Central Coast Watershed Studies

CCoWS

Protocols for Water Quality and Stream Ecology Research

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1 Introduction

This document is a continuing compilation of all protocols relating to the research activities of the Central Coast Watershed Studies (CCoWS) team at the Watershed Institute, California State University Monterey Bay (CSUMB).

The document is intended as a reference point for work in a number of areas, and for a number of research projects.

The protocols are grouped into five major areas, described in the following sections:

- Management protocols
- Monitoring protocols
- Sampling protocols
- Laboratory protocols
- Protocols for data analysis

A final section presents a number of 'methodological comparisons', including results of instrument calibration, and comparisons of measurement techniques for key variables.

2 Management protocols

This section contains protocols relating to general research management activities, including:

- Sample management (bottles, ID numbers, etc.)
- Database management
- Staff training
- Equipment management

2.1 Protocol for sample management

- Sample containers shall be labeled with a unique ID before being taken into the field.
- Containers that may be used include:
    - *Nalgene* bottles (1L)
    - *Nalgene* bottles (500 mL)
    - *Nalgene* bottles (125 mL)
    - *Nalgene* bottles (100 mL)
    - *Nalgene* beakers (1000 mL)
    - Bedload bags
    - Amber glass jars w/Teflon lined lids (60 & 120mL)
    - Sterile bottles provided by external laboratories (various)
- Containers shall be kept in groups, where all containers in a group have a similar ID.
- Re-useable, cleanable containers shall be weighed before use. The weight shall be recorded in the CCoWS database for recurring use.
- Upon taking a sample, the container ID shall be recorded in a *Rite-in-the-Rain* field book (see Section 3.9).
- The combination of Site Code (see Section 3.1.1), Date/Time, and container ID shall serve as the unique identifier of a sample.
- Large samples may be distributed between more than one container, in which case all container IDs shall be recorded.
- Samples shall be transported directly to the CCoWS laboratory. If necessary (see relevant Sections), samples shall be kept on ice in a cooler during transport.
- Upon returning from the field, all samples shall be deposited in the CCoWS laboratory. When necessary, samples shall be refrigerated or frozen. Frozen or refrigerated samples shall be logged in and out on the *Sample Storage Management Log* (Appendix A).
- On the first office day following field sample collection, all available data for each sample shall be entered into the CCoWS MS Access database (see Section 2.2). Fields for results of laboratory analyses shall be left blank.
- If necessary, certain samples (see relevant Sections) shall be analyzed without delay.
- If samples are to be analyzed at a laboratory other than CCoWS, samples shall be transported to the external laboratory and transferred according to that laboratory's chain of custody procedures. An additional container

ID for the external laboratory may be given to the original container, which would then have two container IDs.

- Samples analyzed in the CCoWS laboratory may also result in the use of additional containers and/or container IDs.
- Samples may be split in the CCoWS laboratory, such that the resulting fractions may be analyzed using either multiple techniques and/or multiple laboratories. Any fractional sample shall be transferred to new containers, with new container IDs.
- Upon completion of laboratory analysis, the analysis results shall be immediately recorded in the CCoWS *MS Access* database. The sample container shall then be cleaned and prepared for future sampling, or discarded.
- CCoWS sample containers shall then be cleaned and prepared for future sampling.

2.2 Protocol for data management

2.2.1 All data

- The primary data storage shall be on a central University server.
- The data shall be backed up on CD at least every 6 months. Backup CDs shall be stored in Watershed Institute offices in a fireproof safe.
- The data file names shall contain the last date on which they were significantly modified (in the format Name_YYMMDD_initials of user. *).
- Previous versions (with earlier dates) shall be maintained on the server as intermediate backups until they are backed up to CD (see above).
- All initial data shall be entered into the appropriate database on the day following field sample collection.
- After laboratory analysis is complete, all results should be immediately entered into the database record for that particular field monitoring campaign.
- All data entered into the database will be later verified by the project leader during the data analysis phase.
- CCoWS shall keep all original data sheets and field books on file at the Watershed Institute.

2.2.2 Primary water quality data

- Primary water quality data include all data pertaining to monitoring of streams and agricultural runoff.
- Primary water quality data shall be maintained in the CCoWS *MS Access* database.
- The following exception applies:
    - Individual flow and depth measurements within stream flow cross-sections shall be maintained in *MS Excel* spreadsheets (as opposed to the total calculated discharge that results from these measurements which is maintained in the CCoWS *MS Access* database).
- The CCoWS *MS Access* database shall be a relational database, with tables for:
    - Site information (e.g. site code, Bridge/Road crossing, GPS coordinates)
    - Site visit information (e.g. Date/Time, container ID, sample type)

- Lab analysis information on water quality samples (lab date, method number/code, detection limits if applicable, etc)

2.2.3 Other data

- Other data include: Regional lagoon monitoring and stream ecology data (stream reconnaissance, detailed stream habitat assessment, and fish population assessment).
- These data shall be maintained in separate *MS Access* databases.

2.3 Protocol for staff training and responsibility

2.3.1 Staff structure

The CCoWS staff hierarchy is as follows:

- Team leader
- Research manager
- Field coordinator
- Lab manager
- Senior technicians x 2
- Technicians x 2
- Students x 4

2.3.2 Laboratory training

- The laboratory manager shall oversee the development of new laboratory procedures, training of staff for new laboratory procedures, and laboratory training for new staff.
- Technicians shall be knowledgeable of all equipment and tests before analyzing samples independently. This should include both training with the laboratory manager and/or an experienced technician as well as the study of instrument and procedure manuals. This training shall be documented on the *Technician Training Tracking Sheet* (Appendix B) and kept on file by CCoWS.
- The laboratory manager shall be responsible for laboratory safety. It is their responsibility to assure that all technicians performing lab analysis have participated in a safety training session.
- Training on laboratory safety procedures is provided by the Earth Systems Science and Policy (ESSP) laboratory staff at CSU Monterey Bay and is a requirement prior to laboratory use. Documentation of lab safety training is kept on file by the ESSP laboratory staff.
- All accidents and incidents shall be reported to the lab manager and the ESSP lab director. Accidents and incidents shall be documented on the *Accident/Incident Report Form* (Appendix C).
- Students shall not undertake any potentially dangerous activity without staff supervision.

- Management and senior staff shall be responsible for the accuracy of analyses performed by students.

2.3.3 Field training

- The field coordinator shall oversee development of new field procedures, training of staff in new field procedures, and field training for new staff.
- The field coordinator or a senior technician shall be responsible for safety in the field.
- Staff shall not undertake any field activity without prior training by the field manager or designee.
- Staff shall be responsible for the accuracy of field data collected by students.

2.4 Protocols for equipment management

All the sampling equipment that CCoWS uses has been previously used by CCoWS and has proved to be both reliable and adequate for project needs. Any additional supplies needed for future projects such as sample bottles, standards, and filters will be ordered by the research, field, or laboratory manager. All equipment is inspected by management upon arrival from the supplier and given a unique ID. Factory manuals, specifications, and instructions are kept on file by CCoWS in Watershed Institute offices.

Prior to each sampling run, all equipment is visually inspected and assembled into field kits. Following each sampling run, field equipment is cleaned and stored until future use.

Various pieces of CCoWS equipment require periodic calibration and maintenance to assure accuracy and reliability. Following is a complete list of CCoWS equipment that requires calibration. The calibration schedule is presented in Table 2-1.

- *YSI 556 MPS* (measures dissolved oxygen, temperature, salinity, oxidation/reduction potential, conductivity, and pH)
- *EL301* strip-reader (microwell photometer for ELISA use)
- *Hach DR/2500* Spectrophotometer (nutrient analysis)
- *Hach 2100P* Turbidimeter
- *Micromeritrics* OptiSizer Particle Size Distribution Analysis (PSDA)
- *Oakton* Total Dissolved Solids (TDS) probes
- *Oakton* pH probes
- *Global Water*, Pygmy, and *CCoWS* water velocity meters (flow probes)
- Pipettes, various brands

The scheduling of the calibration and maintenance varies according to the amount of use and manufacturer's requirements. All equipment used by CCoWS is calibrated according to instructions provided by the manufacturer, with the exception of the water velocity meters constructed by CCoWS. The protocol for calibrating CCoWS flow probes is presented in Section 7.1. CCoWS maintains an "Equipment Calibration & Maintenance Records" document that outlines specific calibration and maintenance schedules/procedures along with logs for the

recording of calibrations and all maintenance performed. These records may be reviewed upon request.

Table 2-1. Equipment Inspection and Calibration Schedule

Equipment Type	Inspection Frequency	Inspection Method	Calibration Frequency	Calibration/Maintenance Method
YSI 556 MPS	Prior to each use	Accuracy check with factory standards	Prior to each monitoring campaign; if problems are detected	Factory prepared standards, method varies with constituent measured, sensors cleaned
Hach 2100P turbidimeter	Prior to each use	Accuracy check with Gelex factory standard	Quarterly	Factory Formazin standards, cell compartment cleaning
Oakton TDS probes	Prior to each sampling run	Battery check, accuracy check with factory standard	Prior to each monitoring campaign; if problems are detected	Factory prepared standard, electrode cleaning with alcohol
Oakton pH probes	Prior to each sampling run	Battery check, accuracy check with factory standard	Prior to each monitoring campaign; if problems are detected	Factory prepared standard, electrode soak in buffer solution
Global Water, Pygmy, and CCoWS flow probes	Prior to each sampling run	Visual propeller check, computer calibration function check	Annually	Propeller cleaning; metered velocity vs. actual velocity test conducted at swimming pool
Mettler Toledo balance	Prior to each use	Level	Balance is auto-calibrating	If problems are detected during quality assurance checks, maintenance will be provided by manufacturer

3 Monitoring Protocols

This section contains protocols relating to field activities, including:

- Site selection and preparation for source analysis monitoring
- Storm event water quality monitoring
- ‘Snaphot’ ambient water quality monitoring
- Water quality monitoring on agricultural fields
- Lagoon water quality monitoring
- Field notes and data sheets
- Stream reconnaissance
- Detailed stream habitat assessment
- Fish population assessment

3.1 Protocols for site selection and preparation for source analysis

3.1.1 Site selection

With respect to the objective of conducting a surface water impairment source analysis based on stream monitoring, loads of water quality constituents should be measured at as many sites as possible. Site selection is subject to the following goals and constraints:

- Sites should be established at multiple locations along major rivers.
- Sites should be established on major tributaries.
- Sites should be established near confluences (ideally one on each of the two streams above each major confluence, and one below the confluence).
- Sites should be established at major breaks in stream class (e.g. between headwater, foothill, and floodplain reaches).
- Sites should be established at bridges, to allow for monitoring during flood events.
- Bridges should be safe from traffic, with broad shoulders, and few vehicles.
- Sites should be safe from nighttime social dangers.
- Sites should be accessible by public roads.
- A single vehicle should be able to visit all sites in a single day.
- Sites should allow convenient parking.
- If site is privately owned, permission to access shall be obtained from the landowner.
- Each selected site shall be given a unique Site Code (e.g. SAL-DAV). The first three letters of the Site Code are the first three letters of the water body or stream name. The second three letters of the Site Code are the first three letters of the bridge or nearest road crossing. For instance, the Site Code SAL-DAV represents the monitoring location on the Salinas River at Davis Road bridge.

3.1.2 Site preparation

Staff plates measure river ‘stage’ and are the most robust, accurate record of river level available. Their permanency is vital.

- Except for existing USGS sites, sites shall be equipped with one or more 1-meter metric metal staff plates.

- Where possible, these should be mounted on the concrete of bridge foundations. In cases where the concrete is too hard, or there is no bridge, staff plates should be mounted on steel piles driven into the substrate.
- Note that “zero” stage does not need to be set to any particular level, such as the level of zero river discharge recorded at a particular time.

3.2 Protocol for storm-event water quality monitoring

3.2.1 Introduction

Storm water quality monitoring is based around rainfall during storm events. A storm event is a subjectively defined, discrete period of rainfall lasting between a few hours and many days. The objective of storm-event monitoring is to estimate the event total and peak flow and pollution load passing all sites of interest. Resource and personnel limitations dictate that a compromise is involved between the number of sites, and the number of times that each site can be visited during the event. The techniques presented below differ from many previously published techniques by being optimized as much as possible for maximization of useful information with the available labor resources.

Storm-based monitoring shall be planned as follows:

1. Prepare for rapid response.
2. Follow weather forecasts until precipitation is forecast a few days in advance.
3. Determine team availability.
4. Observe WWW weather radar animations every six hours.
5. Observe WWW quantitative precipitation forecasts (QPFs).
6. If more than 10 mm is forecast, notify team of impending mobilization.
7. Prepare round-the-clock field staffing schedule.
8. Take pre-event samples.
9. Watch WWW USGS stream-flow reports and radar to identify runoff areas.
10. Target field trips to runoff areas at regular intervals for duration of runoff.
11. Take post-event samples.

Each of these steps is described in detail as follows.

3.2.2 Rapid response

- The monitoring team shall be able to respond rapidly after extended breaks in fieldwork. The first 8 steps above can occur within a few hours. If pre-event samples are not taken before the event, total loads will not be able to be determined from the resulting data. This is particularly so for urban sites, which have a very short time of concentration of runoff.

Distant sites are also critical because of the time taken to reach them once a significant event has been determined to be likely.

- All storm-sampling equipment shall be prepared in color-coded sampling kits. The contents of each kit are listed in Table 3-1. This table is a list of basic equipment, though more may be added to fulfill individual project specifications. Kits should be kept in vehicles throughout the storm season.
- Sample bottles shall be pre-numbered (see Section □) and stored in bins ready to be taken in to the field. Pre-numbering saves valuable time in the field, where it can be difficult to number wet bottles with markers or tape, especially during nighttime monitoring. It also saves time in the lab, as the dry weight of each bottle can be stored on file indefinitely.

Table 3-1. Contents of storm monitoring kits

Storm Monitoring Equipment List		
Item Type	Items	
General	Rite-in-the-rain field book	funnel
	pencils x 4	hammer
	permanent marker	Stopwatch
	stakes	Zip-loc bags
	duct tape	towels
Safety	orange cones x 2	antibacterial lotion
	reflective vests x 3	gloves
	first aid kit	cellular phone
	flash light	head lamp
Sampling	TDS probe	Nalgene sample bottles
	pH probe	DH-48 sample bottles
	thermometer	DH-48 sampler
	optical range finder	flow probe
	measuring tape	flow probe top setting rod
	transparency tube	Helly-Smith bedload sampler
	ice chest w/ ice	bedload bags

3.2.3 Weather forecasts

Central Coast winter storms usually arrive from the west, northwest, or north. Typically, a low-pressure system moves generally southward along the coast from Oregon, spiraling counter-clockwise. This means that individual storm cells arrive from the west, as arms of the spiral. They often dissipate around the latitude of the Salinas Valley. It can be difficult to predict whether cells will cross the coastline and precipitate, or whether coastal effects, including the Coast Range, will block their progress.

- Team members should be aware that numerous false alarms are to be expected. A number of unexpectedly small, insignificant events may need to be monitored before a large event occurs.

3.2.4 The sampling team and their safety

For a typical event, the sampling roster may contain over 10 names.

- For each event, the team shall be divided into smaller field teams operating in sequence, such that a team is always in the field during peak days. Teams of two are economical, but three is safer and better for morale.
- Team members shall be made aware of safety hazards such as:
    - *Suspicious activity.* Over time, certain places become recognized as areas where suspicious or criminal activity is frequently observed, often at night or at dawn. Such sites shall be avoided outright, avoided at night, or only visited by teams of three of more, including at least one male.
    - *Trash.* Certain sites are frequent dumping grounds for trash. Trash may pose biological, physical, and mental hazards – such as large decapitated animals. Rubber gloves should always be used to protect the skin during sampling. Hands shall be cleaned with antibacterial cream at the completion of each site visit.
    - *Wading in fast and deep water.* In fast-flowing water, streams shall not be waded (particularly in waders) when the water is above thigh-height.

- *Bridge-based sampling of floodwaters*. Fast, deep water shall be measured using a bridge crane where applicable (see Section 4.1.9).

3.2.5 Weather radar

The United States has exceptional coverage by weather radar stations. The dissemination of radar data is licensed to private purveyors, each of whom choose to present the data in different ways. The `weather.com` site[1] offers an easily readable animated display covering a large area that merges data from multiple radar transceivers. The `wx.com` site[2] displays more detail over a shorter time period and smaller area.

- Weather radar shall be used to predict imminent, significant runoff producing events.
- Radar rainfall measurements should be ignored until significant patches or yellow, orange, or red coloring form a trajectory toward the study area.
- Multiple sources of radar information should be used in conjunction.

3.2.6 Quantitative precipitation forecasts

Radars only display precipitation that is currently occurring at a site, or that is occurring elsewhere from storm cells that are traveling towards a site of interest. They can be used to predict runoff in areas of interest with about two hours notice.

Longer notice is given by a number of quantitative precipitation forecast (QPF) products on the World Wide Web, which are produced by mesoscale computer simulation models. Total 6-hour precipitation depths for individual sites are given by a National Weather Service web site[3]. This site also produces a useful 72-hour animation for the western US[4].

- QPFs should be used to plan for storm events between about 4 hours and 2 days in advance.

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[1] `weather.com`: http://www.weather.com/weather/map/USCA0724

[2] `wx.com`: http://www.wx.com/wxradar/wxradarSS.cfm?radar=MUX

[3] `NWS 6-hour QPF`: http://www.wrh.noaa.gov/cnrfc/prods/RNOHD1RSA.htm

[4] NWS 72-hour QPF animation: http://www.wrh.noaa.gov/cnrfc/qpfloopfill.htm

3.2.7 Mobilization threshold

Almost any Central Coast rainfall amount will lead to runoff in urban areas. However, significant pollution loads are not usually generated until event totals exceed approximately 10 mm. Most agricultural areas do not typically generate runoff that reaches streams with sampling sites until over 20 mm of rainfall has been received. Depending on the antecedent conditions, the large tributaries of non-perennial rivers do not connect with the main stem of the rivers until a few events around 30 mm have occurred in any given season. Until then, all rainfall either evaporates or infiltrates into dry riverbeds.

- These thresholds, as predicted in the QPFs, should be used to determine whether or not to mobilize sampling teams.

3.2.8 Staffing schedule

During peak days of large monitoring campaigns, multiple teams may be required to be in the field at any one time in order to cover the major provinces of the study area. Rostered field trips generally last from between four and twelve hours. During pre-event and post-event days, a single team will often suffice, as most river stages will then only change gradually.

- Upon mobilization, a staffing schedule should be drawn up on a white-board (Figure 3-1).
- Compatible field teams should first be identified, with groups of workers that live near each other, have at least one experienced member, and at least one usable vehicle.

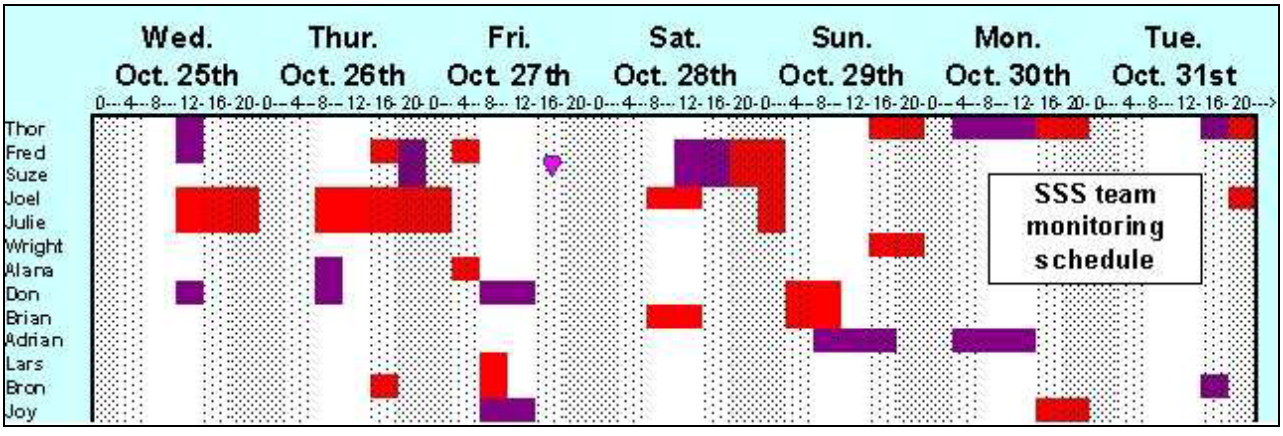


Figure 3-1. Example staffing schedules for storm-event sampling.

3.2.9 Tracking the peak

For a given sampling site during a given event, the most important result is an estimate of the total pollutant load passing that site during the event. This estimate is made using the integration of instantaneous load measurements made at several times during the event.

- At least three samples shall be taken per event: one before the event, one at the time of peak load, and one afterwards. The pre- and post-event samples define the start and end of the event, where both river stage and pollutant concentration should be at near ambient levels. If these samples are not taken, it is impossible to calculate the magnitude of the event when analyzing the results.
- Preferably, six or more samples should be taken. There may be two or three pre-event samples taken, in an effort to identify the exact moment that the river stage began to rise. Most of the load is generally transported near or before the time of peak discharge. This is also normally the time of peak sediment concentration. It is vital to take frequent samples and measurements of river stage during the peak. This ensures that the data clearly reveal that the peak was actually sampled, and did not occur sometime before or after a sample that was presumed to have been taken at the peak. Often, additional information can be gathered, such as the level of wetting on the concrete surrounding the staff plate. This will suggest whether or not the stage is still rising, or is falling. At times, there are multiple peaks, which complicates sample planning. Post-event samples are required to define the point at which the event is declared “complete”. This can take many days, as river stages recede much more gradually than they rise.

For large watersheds, the peak occurs at different times in different places. This is both due to different timing of incident rainfall, and to the time it takes the peak to travel downstream. For instance in the Salinas River watershed, rainfall timing introduces discrepancies of about 2 days, and travel time adds a further 7 days for the full length of the Salinas River. This is useful, as it allows a more even distribution of sampling resources. On most days, crews will be moving back and forth between a site that is currently peaking, a site 20 miles upstream

that has already peaked and needs post-peak samples, and a site 10 miles downstream that has not yet peaked.

- For large watersheds, sites should be located such that floodwater peaks move approximately one or two sites per day.

Logistics are more difficult toward the end of the event so it is important to stay organized. The team is often exhausted and need to catch up with sleep and their home lives. The vehicles become disorganized. Sample-bottle stocks are declining, and equipment is in need of calibration. On the positive side, it is usually sunny after the storm has passed.

3.2.10 Measurements at a single site

On a given site visit, one of four levels of measurement shall be used:

1. If time is limited and sampling has recently been conducted at the site, only a stream stage reading shall be taken (2-10 minutes).
2. Normally, this is not the case, and so a suspended sediment or other pollutant sample shall be taken from the river (5-15 minutes).
3. Where possible, a bedload sample should also be included (15-30 minutes).
4. If the river is flowing at a stage that has not previously been observed, a full stream discharge measurement should be taken (30-120 minutes).

3.3 Protocol for 'snapshot' ambient water quality monitoring

Whole valley snapshots are sometimes conducted during non-storm event periods. Snapshots provide information on the ambient flow conditions and pollutant concentrations throughout the long, low-flow periods that are typical of the Central Coast.

- Representative sites distributed widely throughout the study area shall be selected.
- Each site shall be monitored at least once during the snapshot.
- The duration of the snapshot should not be such that regional flow conditions change greatly.
- Variables to be monitored at each site shall include: stage, discharge, SSC, bedload, temperature, conductivity, pH, and any other pollutants or variables of concern.

3.4 Protocol for water quality monitoring on agricultural fields

In order to better understand how potential pollutants such as suspended sediment are transported on agricultural fields or how effective management practices are at retaining these pollutants, CCoWS often conducts on-farm monitoring. Agricultural fields experience two types of flow events that can be monitored: irrigation events and storm events.

3.4.1 Field selection and setup

Fields shall be selected according to the following requirements:

- The field shall drain to a well-defined point where runoff can be sampled. This may be at the end of a furrow or gutter, at the inflow or from the outflow a sump, the outflow from a pipe drain, or the outflow from a sediment detention basin.
- The type of sampling point shall be recorded, and each sampling point shall be given a confidential code in the CCoWS *MS Access* database.
- A map of the field shall be drawn up, including:
    - orientation of north
    - location within the farm parcel
    - orientation of furrows, gutters, and drains
    - location of sumps
- The drainage area of the runoff shall be determined, and its boundaries shall be well defined. The area shall be measured using farm maps and/or surveyed using a theodolite and an electronic distance meter (EDM).
- The slope of the field shall be measured, both along furrow lines and gutter lines. Undulating fields with variable slope should be surveyed using a theodolite and EDM, and the major slope classes should be mapped accordingly.
- The following shall be inquired of the farm manager and recorded:
    - type and condition of any crop
    - recent irrigation history of the soil
    - any expectations of runoff or infiltration based on the sealing state of the soil
    - date and type of last tillage
    - soil type

- Additionally, the soil type shall be determined from county soil maps and shall be recorded.
- If necessary, a system for sampling runoff from the site shall be installed at least one day prior to monitoring. The runoff sampling system may include devices such as PVC sheeting for confining the flow to a narrow stream.
- The act of measuring the runoff should not alter the runoff rate or the ability of the overall flow system to carry sediment past the sampling point.
- Multiple sampling points may be used.
- The level of sediment in any sumps, catch basins, or detention basins shall be recorded by placing a reference pin marked at the sediment surface.

3.4.2 Runoff sampling strategy

- The sampling strategy for the site shall be finalized at least one day before the storm or irrigation event.
- The initiation of runoff shall be observed. Reliable estimates of load are of limited accuracy if the sampling team arrives after the initiation of runoff.
- The time of initiation and cessation of both runoff and rainfall or irrigation shall be recorded.
- Sample collection shall commence at the initiation of runoff, and shall continue until runoff has ceased.
- Samples shall be taken every 5 to 30 minutes. This frequency should be increased during and before times of peak runoff, and decreased during runoff decline.
- The time shall be recorded for every sample, measurement, or observation of any kind.
- Runoff rate shall be measured using a vessel that can capture the entire field runoff for at least 2 seconds. A 5-gallon bucket with pre-marked volume increments may be used. Both the duration and volume of the sample shall be recorded.
- Water quality samples shall be taken by placing a pre-labeled sample bottle under the flow. Where the width of the flow stream exceeds the size of the opening on the bottle, the bottle shall be moved within the flow stream at an even rate so as to uniformly sample the flow stream.

- A water quality sample shall be taken immediately after each runoff measurement, except when runoff rates are relatively constant, in which case a water quality sample should be taken at least once for every 5 runoff measurements taken.
- After runoff ceases, the level of sediment in any sumps, catch basins, or detention basins shall be re-recorded against the reference pin placed earlier.

3.4.3 Rainfall or irrigation sampling

- The time of initiation of irrigation or rainfall shall be recorded.

3.4.3.1 Rainfall

- The amount of rainfall shall be measured using either one or more storage rain gauges, and/or one or more tipping bucket rain gauges with electronic loggers.
- The level of manual rain gauges shall be recorded at half-hourly intervals, and more frequently during periods of intense rain. The maximum rate of application of water to the soil is a critical variable in prediction of erosion.
- Rainfall may be measured at multiple points, in order to determine the average over spatially heterogeneous rainfall fields.
- Rainfall measured at the field should also be compared with hourly data obtained from the nearest three *NWS* or *CIMIS* sites published on the WWW.

3.4.3.2 Irrigation

The rate of application of irrigation water should be measured in *all* of the following ways:

- The farm manager should be asked to state the total irrigation amount (in inches), and to note whether this is expected to agree with pump measurements.
- The pumping rate shall be recorded in gallons per minute.
- The total amount of pumping shall be recorded in gallons.

- The total area under irrigation from the measured pump shall be recorded, as shall the fraction of the runoff-sampled area that is subject to this irrigation.
- The type of irrigation shall be recorded (e.g. sprinkler, linear, center pivot, drip, or flood).
- The rate of travel of linear irrigation systems shall be enquired of the farm manager, and verified by placing a reference pin and measuring the distance traveled over approximately one hour.
- The instantaneous width of the area under direct irrigation beneath linear systems shall be recorded periodically. This width is used to calculate instantaneous application rates per unit area.
- Care shall be taken to note whether the irrigation rate or the rate of travel of a linear system is deliberately increased or decreased at any time by the farm staff.
- The diameter of any sprinkler nozzles shall be recorded (in fractions of an inch).
- The total number of sprinkler nozzles in use shall be recorded.
- The rate of flow from a typical sprinkler nozzle shall be recorded by capping it with a calibrated bucket.
- The rate at which sprinkled water hits the field shall be recorded using one or more buckets periodically moved around the field. Note that wind may significantly enhance evaporation or otherwise remove water from the area to be irrigated.

3.5 Protocol for lagoon water quality monitoring

3.5.1 Monitoring

CCoWS monitors water quality in regional lagoons. Sites are chosen to evenly sample the lagoons with respect to the following likely correlates of variation in water quality:

- Distance from ocean
- Depth to bottom
- Proximity to aquatic vegetation
- Proximity to river
- Windward/leeward side of lagoon

At each site, the following parameters shall be measured:

- Location
- Depth to bottom
- Water temperature (every 50 cm depth to bottom)
- Salinity (every 50 cm depth to bottom)
- Dissolved oxygen (every 50 cm depth to bottom)
- pH (every 50 cm depth to bottom)

Sampling location is determined by using a *Garmin eTrex Summit* global positioning system (GPS) unit. By using GPS coordinates we are able to return to the same locations in the lagoon with approximately 10-meter accuracy.

Physical water quality data shall be collected using *YSI Environmental* 556 MPS Multiple Probe System. Accuracy, range, and resolution for temperature, dissolved oxygen, and salinity are listed in Table 3-2. Each parameter is measured at the surface and then downward at 50 cm intervals until the bottom is reached. To measure every 50 cm, the cable used for the *YSI* is marked at 50 cm intervals. The final overall depth is measured based on the amount of cable released into the water.

The necessary equipment required to conduct this type of monitoring is listed in Table 3-3. This table is a list of basic equipment, though more may be added to fulfill individual project specifications.

Table 3-2. YSI 556 MPS Sensor Specifications

Sensor Type	Accuracy	Range	Resolution
Temperature (YSI Precision™ thermistor)	± 0.15 °C	-5 to 45 °C	0.1 °C
Dissolved Oxygen (% saturation) (Steady state polarographic)	0 to 200%: ±2% of reading or air saturation 200 to 500%: ±6% of reading	0 to 500% air saturation	0.1% air saturation
Dissolved Oxygen (mg/L) (Steady state polarographic)	0 to 20 mg/L: ±2 of reading or ±2 mg/L 20 to 50 mg/L: ± 6% of reading	0 to 50 mg/L	0.01 mg/L
Conductivity (4-electrode cell w/ autoranging)	±1% of reading or ±0.001 mS/cm whichever is greater	0 to 200 mS/cm	0.001 mS/cm to 0.1 mS/cm (range-dependent)
Salinity (Calculated from conductivity and temperature)	±1% of reading or ±0.1 ppt whichever is greater	0 to 70 ppt	0.01 ppt

Table 3-3. Lagoon monitoring field equipment

Field Equipment	
Kayak	gps unit
mounted storage bin	YSI 556 MPS
duct tape	secchi disc
Camera	pencils
2 meter stadia rod	Rite-in-the-Rain notebook

3.5.2 Access

The shallow waters of the lagoons are easily accessible by kayak. The use of a tandem kayak allows for easy launching, ability to maneuver between sites with ease and efficiency, and it also allows for transportation and support of monitoring instruments.

3.5.3 Mapping

A Global Positioning System (GPS) logging unit is used to locate sampling sites, measure the lagoon perimeter, and assist in the collection of bathymetrical data. The *Garmin eTrex Summit* handheld data logger normally results in horizontal positioning errors around ± 5-6 m with no differential correction needed.

3.5.4 Bathymetry

Bathymetric transects are measured and mapped in lagoons. The locations of the transects are pre-selected to cover all major geomorphic provinces of their respective lagoon. Measurements are taken with a two-meter stadia rod in the shallow sections of the lagoons. In the deep-water areas a measuring tape weighted with a lead sinker is used to measure all sites deeper than two meters. A digital depth sounder (Hondex) may also be used.

Access is achieved by foot for the shallow transects and a tandem kayak with anchor is used in the deeper areas. The anchor is used to minimize drift caused by wind. Use of a transect tape for measuring distance from the bank is often not practical. Instead, a GPS unit is used to estimate the distance from the previous measurement and orange markers, placed on both banks, are used for navigation.

3.5.5 Benthic Sediment

Benthic sediment samples are randomly collected in areas of the lagoon that are pre-selected based on the same likely correlates of variation as the water quality sites.

Sediments are collected from a kayak using a lightweight bottom-sediment sampling dredge with a 36 square-inch capacity. The location of each collected

sample is mapped with a GPS unit. In the field, each collected sample is poured directly into a pre-numbered cloth oven-drying bag.

In the lab, all samples are dried at 70° C for at least 48 hours before a total weight is measured. After drying, each sample is weighed to the nearest milligram. Next, each sample is dry sieved through a 25 mm sieve. All particles >25 mm are weighed and recorded. All samples are then wet sieved through 0.063 mm sieve to measure the distribution of particles smaller than 0.063 mm. The remainder of the each sample, or the median particle sizes, is then placed into a numbered tin and dried again as before.

After the second drying, all samples are re-weighed to find the weight percentage of particles smaller than 0.063 mm. The median classes of each sample, if one exists, are then processed through a *Micromeritics* (R) OptiSizer Particle Size Distribution Analysis (PSDA).

3.6 Protocol for stream reconnaissance

Stream reconnaissance involves detailed stream and habitat surveys with the main goal of locating perennial water and any obstructions that may prevent the migration of anadromous fish. This involves first, determining the exact location of the portion of the creek to be surveyed and the adjacent land ownership. If necessary, landowners shall be contacted in order to gain permission to access the creek. The next step of the field survey involves assembling the necessary field equipment, listed in Table 3-5.

Table 3-4. Stream reconnaissance field equipment

Field Equipment	
GPS: Garmin eTrex Summit	Optical range finder
Reconnaissance data sheets	Reel measuring tape
Digital Camera	2-meter measuring tape
Topographic maps	Ruler and grain size card
Plant and fish guides	Thermometer
Waterproof field book	Stopwatch
Boots and waders	Small dowels

Teams (usually of two) then conduct the survey. The survey includes walking and mapping portions of the creek using GPS, while also taking detailed field notes. These notes shall include general descriptions of the creek pattern (for example meandering, braided, or straightened), creek profile, and roughness followed by a determination of a Rosgen stream type classification (Rosgen 1998). In addition, total channel width and depth shall be measured using an optical rangefinder and/or measuring tape. Surface substrate composition (i.e. boulder, cobble, gravel, sand, or silt) within each section shall be determined by visual estimation. Estimates for average percent overhead cover shall also be made and all plant species observed shall be noted. If perennial water is present, low flow width and depth shall be measured using a measuring tape. Surface velocity (m/s) shall be measured using a 2-meter measuring tape, stopwatch, and dowel. Water temperatures shall be periodically taken throughout the survey. For major pools encountered, length, width, and depth measurements will also be taken. For each reach, pools and large woody debris counts shall be made. Important features such as large pools, areas with unstable bank conditions or visible erosion, invasive plant species, obstructions, road crossings, pollution sources, and all fish, amphibian, reptile, crustacean,

and mammal species encountered shall be noted and marked with GPS. This information shall be recorded on the *CCoWS Stream Reconnaissance Data Sheet* (Appendix D).

3.7 Protocol for detailed stream habitat assessment

Following stream reconnaissance, previously outlined in Section 3.6 of this report, habitat assessment for steelhead/rainbow trout rearing shall be performed. Table 3-5 lists field equipment needed to perform habitat assessment:

Table 3-5. Detailed stream habitat assessment field equipment

Field Equipment	
Habitat assessment data sheets	Ruler and grain size card
Boots or waders	Pin flags
GPS unit-Garmin eTrex Summit	V* rod
Optical range finder	Raytek laser thermometer
Reel measuring tape	Stakes and clamps
2-meter measuring tape	Digital camera
Stopwatch	Random number chart
Small dowels	Densitometer

Habitat assessment shall be performed as follows:

- Stratify the entire stream into bio-geomorphic provinces based on information gathered from the stream reconnaissance (Section 3.6), such as presence or absence of perennial water, major breaks in stream class, temperature, and density of riparian vegetation.
- Identify a random set of reaches within each province. Each reach shall contain 500 meters of stream and shall be representative of its province.
- GPS the start and end of each 500-meter reach.
- Within each 500-meter reach, 10-meter intervals shall be determined using a measuring tape or a 10-meter rope.
    - At each 10-meter location, cross-sectional transects shall be made.
    - Begin taking measurements on the right bank. All measurements shall be made within the boundaries of the wetted area and recorded on a *CCoWS Habitat Assessment Data Sheet* (Appendix E).
    - If entire transect is dry, no measurements shall be made. Record as "dry" on the field sheet and move on to the next transect.
    - Note habitat type (pool, glide, run, or riffle).

- Rate the instream shelter complexity (0 to 3) for the wetted area including 5 meters upstream and 5 meters downstream using the California Department of Fish and Game Method (Flosi et. al 1998).
- Record the wetted width of the transect.
- Within the transect, measure the surface temperature of the thalweg.
- Measure the surface velocity (m/s) at the thalweg using a stopwatch, 2-meter measuring tape, and orange dowel. If water velocity is less than or equal to 0.01 m/s, record as 0.01 m/s.
- Divide the transect into approximately 9 evenly spaced points.
    - At each point, measure and record the overhead vegetative cover using a densitometer. Data shall be recorded as 'yes' or 'no'.
    - At each point, measure and record the depth of water using the V* rod. If water is too deep to be measure with the V* rod, use a weighted measuring tape. If the point is dry, record as "0".
    - At each point, measure the amount of fine sediment accumulation overlying the coarser substrate by inserting the rod until a change in resistance is observed as the rod contacts coarse material. Total depth (water depth plus fine sediment accumulation depth) shall be recorded. If total depth is greater than the length of the V* rod record as ">180 cm".
    - At each point, randomly select one sediment particle and measure along the intermediate axis using a ruler or grain size card. If bedrock, record as "999". If no sediment is present and substrate is LWD or a root mass, record as "0".
    - Find the thalweg of the transect and repeat the same measurements.

All habitat assessment data shall be entered into the CCoWS Habitat Assessment *Microsoft Access* database.

3.8 Protocol for fish population assessment

The following methods (adaptation of California Department of Fish and Game method, Flosi et. al 1998) detail the procedures for performing stream bank and underwater fish observations. This procedure will provide information on species composition, distribution, and abundance for a given reach of stream. Population assessment shall be performed following previous stream reconnaissance and habitat assessment. Table 3-6 lists the field equipment needed to perform population assessment.

Table 3-6. Fish population assessment field equipment

Field Equipment	
Snorkel	Pencil
Dive mask	Thermometer
Slate board	Wet suit and booties
Waterproof camera	Polarized sunglasses

Population assessment shall be performed as follows:

- Navigate to the start location of the 500-meter reach to be assessed.
- 1 or 2 divers, depending on width of stream, shall survey the entire reach of stream either by snorkel or a combination of snorkel and stream bank observation.
- Starting at the downstream end of the reach, diver(s) shall swim/crawl in an upstream direction and record # and species of fish observed within a given habitat type (i.e. riffle, run, or pool) on an underwater slate. Immediately after the survey, all data shall be transferred to a *CCoWS Population Assessment Data Sheet* (Appendix F).
- If 2 divers are needed, divers shall swim side by side while each observing fish on either the left or right half of the stream channel.
- If sections of the reach are too shallow to snorkel (depth less than 10 inches or from chin to top of head), observations shall be made above the water either from within the channel or along the stream bank using polarized glasses.
- Continue until entire reach is surveyed.

- Any observations of fish behavior and habitat utilization as well as a brief summary of the assessment shall be recorded in the notes section of the *CCoWS Population Assessment Data Sheet* (Appendix F).

Fish shall be counted as follows:

- Only fish ≥ 4 inches shall be counted except for the following:
    - Rainbow Trout/Steelhead
    - Smaller species that can be easily identified (i.e. speckled dace, sculpins, and threespine stickleback)

- Size classes for Rainbow Trout/Steelhead are as follows:
    - <3 inches = young-of-the-year (0+)
    - 3-6 inches = yearling (1+ yr)
    - >6 inches = yearling (2+ yr)

All population assessment data shall be entered into the CCoWS *Microsoft Access* database.

3.9 Protocol for field notes and data sheets

- Field data collection and notes shall be organized as follows:
  Site Visit >> **Sample Run** (~5) >> **Monitoring Campaign** (2)
- A record of each visit shall be made in either:
  - a numbered *Rite-in-the-Rain* field book, or
  - a previously prepared datasheet
- The record for each visit shall included the following information:
  - Name of field trip leader
  - Name/s of field party
  - Date of visit, with month written in letters (e.g. 2-April-2002)
  - Time of visit, using 24 hr time **and** AM/PM notation (to reduce possibility of ambiguity)
  - Site code
  - Site observations and notes
  - Present weather conditions
- For stream visits, the following information shall also be recorded:
  - Presence/absence of water
  - Presence/absence of flow
  - Stage (where a staff plate is installed)
  - Type of sample collected
  - Collection or measurement time
  - Instrument type and ID, if applicable
  - Container ID (Section □)
  - Method of collection (e.g. “grab” or “DH-48”)

4 Sampling Protocols

This section contains protocols for collection or measurement of the following types of water quality constituents:

- Flow
- Suspended sediment
- Bedload
- pH
- Conductivity/Salinity
- Temperature
- Dissolved Oxygen
- Dissolved nutrients
- Pesticides
- Pathogens
- Benthic macroinvertebrates

4.1 Protocol for taking flow measurements

A number of techniques for flow (discharge) measurement may be used, depending on the nature of the flow. Protocols for each technique are listed below, in increasing order of flow magnitude. In all cases, the type of measurement used shall be recorded.

Stage is always recorded. After taking a discharge measurement, stage is recorded again. The stage for that discharge measurement is represented by the average of the before and after stage levels. If stage level changed significantly between the time that the discharge measurement began and ended then a second water quality sample is collected.

4.1.1 Presence absence

The simplest possible measurement pertaining to flow is whether or not any water is present. This should a visual observation usually made by an observer standing at a site. It may be made from a vehicle, although there are times when this is inaccurate. It may be made by interpolation between observations made above and/or below the site, although again, this can be inaccurate at times.

4.1.2 Flow / no-flow

The next simplest measurement of flow is whether or not the water in a channel can be seen to be moving in a net downstream direction. Again, this should be a visual observation made by an observer standing at a site. Unless obvious, the observation shall not be made from a vehicle. The observation shall never be made by interpolation. On one instance in a central coast stream, approximately 30 m^3/s of flow was observed at a site below which there was no flow or water present at a site approximately 5 km downstream along the same, single channel.

4.1.3 Visual estimation

In situations where logistics prevents all the methods listed below, flow rate should be visually estimated based on personal experience. Conversely, personal experience should be calibrated by memorizing the visual

characteristics of flows for which discharges are known. Appropriate visual characteristics are the estimated width, depth, and surface velocity of a flow. Additional characteristics include turbulent features and standing waves, turbidity, sound, and the presence of waterborne litter and debris.

4.1.4 Calibrated bucket

A 5-gallon bucket may be used to measure discharge from flows falling over a vertical drop under which the bucket can be placed. The bucket should be marked on the inside surface at 1 liter intervals by pouring twenty 1-liter water samples into it. Care should be taken to record the exact duration and volume of each sample. The longer the duration, the more accurate the measurement will be.

Smaller flows with small vertical drops may be measured using a calibrated jug.

4.1.5 Rapid filling bucket

Where flows are so great as to overtop a bucket or jug in less than 2 seconds, a number of repeated measurements of the time taken to fill the bucket completely should be made using a stopwatch. Estimates made in this way are relatively inaccurate.

4.1.6 Rapid filling bin

Flows overtopping a bucket or jug in less than half a second may be measured using a 20-gallon bin. If the bin is overtopped in less than half a second, the bin may be placed successively under separate parts of the flow. Estimates made in this way are relatively inaccurate, but may be more accurate than current meter measurements where very slow flowing streams spill over broad crested weirs.

4.1.7 Estimation based on surface velocity and depth

In many natural channels, the mean velocity of a stream at a given point across its width is 85% of the surface velocity at that point (Gordon, McMahon, & Finlayson, 1992). Bright, floating objects such as a fluorescent wooden dowel may be used to estimate the surface velocity. In large rivers, orange peels may be thrown from bridges and the velocity estimated from a) the time taken for a

peel to traverse under the bridge, and b) the measured width of the bridge. In smaller streams, a useful measuring device a fluorescent orange 5 cm wooden dowel, measured against a 2 m stadia rod. Where possible, the velocity at three points across the width of the stream should be measured. In this case, the flow rate (m^3/s) shall be estimated as the sum of the products of the width represented by each surface velocity measurement, the depth of the water at each measurement, and 85% of the surface velocity. In cases where only one surface measurement is possible, the flow rate shall be estimated as half of the sum of the products of the width, depth, and estimated mean velocity in the center of the channel.

4.1.8 Cross section with a current meter

The most common method of measuring flow rate in small streams is to wade and record cross-sectional measurements using a current meter (flow probe). A number of different types of current meter may be used:

- Pygmy meter. This is the standard meter for small streams in the US. Three stainless steel cones are mounted on arms extending from a vertical axle with pointed ends mounted within a precision smooth conical bearing. The meter is sensitive to very slow flow but works well in fast flow. It is very expensive. It easily becomes un-calibrated when bumped during transport from a vehicle to the stream, or when in contact with bedload of significant size. It is expensive to re-calibrate. It requires partial dismantling before transport, and partial assembly before use; a small pin must be re-installed. It is thus generally unsuitable for conditions where:
    - Many measurements must be taken at many sites
    - At night
    - By new operators
    - Transport by small vehicles
    - Streams with large bedload particles
    - Extremely muddy conditions

  However, it is useful for calibration of more robust meters.

- Plastic impellor meters. CCoWS uses plastic impellor meters purchased from retailers such as *Global Water*, but also has developed

the capability to construct this type of plastic impellor meter (flow probe) by using model boat propellers. These can be fitted inside PVC plumbing housings of various sizes and mounted on various tubes for handheld use. Bike computers may be used to count the rotations of the propellers, and calibrated internally to display flow rate in m/s. Methods for the calibration of CCoWS constructed flow probes are summarized in Section 7.1). Additionally, a comparison study of the three types of current meters was conducted. The results are summarized in Section 7.1. The impellors can sometimes become blocked or jammed with sand or leaves, but are easily cleared. Short mounting tubes may be constructed for wading use. Longer, triple-extendible tubes are useful for reaching in from stream banks, or down from low bridges. Impellors may also be mounted on heavy instrument packages suspended from large bridges. The instruments are inexpensive, easily repairable, and robust.

The following steps shall be taken when measuring stream flow rate by wading with a current meter:

- It shall be determined that the deepest part of the stream is safe to wade, and that no dangerous debris is likely to enter the site. One team member should serve as a spotter for any debris moving downstream.
- One end of a tape measure shall be firmly anchored at any low point on one bank of the stream. The other end shall be firmly anchored to the other bank. Intermediate supports shall be used in wide streams, such as metal stakes driven into the streambed, with clamps on the upper ends.
- A table shall be drawn up in a notebook with columns for ‘offset’, ‘depth’, and ‘velocity’.
- The times of commencement and completion of measurements shall be recorded, as shall the river stages at those times.
- Two people shall be employed, one as recorder, the other as measurer.
- Where time permits, an even measurement interval shall be used, and at least 10 velocity measurements should be taken across the width of the stream. When time is scarce, an uneven measurement interval may be used, with most measurements taken at points of rapid change in velocity, and at points of high velocity and/or high depth.
- Starting from one bank, preferably the left bank, the offset at which the free water surface begins shall be recorded.

- Velocity measurements shall then be taken across the width of the stream until the opposite bank is reached and the offset at which point the free water surface end is recorded.
- Streams with multiple channels shall be measured as the sum of multiple streams.
- Each velocity measurement shall be taken as follows:
    - The measurer should stand well downstream of the instrument
    - The instrument should be placed in the water and rested against the bed such that the flow depth shall be recorded.
    - The current meter shall be mounted on a top-setting rod such that it may be held steadily at 60% of the flow depth above the bed.
    - The impellor shall be checked for blockages and free-running operation, and the computer shall be reset to zero average velocity.
    - The impellor shall be allowed to run freely while the average velocity is observed over a period of 10 seconds to 1 minute in order to measure a steady mean value. This value shall be recorded as the (vertically-averaged) mean velocity of the stream at that offset across the stream.

The total flow rate for the stream shall be estimated in the laboratory using a Microsoft Excel spreadsheet as follows:

- The field book table shall be copied to the spreadsheet.
- Each velocity measurement is assigned a representative width, calculated as the difference in offset between the halfway points to adjacent measurement points either side of the point at which the velocity was measured.
- The flow rate for each measurement point shall be the product of the velocity and the representative width.
- The total stream flow rate shall be the sum of that for all measurement points across the stream.

4.1.9 Cross section with crane from a bridge

When a stream is unsafe to wade it is possible to measure stream flow rate from the bridge at the site using a USGS Type AA Crane with Four-Wheel Truck

(Model 4350, purchased from Rickly Hydrological Company). This procedure is similar to the flow measurement procedure for a cross section with a current meter (section 4.1.8), but requires much more time at each visit to a site for unloading, assembly, operation, and loading, as well as time preparation of field equipment.

4.1.9.1 Current meter maintenance

The USGS Type AA current meter has six cone-shaped cups mounted on a stainless steel shaft. A pivot bearing supports this shaft. There is a contact chamber that houses the upper part of the shaft and contains slender bronze wires (cat's whiskers) that are attached to binding posts. These parts are very small and must be set in a specific way for the meter to work properly, see the manufacturers detailed instructions and diagram.

Because this current meter is so sensitive, it needs to be stored and packed for travel with the raising nut tightened all the way. To make measurements with the meter, the raising nut is unscrewed, the tightened again when packed for travel. All field technicians should be familiar with the inner workings of the meter before using it in the field. The routine cleaning and oiling is a good opportunity for field technicians to become familiar with the current meter. Cleaning and oiling, as well as assembly, disassembly, and pivot adjustments should be done following the manufacturers detailed instructions.

4.1.9.2 Cross section measurements from bridge using the crane

Before measurements can be taken the crane needs to be unloaded assembled at each site. See Appendix R on *Equipment* and *Assembly* for instructions.

Measuring from the upstream or downstream side of the bridge is site-dependant and is determined from the flowing criteria:

- Lack of vegetation in the vertical path of the sounding line
- Presence of pillars/pylons/columns of the bridge that could accumulate debris and trash on the upstream side and thus interfere with flow measurements
- Presence of a sidewalk or walkway
- Traffic/safety

Taking measurements on the upstream side allows the operators to easily see drifting debris moving downstream before it has the chance to bump or get

tangled up with the sounding line. Taking measurements from the downstream side would allow vertical angles to be more easily measured because the sounding line will move away from the bridge.

- Traffic signs ('Slow' and 'Survey Crew Ahead') and cones are placed on either side of the cross section to guide traffic away from the crane, personnel, and cross section.
- A tape measure is stretched across the bridge.
- At least two people should be employed; one operating the crane, the other recording measurements and looking out for traffic on the bridge and debris moving downstream. When the field technicians are not familiar with the crane, or on bridges with heavy traffic, or during very, very large flows, three people are preferable. The operator should wear apersonal floatation device, and other technicians should wear fluorescent orange mesh vests with reflectors.
- A table is drawn up in notebook with columns for 'offset', 'depth', 'count' (or 'revolution'), and 'time'. River stage and time of commencement and completion of the measurements is recorded.
- An even measurement interval along the cross section is easiest to use because high depths and velocities and rapid changes in flows are difficult to ascertain from the bridge. At least 10 velocity measurements should be taken. At times positions in the cross section may be skipped due to debris accumulated against pillars/pylons/columns of the bridge or vegetation in the vertical path of the sounding line.
- After the crane is assembled (), the current meter is attached to the hanger bar above the sounding fish weight. This unit is then lowered over the bridge into the stream by cranking the sounding wheel. To lower the sounding line, the brake on the sounding reel must be disengaged.
- At each position in the cross section, the depth is measured and recorded. This is done by first lowering the current meter/fish unit until the bottom of the fish is at the water's surface, engaging the brake, and clearing the depth indicator to 0. Disengaging the brake, the fish is then lowered to the bottom and the brake is engaged again. This depth is recorded.
- Velocity measurements are taken at 6/10 the depth (from the surface) at the position on the cross section. Because there is 6 inches between the propeller of the current meter that takes the measurement and the bottom of the fish (depth 0), ½ a foot or 6 inches are added to the 6/10

depth so that the velocity measurement is taken at the correct depth. (6 inches applies to this specific hanger bar. If the hanger bar is replaced, then the difference between the pygmy meter and the bottom of the fish should be added to every 6/10 depth). A laminated field chart is available with a list of depths and corresponding flow measurement depths for easy reference.

    - The sounding line can be cranked up while the brake is engaged, but it cannot be lowered. It is recommended to keep the brake engaged while adjusting the fish depth for the velocity measurement.

- When the fish is at the proper depth, the Aquapulse Counter-Timer is turned on and started. This unit counts revolutions the propeller makes in a specified time interval (100, 60, 50, 40, or 30 seconds). The number of counts and seconds are recorded. This unit automatically turns off 30 seconds after the reading is finished.
- The fish is raised out of the water and the entire crane is advanced to the next position on the cross section. If the bridge is level, the 0 depth reading at the water's surface should not change from position to position, but should be adjusted accordingly if it does change.
- When the cross section is complete, the crane is disassembled and packed for travel (be sure that the raising nut on the current meter is tightened).

After every day of use the current meter should be cleaned, set to air dry, and oiled according to the manufacturer's detailed instruction manual 'Routine Cleaning and Oiling of Current Meters'.

4.1.9.3 Calculating total flow

The estimated total flow rate is calculated using a Microsoft Excel spreadsheet in the same manner as the Cross section with a current meter (section 4.1.8), but it includes an additional equation. As instructed by the manufacturer, the revolutions/second measurements are converted to feet/second velocities using the following equation:

$$V = 2.2048R + 0.0178$$

Where R is the revolutions per second.

4.2 Protocol for sampling suspended sediment

This section describes field-monitoring protocol for collecting a suspended sediment sample. Depending on a number of factors such as stream conditions, safety, equipment availability, and time, the method for collecting a suspended sediment sample in a stream may vary.

Depending on the magnitude of stream flow, the concentration of suspended sediment can range from well mixed to a vertically and horizontally stratified solution. To ensure that an accurate representation of the water column is collected, a DH-48 integrated suspended sediment sampler is used. When using a DH-48 sampler, a vertically integrated sample should be taken from several evenly spaced stations along a transect. At each collection station, insert the instrument, with the in-take nozzle facing upstream, vertically downward through the water column and then back to the surface in a uniform motion. Special caution should be taken not to disturb sediment on the channel bottom. The same motion should be used at each station along the transect. However, due to the nature of the continuous sampling method used and the resulting restraints on time, a single sample may be taken in the thalweg, or the deepest portion of the stream channel. Each sample is taken immediately following the stream height, or stage reading.

When stream conditions are too dangerous for wading, the thalweg cannot be accessed, or the water is too shallow for the instrument, a surface water sample or 'grab' is collected. Grab samples are taken by simply reaching out from the bank and inserting the sample bottle into the water column in a quick downward motion with the mouth of the bottle facing upstream. A quick downward motion will facilitate the collection of a relatively integrated sample, rather than only water from the surface. Once again, special caution should be taken not to disturb bottom sediment. If a bridge is present, a sample bottle may be strapped to a rope and lowered into the thalweg to collect a 'grab' sample. Fast moving streams tend to be well mixed as opposed to slower moving streams, which are more stratified. A grab sample is not as accurate as a DH-48 sample. However, when collected in fast moving streams it can provide a fairly accurate representation of the stream concentration.

When stream conditions are too dangerous for wading and the crane is set up to collect velocity measurements (Section 4.1.9) then it is possible to collect a

depth-integrated sample using a DH-76 sampler suspended over the bridge from the crane. A DH-76 is similar to a DH-48, but is much larger and heavier. It is attached to end of the sounding line in the same manner as the current meter/fish and hanger bar (), lowered into the water and raised out of the water at equal rates. This requires rapid cranking of the sounding reel as the water is usually very deep and the sample bottle fills quickly. Special care should be taken not to fill the bottle entirely, which would result in incomplete depth integration. If a single sample is to be taken, it should be taken at the deepest station on the transect.

4.3 Protocol for sampling bedload

Bedload measurements are taken using a Helly-Smith bed sampler. The technique used on site is dependent on the stream flow, water clarity, and absence or presence of bed material. The standard USGS protocol for collecting bedload samples requires taking a minimum of 20 samples at equally spaced stations along a cross-section. This method is used on larger streams during moderate to low flow conditions.

For smaller streams, if the stream bottom and bedload movement are visible, then a technique known as the representative width may be used. Samples are taken in areas of equal visual bed movement. These areas are measured for their widths, and the mass of material collected in that width is its representative sample. For both techniques, bedload samples are collected for a pre-determined amount of time; based on visual observations and stream flow. The amount of time, in addition to the mass and representative width, is later used to estimate the load for that station in the stream.

Bedload samples are also analyzed for load per time. Width interval loads are calculated by dividing the product of the sample mass and its representative width by the width of the instrument (0.075m). The width interval loads are divided by the number of seconds that the sample was collected to find an estimated load per time (g/s). These values are then given time slots that they represent (same method as SSC) to calculate a load per day. The final data for bedload is tonnes.

4.4 Protocol for taking a pH measurement

The pH, negative logarithmic (base 10) hydrogen ion concentration, shall be measured in the field using an *Oakton pHTestr* probe. This probe is capable of measuring pH in the range of -1.0 to 15.0 using the SM 4500B technique (APHS Standard Methods, 1998). Instrument specifications and calibration instructions are kept on file by CCoWS. pH probes should be calibrated after each field campaign or storm event monitored.).pH may also be measured in situ with the *YSI*556MPS. The specifications for the *YSI* 556 MPS are presented in Table 3-2.

A pH measurement should be made as follows:

- Use a clean Nalgene beaker (1000mL) for sample collection
- Rinse beaker in sample water 3 times
- To collect sample, insert beaker into water column just long enough to collect approximately 100 mL of water (enough to submerge the electrode on the pH probe). Take caution not to disturb sediment on the bottom of the channel.
- Remove cap of probe, turn instrument ON, rinse with DI water, and insert into sample container.
- After reading has stabilized, approximately 1 minute, record reading in the field book.

pH measurements shall be made with the *YSI* 556 MPS as follows:

- The *YSI* 556 MPS instrument should be calibrated before entering the field according to directions provided by the manufacturer.
- Measurement shall be taken directly in stream if possible.
- Insert probe directly into water.
- After reading has stabilized, approximately 30 seconds, record the pH.
- If conducting depth profile, continue measurements at desired depths recording the reading and depth at which it is taken.

4.5 Protocol for taking a conductivity/salinity measurement

Water conductivity shall be measured in the field by either an *Oakton TDSTestr* 10 conductivity probe with automatic temperature compensation or a *YSI* 556 MPS. The *Oakton TDSTestr* 10 is capable of measuring conductivity in the ranges of 0 to 1990 uS and 2.0 to 19.90 mS using the SM2510 technique (APHS Standard Methods, 1998). The specifications for the *YSI* 556 MPS are presented in Table 3-2.

Conductivity measurements shall be made with the Oakton TDSTestr 10 as follows:

- Using a clean Nalgene beaker (1000mL) for sample collection
- Rinse beaker in sample water 3 times
- To collect sample, insert beaker into water column just long enough to collect approximately 100 mL of water (enough to submerge the electrode on the conductivity probe). Take caution not to disturb sediment on the bottom of the channel.
- Remove cap of probe, turn instrument ON, rinse with DI water, and insert into sample container.
- After reading has stabilized, approximately 1 minute, record reading (µS or mS) in the field book.

Conductivity/salinity measurements shall be made with the *YSI* 556 MPS as follows:

- The *YSI* 556 MPS instrument should be calibrated before entering the field according to directions provided by the manufacturer.
- Measurement shall be taken directly in stream if possible.
- Insert probe directly into water.
- After reading has stabilized, approximately 30 seconds, record conductivity reading as (µS or mS) and salinity as (ppt).
- If conducting depth profile, continue measurements at desired depths recording both conductivity/salinity reading and depth at which taken.

4.6 Protocol for sampling dissolved nutrients

CCoWS currently monitors waterbodies for the following dissolved nutrients:

- Oxidized nitrogen-nitrogen (NO_x-N)
- Ammonia-nitrogen (NH_3-N)
- Reactive phosphorus as Orthophosphate (PO_4^{3-})

When sampling for these nutrients, the following shall apply:

- Use sample bottles that have been cleaned in Liquinox™ or similar phosphate free detergent and acid rinsed. If samples are to be analyzed by an external lab, use sterile bottles provided by that laboratory.
- Rinse sample bottle & cap in sample water 3 times prior to taking sample.
- Technician shall wear latex gloves to prevent contamination of the sampling container and for health safety.
- Insert the sample bottle just below the water surface with the mouth of the bottle facing upstream & fill bottle. Take caution not to disturb bottom sediment.
- Temperature and pH will also be recorded at the time of sample collection. Temperature will be measured with a thermometer and pH will be measure with an Oakton pH tester, if the YSI MultiProbe System is not used.
- Pour off a little sample to leave room for expansion if frozen.
- Place sample in cooler with ice for return to laboratory.
- Record time, temperature, pH, & sample bottle # used in field book.
- If any samples are to be analyzed externally (Monterey County Consolidated Environmental Laboratory), they shall be delivered to the external laboratory immediately following the sampling run. Remember the chain of custody form.

Upon returning to the lab, samples shall be initially processed in the following manner:

- Place in refrigerator (if analysis is to take place within 48 hours) or freezer until lab analysis is performed.
- Thoroughly wash all filtering equipment in Liquinox™, rinse in warm tap water, and then finally rinse in DI.
- Record campaign and sample information on the *Sample Storage Management Log* (Appendix A).

4.7 Protocol for sampling pesticides

This section describes the collection of samples for the analysis of pesticides from various water bodies. It covers the collection of water, suspended sediment (SS) and benthic samples. The types of sample that may be taken depend upon the dynamics of the specific water body. For example, an SS sample may not be indicated for receiving water bodies, or a benthic sample may not be indicated during high flow, storm events. Particular strategies will be dictated by the specific project/task.

It is important to determine the fraction of pesticides transported by adsorption to suspended sediments, in addition to that transported in an aqueous manner. Because of the low concentrations of adsorbed pesticides involved, techniques must be used that both maximize the weight of samples obtained in the field, and that allow extraction of pesticides from samples that may be smaller than would otherwise be ideal. Katznelson and Feng (1998) indicate that 10 grams of sediment are normally required in order to obtain detectable levels of pesticides from the resulting methanol extractions. This is the limit used under the present protocol for benthic samples, where large sample weights are not difficult to obtain. However, it is often not possible to obtain 10 grams of filtered, suspended sediment, and so modified procedures are described below for performing extractions on samples smaller than 10 grams.

A further constraint is that adsorption concentrations must be expressed with respect to the dry weight of the sediment sample, but oven drying of samples potentially alters the molecules of interest. Dry weights must therefