within the stream channel or the pith breaks the bankfull plane are included in the survey. The thalweg tape layed for the longitudinal survey is used to record the horizontal distance of the pieces. As the team walks up the channel each piece is numbered and tagged for tracking purposes and the horizontal distances are recorded. The type of piece is determined as log or root wad and species is recorded. Total length and the length within bank-full are measured. Using a Spenser tape the team measures a number of different diameters including diameter at bankfull LWD must always be measured with a Spenser tape.

The LWD survey will always be conducted in 200’ segments after each tape lay of the longitudinal survey has been completed. It is important to work as a team. One surveyor is the recorder and their duties consist of reading the horizontal distance, recording the measurement information and helping to take the physical measurements. The other surveyor is the LWD tagger and the primary measurement taker.

In small streams bankfull and the LWD is fairly evident from mid-channel so you can inventory both banks as you walk up the steam segment. In larger streams it may be necessary to survey the left and right banks separately.

Directions for Performing the LWD Survey

- Step 1: LWD form.
  Fill out the LWD form with all location, date and crew information.
- Step 2: Horizontal distance.
  Start at the beginning of your tape, which will be the downstream position of your segment.

  Note: If it is the start of the study reach then your starting point is 0+00’.
- Step 3: LWD size assessment.
  1. Determine if the piece is 6 inches in diameter for a length of 4 feet. If not, the piece is too small to include in the survey and is not considered to be LWD.

2. Next determine if the piece is in the bankfull channel. LWD that is partially within bankfull is included if the pith breaks the bankfull plane of the bankfull line.

- Step 4: LWD Horizontal Distance.
  If the piece is considered to be LWD then first determine and record the horizontal distance. The horizontal distance is always taken at the LWD downstream point of contact.
- Step 5: LWD Number.
  Tag and number the piece. Record the number on the form. Plastic tags with pre-determined numbers will be provided. In addition, with the landowner's permission, spray paint the number so it is visible from the survey channel.
  Note: Staple guns will be used to secure the tags. Try to attach tags in cavities or areas that are protected. Painting large numbers on the LWD will assist future survey crews.
- Step 6: LWD Species and Location.
  Determine the LWD Species and record the wood Location. If the pith of the LWD breaks the bankfull plane then the wood is not considered to be in bankfull but on the left or right bank.
  Note: Left and right bank are always determined by looking downstream.
- Step 7: LWD Quality.
  First decide if the piece is part or a logjam or possibly perched above the stream. If not, then decide if the piece is keyed in or mobile. Always envision the piece reacting to bankfull stage to make this determination.
- Step 8: LWD Source.
  To determine the source of the LWD first look to see if the wood is part of a restoration project. Wood that has been manually placed in the streams is usually marked. If you can't see markings you can sometimes see cables or bolts. If the wood does not appear to be part of a restoration project then try to determine how the piece entered the stream. Most pieces will be simply "unknown" which means the origin cannot be determined.
- Step 9: LWD Total Measurements.
  a. Length: If the LWD is a log measure the total length. If the LWD is a log with a root wad attached, measure only to 1 ft. above assumed ground level of the tree if it was upright.
     Note: The rootwad will be measured separately. Measurements for length are taken to the original LWD size parameter of 6" in diameter. Always stop your length measurement when the diameter of the LWD goes below 6".
  b. Diameters: First measure the large end of the log this is the D1. If the log has a root wad attached then measure the diameter at 1 ft. above assumed ground level. Second measure the small end this is the D2.
     Note: For diameter measurements make sure you use the appropriate side of the Spenser tape (the numbers are red). Remember, the small end diameter will never be less than 6".
- Step 10: LWD Bankfull measurements.
  Note: You will always measure the portion of the log that is within bankfull as if it is a separate log.

a. Length: If the LWD is a log measure the length of the log within bankfull. This means measure from the instream end of the log to where it breaks the bankfull line or plane. If the LWD is a log with a root wad attached, remember to measure only to 1 ft. above assumed ground level of the tree if it was upright. If the whole log is within bankfull then the Bankfull length is equal to the Total length.

   Note: The rootwad will be measured separately. Measurements for length are taken to the original LWD size parameter of 6" in diameter. Always stop your length measurement when the diameter of the LWD goes below 6".

b. Diameters: First measure the large end of the log this is the D1. Depending how the log is situated this measurement could be either the instream end of the log or the diameter of the log where it breaks the bankfull line or plane. If the whole log is within bankfull then the Bankfull diameters are equal to the Total diameters. If not, then measure the length of the log within bank-full and record as bankfull length. Second measure the small end this is the D2.

   Note: For diameter measurements make sure you use the appropriate side of the Spenser tape (the numbers are red). Remember, the small end diameter will never be less than 6" and if the log has a root wad attached then measure the diameter at 1 ft. above assumed ground level.

- Step 11: LWD Rootwad Measurements.
  Root wads are measured by first measuring the height of the wad. This is the distance from the roots to 1 ft. above ground level point. Next measure the width and then the depth.

Equipment & Forms List for 1,000 ft. Reach

- ❑ Installed Horizontal Distance Tape (200 ft.)
- ❑ Spenser Tape
- ❑ Large Wood Forms (5)
- ❑ Clipboard
- ❑ Pencils
- ❑ Paint
- ❑ Plastic Numbered Tags
- ❑ Aluminum Tags and Nails
- ❑ Hammer and Staple Gun

Clean-Up

Remove all the temporary stakes from the channel bed. Remove all the excess flagging. Wind up all of the tapes. Pick up any trash you may have dropped.

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found attached. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique,* USFS General Technical Report RM-245.

Jackson, Dennis, Marcus, Laurel (1999) *Creating a Watershed Atlas and Monitoring Program, Watershed Stewardship Workbook.*

Leopold, Luna B., *A View of the River*, 1994, Harvard University Press, Cambridge, MA.

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual,* Third Edition.

Large Woody Debris Inventory Form

Modified on 03/10/03

		Species	Code	**Location**	Code	**Quality**	Code	**Source**	Code
Station ID:	______	Redwood	1	In Bankfull	2	Keyed	1.0	Unknown	1.0
		Douglas Fir	2	Left bank*	3	Digger wedged	1.2	Green Unknown	1.4
Date:	______	Pine	3	Right bank*	4	Digger cabled	1.3	Windthrow	5.0
		White Wood	4	Bank to bank	5	Buried	1.4	Green Windthrow	5.4
Crew:	______	Tanoak	5	***Note:*** *To qualify as LWD a piece of wood must be at least 6" in diameter for 4' in length.*		Mobile	2.0	Undercut Bank	6.0
		Alder	6			Log Jam	5.0	Green UC Bank	6.4
Reach		Maple	7			Perched	6.0	Landslide	7.0
Length:	______	Willow	8					Green Landslide	7.4
		Other HW	9					Project	9.0

Distance From 0' (Feet)	LWD#	Sp.	Loca-tion	Quality	Source	Log Total Length	Log Total D1 *Large End*	Log Total D2 *Small End*	Log Bankfull Length	Log Bankfull D1 *Large End*	Log Bankfull D2 *Small End*	Root Wad Size (Feet) A Axis Height	Root Wad Size (Feet) B Axis Width	Root Wad Size (Feet) C Axis Width

* Left bank and right bank determined by looking down stream.

Appendix H
Riparian Surveys

__Introduction__

Riparian surveys use a fixed 20th acre plot every 200’ starting at the zero point along the steam monitoring reaches. The plots run perpendicular to the stream channel, are 21.8’ wide and extend from a permanent point at bankfull to a permanent point 100’ inland (adjusted for slope). All trees larger than 5.6” in diameter at breast height (DBH) are recorded as to size, species and placement within the plot. A sampling method for tree height allows for a statistical projection of tree height per acre. A smaller 100th acre lesser vegetation plot is established 15’ inland from the bankfull point. The lesser vegetation survey records the number and the species of trees and brush less than 5.6” DBH plus the vegetation type and percent of ground cover.

Canopy density is measured by using a spherical densiometer. Measurements are taken in conjunction with the riparian surveys every 200 ft. starting at the zero point of the survey reach. The density is measured at center of channel, left and right bank and 50 ft. inland from bankfull.

The Riparian surveys need to be conducted by a survey team (2 or more) and are completed after the longitudinal profile and LWD surveys are finished. The start or zero points of the riparian plots are always the left and right bankfull sites that were flagged during the longitudinal survey.

Riparian surveys are not conducted where the slope is greater than 75%.

Before starting the riparian survey review the material in Field Equipment, Appendix D.

Directions for Performing the Riparian Survey

- Step 1: Riparian survey form.
  Fill out the top box of the riparian survey form. Include station (reach name & number), date, the form number in relationship to the total number of riparian forms for the study reach and crew names. For plot location always use the HD of the plot <u>along the study reach</u>. Make sure you designate left or right bank (i.e. 0+00RB).
  Note: Left and right bank are designated when looking downstream.
- Step 2: Laying out the riparian plot.
  1. Always start with the left bank plot. Place rebar at the bankfull point, paint for easier identification.
  2. Using your compass, stand perpendicular to the stream then sight on a feature approximately 100 ft. inland and record the azimuth on your plot form. Keep the bearing on your compass because this will be the lay line for your tape.

Note: The reciprocal bearing is the tape lay line for the right bank plot.

3. Attach the riparian plot lineal tape to the rebar. This will be your start point (zero).
   Note: This tape will be in feet and inches.
4. One team member stays at bankfull, the second team member starts to lay the tape 100 ft. inland using a compass and following the plot bearing.
5. As the second team member lays the tape they flag both the 15 ft. point and the 50 ft. point. This will be the center of the 100th acre lesser vegetation plot (15 ft.) and where canopy density (50 ft.) is measured.

- Step 3: Determining slope.
  The horizontal distance of the plot is always adjusted to compensate for slope. A clinometer and the slope adjustment table are used to develop a specific horizontal distance for each riparian plot.
  1. Using a clinometer, the team member at bankfull sights on the team member at 100 ft.
     Note: To determine slope the person using the clinometer always sights on an object at eye level.
  2. Record the slope percent and using the slope adjustment chart (Table 2) determine and then record the true horizontal distance.
  3. The team member now adjusts the tape to the true horizontal distance and places and paints a piece of rebar. Flag above the rebar for easy identification.
- Step 4: Measuring tree diameters.
  Record the location and measure the diameter of all trees that are larger than 5.6” diameter at breast height (DBH) within 10’, 10.7” of either side of the tape. In addition, record the distance and measure the diameter of any downed log at the point the tape transects the log.
  1. First determine if the tree is within the plot. If it is larger than 5.6” DBH and located within 10’ 10.7” of either side of the tape then fill in the location number.
     Note: The location number is the distance the tree is from bankfull on the horizontal distance tape.
  2. Using the code tables attached to your Riparian Form fill in the codes for Tree Species (Table 2) and Group (Table 4).
  3. Using a Spenser tape measure the diameter and record.
  4. If a log transects the tape, is larger than 4 inches in diameter for 6 ft in length then record Location, Species and Group and measure the diameter at the point the log transects the horizontal distance tape.
     Note: Downed logs are only measured if they transect the horizontal distance tape.
  5. Continue until all trees are measured and recorded.
- Step 5: Measuring tree height.
  Measure the diameter, height and crown ratio of the first 3 conifers from bankfull in the riparian plot.
  1. After recording the Location, Species and Group of the first conifer from bankfull attach a Spenser tape to the tree. Walk 66 feet to an area where you can see the base and the top of the tree.
     Note: Although it is not always possible, the reading will be more accurate if you try to stay at the same elevation as the tree you’re measuring.

2. Using a clinometer first site on the base of the tree, record. Make sure you record whether the number is negative or positive. Next site on the top of the tree, record reading in the Top column. Using the formula, add negative numbers and subtract positive numbers, record tree height in the Total column.
3. Next estimate the percent of live crown.
4. Measure the diameter, height and crown ratio of the next two conifers, for a total of 3 conifers.

- Step 6: 100th Acre Lesser Vegetation Plot.
  Lesser vegetation plots are fixed radius plots measured 11.78' from a point 15' inland from the bankfull rebar. Trees less than 5.6" DBH are recorded along with the percent of lesser vegetation ground cover.
  1. Stand at the 15' point along the horizontal distance tape. This will be the center of the fixed radius plot. Extend a tape out 11.78".
  2. Rotate the tape 360 degrees and record all trees less than 5.6" DBH as to Species, Group and Diameter that are within the circle.
     Note: Lesser vegetation trees may be grouped into size categories by species.
  3. Next within the same plot area, record the lesser vegetation using the codes listed in Table 3. Estimate the percent of area covered for each lesser vegetation species within the plot area and record in the % Cover column.
     Note: The total of the % Cover column for the lesser vegetation may be larger than 100% because of vegetation layers.
- Step 7: Canopy density.
  In the study reach canopy density is always surveyed in conjunction with the riparian plots. Density is measured using a spherical densiometer at the center of channel, left and right bank at bankfull and left and right at the 50' point in the riparian plots.
  1. Fill out canopy form with station (reach name & number), date and crew initials.
  2. Next fill out the plot location. This will be the horizontal distance of the riparian plot along the study reach.
  3. Measure the bankfull width by stretching a tape from the left bankfull rebar to the right bankfull rebar, record.
  4. Stand in the center of channel between the bankfull rebar facing upstream. Hold the densiometer 12-18 inches in front of your body and at elbow height, so that your head is not visible in the mirror. Make sure the level bubble is level.
  5. In each square of the grid, assume that there are four dots, representing the center of quarter-square subdivisions of each of the grids. Systematically count the number of dots NOT occupied by canopy.
  6. Multiply the total count by 1.04 to obtain the percent of overhead area not occupied by canopy,
  7. The difference between this and 100 is the canopy cover in percent. Record this number in Column 1. Make four readings per location – start by facing upstream then turn in a clockwise fashion taking a reading every 90 degrees – and average them to provide an estimate of canopy cover from that point.
  8. Repeat the above instructions at all canopy measurement sites.

Clean-Up

Wind up all of the tapes. Pick up any trash you may have dropped.

Equipment List for 1,000 ft. Reach

- ❑ Compass
- ❑ Clinometer
- ❑ Spherical Densiometer
- ❑ Calculator
- ❑ 200 ft. tape (tenths) for Bankfull Width
- ❑ 150 ft. tape (inches) for Riparian Plots
- ❑ Spenser tape
- ❑ 24 pieces of rebar
- ❑ Hammer
- ❑ Paint
- ❑ Flagging

Forms List for 1,000 ft. Reach

- ❑ 12 sheets of Riparian Survey Forms (24 forms)
- ❑ 1 Set of Riparian Tables (Tables 1-4)
- ❑ 1 Canopy Density Form
- ❑ Clipboard
- ❑ Pencils
- ❑ Permanent Marker (black)
- ❑ Study Reach Level Notebook

References

Dr. James D. Arney, Forest Biometrics, Forest Projection and Planning System (FPS)

State of California Resources Agency, Department of Fish and Game (1998), *California Salmonid Stream Habitat Restoration Manual,* Third Edition.

Riparian Survey Form

Station ID: ____________ **Date:** _____________ **Page:** _______ **Of:**_____

Plot Location: ____________ **Fixed Plot:** 20th acre **Minimum DBH:** 5.6" **Vegetation Plot:** 100th Acre

Slope: ____________ **Azimuth:** ________ **Offset from HD tape:** 10’, 10.7”

20th Acre Plot								100th Acre Plot			
				Tree Height & % Crown							%
Location	Species	Group	DBH	Base	Top	Total	Crown	Species	Group	DBH	Cover

Riparian Survey Form

Station ID: ____________ **Date:** _____________ **Page:** _______ **Of:**_____

Plot Location: ____________ **Fixed Plot:** 20th acre **Minimum DBH:** 5.6" **Vegetation Plot:** 100th Acre

Slope: ____________ **Azimuth:** ________ **Offset from HD tape:** 10’, 10.7”

20th Acre Plot								100th Acre Plot			
				Tree Height & % Crown							%
Location	Species	Group	DBH	Base	Top	Total	Crown	Species	Group	DBH	Cover

Riparian Survey Tables

Table 1

Slope Adjustment Table

% Of Slope	Horizontal Distance (feet)
0	100'
5	100.12'
10	100.15'
15	101.12'
20	101.98'
25	103.08'
30	104.4'
35	105.95'
40	107.7'
45	109.66'
50	111.8'
55	114.13'
60	116.62'
65	119.27'
70	122.07'
75	125'

Table 2

Tree Species

Survey Code	Species
BM	Big-leaf Maple
BP	Bishop Pine
BO	California Black Oak
LO	Canyon Live Oak
DF	Douglas Fir
GC	Golden Chinquapin
GF	Grand Fir
PM	Madrone
CX	Misc. Conifers
HX	Misc. Hardwoods
BL	Pepperwood (Bay)
PP	Ponderosa Pine
RA	Red Alder
RW	Redwood
SP	Sugar Pine
TO	Tanoak
MY	Wax Myrtle
WH	Western Hemlock
WI	Willows

Table 3

Lesser Vegetation

Survey Code	Species
AZ	Azalea
BE	Berry, Sp.
BB	Blue Blossom
CE	Ceanothus, Sp.
CO	Coffee Berry
CB	Coyote Brush
OG	Dwarf Oregon Grape
EH	Evergreen Huckleberry
EQ	Equisetum Sp.
FN	Ferns Sp.
FW	Fireweed
FO	Forbes
GR	Grass
LU	Lupine
AR	Manzanita
PG	Pampas Grass
PO	Poison Oak
RH	Red Huckleberry
RD	Rhodendron
RO	Roses
SA	Salal
SB	Scotch Broom
TH	Thistle, Sp.

Table 4

Group

Survey Code	Description
..	Green Trees
.D	Snag
DD	Down Log
LV	Lesser Vegetation
.P	Planted Tree
.C	Fresh Stump

Canopy Density Form

Station ID: ____________________ Date: _________________ Crew: __________

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

		1	2	3	4	Avg.
Plot						
Location: ________	Channel center					
	Bank full left					
BF Width: ________	50' left					
	Bank full right					
	50' right					

Appendix I
Stream Discharge, Turbidity, and Total Suspended Solids

Monitoring Objectives

1. Collect streamflow and water quality data during the rainy season at selected monitoring stations to establish baseline water quality conditions.
2. Monitor water quality and streamflow over several winters and attempt to establish trends in water quality conditions.
3. Develop a data set for water quality and streamflow in a Gualala River sub-watershed for future comparisons to other locations.

Monitoring Overview

Please refer to Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245 for the specific procedures for measuring and monitoring stream discharge.

Establish Monitoring Stations

1. Install staff plate
2. Survey cross-section and staff plate elevation
3. Establish the “course” for observations of surface float velocity

Data Collection

1. Upon arrival at monitoring station, record the following
    a. Sample location (monitoring station name)
    b. Date and time
    c. Description of weather conditions and flow conditions
    d. Gage height of water surface
    e. Repeat gage height observation
2. Water quality sample collection
    a. Turbidity sample (grab sample from surface as near center of channel as possible for immediate processing using field turbidity meter)
    b. Suspended sediment sample (depth integrated using DH- 48 for laboratory analysis for Total Suspended Solids; remove a sample aliquot for turbidity measurement using field meter)
    c. Note approximate location of sample location in relation to staff plate and centerline of channel (e.g. “5 ft downstream of staff plate from surface 4 ft from left edge channel”)

3. Discharge measurement using the current meter **AND/OR** float velocity observations (minimum of 6)
4. Repeat 2 above
5. Repeat 1-4 above at each sampling station
6. Perform turbidity measurements on samples immediately following completion of sampling circuit (process all samples at the same time, noting the time of sample processing)
7. Complete sample storage and chain of custody forms; shipment to laboratory to be arranged.
8. Photocopy data sheets and instrument logs; notify data coordinator regarding data collected.

Monitoring Procedures

- Step 1: Site Information.
  1. Fill in the appropriate station at which observations and samples are collected.
  2. Record initials of the individuals collecting observations and samples.
  3. Date and time of arrival at site.
- Step 2: Current weather.
  Circle one of the five choices that best describes the weather conditions at time of arrival at the site. If conditions change significantly, this can be noted in #7.
- Step 3: Flow conditions.
  This provides two descriptions of stream flow conditions described below.
  1. Circle one of the three choices that best describe the appearance of the water in the stream.
  2. Circle one of the four choices that best describe stream flow conditions regarding whether the stream is at or near a steady and low base flow, whether the stream is rising, falling or at or near a steady peak discharge.
  3. Water temperature measured in the field; circle F if Fahrenheit or C if Centigrade degrees (see Appendix B)
- Step 4: Previous weather.
  This provides two types of descriptions of recent weather affecting streamflow; it is possible that choices from 6a and 6b may apply. Note that this will be used as a supplemental description of rainfall records from rain gages in the watershed.
  1. Circle one of the two choices pertaining to preceding dry weather.
  2. Circle all of the four choices that apply pertaining to preceding rainy weather.
- Step 5: Comments.
  Note any additional information, problems or issues that may affect the data reported. If stream flow is very high and wading the stream is not safe, note that here.
- Step 6: Water surface elevation.
  Data collected pertain to the elevation of the stream observed at the staff plate (stream gage). Observations are made twice as described below.
  1. Time and elevation (staff plate reading) before discharge measurement (or float velocity).
  2. Time and elevation after discharge measurement (or float velocity).
- Step 7: Crest gage reading.

These measurements pertain to previous high water elevation recorded at the crest gage by water dissolving toothpaste smeared on a cedar grapestake fitted inside the PVC tube near the staff plate.

1. Measure and record the distance from the top of the grapestake to the end of the toothpaste remaining on the grapestake,
2. The adjustment factor needed to convert 9a to the equivalent water surface elevation on the staff plate; a value will be established for each station based on cross-section survey data.
3. Adjusted peak water surface elevation at the gage (staff plate).

- Step 8: Water quality samples.
  Three samples are collected: two grab samples and one depth-integrated sample using a DH-48 suspended load sampler (refer to DH-48 manufacturer's instructions or USGS Field Methods for additional details of sampling procedure). Grab samples are collected from the surface in a bottle as near to the thalweg (location of highest stream velocity) and are analyzed for turbidity at the end of the day. The DH-48 sample is sent to a contract laboratory for analysis of Total Suspended Solids (TSS); a small portion of this sample is used for turbidity analysis.
  1. Grab sample #1 is collected prior to discharge measurement.
  2. DH-48 depth integrated sample is collected in the thalweg (if possible) after the discharge measurement is completed.
  3. Grab sample #2 is collected immediately after the DH-48 sample.
  4. Date & time turbidity analysis is conducted, results of analysis, and the initials of the individual conducting the analysis.
  5. Remarks regarding any special circumstances or conditions affecting the timing, location or quality of water samples.
  6. Chain of custody information: Storage conditions for sample #2 for subsequent delivery to laboratory for analysis. Include location (address/residence), date & time, and storage conditions (ice chest, refrigerator, etc.)
- Step 9: Discharge measurement field observations.
  Refer to USGS instructional materials for detailed instructions at background on the technique. <u>Not to be performed by a novice.</u>
  1. Position on discharge measurement cross section measured with zero located on the left bank (facing downstream). This position defines the center of each discharge sub-cell for which a velocity measurement is obtained. LEW is the horizontal position of the left edge of water; REW is the horizontal position of the right edge of water facing downstream.
  2. Water depth at the velocity measurement position corresponding to location (a) above.
  3. Velocity measurement depth-point where velocity meter is positioned on the top set rod. The top set rod is designed to allow rapid positioning of velocity meter at above the bed equivalent to 0.4 times the water depth; this is equivalent to the position 0.6 times the depth below the water surface.
  4. Record the number of revolutions of the current meter as expressed by the number of audible "clicks" in the time interval selected (minimum 20 seconds or as specified by USGS guidance). For relatively low velocity flows, the sensor wire should be positioned to graze the single-revolution cam on the current meter axle. For high

velocity flows, the wire should be positioned to graze the five-revolution cam on the current meter axle. The selected cam for the discharge measurement is set at the beginning of the measurement and should not be changed after measurements begin.

5. Length of velocity measurement interval in seconds. This can vary for different locations in the cross-section, but should not be less than 20 seconds.
6. Mean water velocity computed from current meter rating table. This column is left blank in the field. Qualified personnel perform computations in the office.
7. Discharge of flow cell. This column is left blank in the field. Qualified personnel perform computations in the office. Discharge of the cell is calculated as the product of the width of the cell (horizontal distance between adjacent flow cells entered in column a), flow depth at the center of the cell (entered in column b), and the mean velocity of the cell (column g).
8. Total measured discharge. This column is left blank in the field. Qualified personnel perform computations in the office. Calculated as the sum of discharge cells (column g).
9. Name of operator of current meter.
10. Name of individual who computes discharge and date computed.

- Step 10: Float Velocity Data.
  These stream velocity data supplement current meter measurements and need not be collected in all cases. These data are most useful during periods of high stream discharge and should be collected after discharge measurements are completed at the same location. In some cases, stream discharge may be too high to safely measure by wading with the current meter, and the discharge is estimated from the velocity of surface floats. Over the course of the first sampling season, we would like to obtain paired data from current meter measurements and float velocity measurements to develop an adjustment factor between mean velocity (11f) and mean surface velocity. In the absence of site-specific data, the relationship is mean velocity = 0.85 x surface velocity. Refer to the appendix in the QAPP for technique of float measurements. Dried orange peels are an ideal float.
  1. Record the length of stream channel over which velocity is measured with floats.
  2. Location of float test in cross-section (left, center or right of channel surface); two float observation are required for each third of the channel width.
  3. Time in seconds for each float to travel the test length of stream surface.
  4. Raw float velocity (course distance divided by time of travel (12a divided by 12c). Computed in the office or in the field-may be left blank in the field.
  5. Adjusted float velocity (raw velocity x 0.85 <u>or</u> a site specific adjustment factor determined by qualified personnel)-may be left blank in the field.
  6. Measure mean channel width.

Equipment & Forms List

- ❑ Current meter
- ❑ Wading rod
- ❑ DH 48 suspended sediment sampler
- ❑ Sample bottles for DH 48
- ❑ Flexible nylon measuring tape (165 ft)
- ❑ Stop watch
- ❑ Steel tape measure (pocket size)
- ❑ Toothpaste (for crest gages)
- ❑ Thermometer
- ❑ Floats (dry orange peels)

Clean-Up

- Disassemble, dry and lubricate current meter
- Dry and secure turbidometer

Data Field Form

To assist in the collection and organization of site-specific information, a field data form can be found attached. Please photocopy the form onto Write-in-the-Rain paper for data collection activities. Please use a No. 2 pencil.

References

Harrelson, Cheryl C., C. L. Rawlins, John P. Potyondy, (1994) *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USFS General Technical Report RM-245

Edwards, Thomas K. and Glysson, G. Douglas (no date), Field Methods for Measurement of Fluvial Sediment. U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter C2

Instructions for Sampling with a US DH-48 Depth-Integrating Suspended Sediment Sampler (manufacturer's product)

Gualala River Watershed Council-Hydrologic and Water Quality Monitoring Form-Fuller Creek (3/2002)

1. Station: North Fork South Fork Mainstem Sullivan | **2. Observers:**

3. Date:__________ **Time:** _____ am pm | **4. Current Weather:** Clear Cloudy Showers Rain Heavy Rn.

5. Flow Conditions: **5a.** Clear / Turbid / Muddy

5b. Base Flow / Rising Flow / Peak Flow / Falling Flow | **5c.** Water Temp. ________ F / C

6. Previous Weather: **6a**. Dry: 1-3 days / 3+days | **6b.** Rain: Overnight / Yesterday / Past 2 days / 3+days

7. Comments on 1-6:____

____

____

8. Water Surface Elevation: **8a.** Time______ Elev. ______ ft | **8b.** Time______ Elev. ______ ft

9. Crest Gage Reading: **9a.** High Water Mark (Distance From Top of Wood Insert) __________ ft

9b. Adjustment to Gage Datum _________ft | **9c.** Crest Peak (Gage Equivalent) ______________ft

10. Water Quality Samples: ***Sample Labels Include Station, Date, and Sample #***

10a. Sample #1-Surface grab Location Time___________

10b. Sample #2-Depth integrated (DH-48) Location Interval Time Time___________

10c. Sample #3-Surface grab Location Time___________

10d. Turbidity Analytic Results Sample Turbidity Sample Processing by:_________________

Sample #	Date Processed	Time Processed	NTU's
1			
2			
3			

10e. Comments on samples: ____

____

____

10f. Chain of Custody:

Sample for Laboratory Analysis (Sample #2) Stored At_________________________________

Date __________Time _________ Storage Conditions <

----

11. Discharge Measurement: ***Conduct "spin test" on current meter. Note wire on Cam 1x or 5x. Items f, g and h are not completed in the field.***

11a. Station (ft)	*11b. Depth (ft)*	*11c. Sample Depth (0.4 D) (ft)*	*11d. # of Revolutions*	*11e. Sample Duration (sec)*	*11f. Velocity (ft/s)*	*11g. Discharge (cfs)*
LEW						
REW						

				11h. Total Discharge=	

11i. Current meter operator:_______________________________________

11j. Discharge computations by: ___________________________________Date____________

12. Float Velocity *(if performed)* 12a. **Float Course Distance (feet)**

12b. Observation # & Location	1-	2-	3-	4-	5-	6-
12c. Time for Float (seconds)						
12d. Raw Velocity (ft/s)						
12e. Adjusted Velocity (ft/s)						

12f. Mean Width of Water Surface (feet)

Discharge Measurement Notes & Comments: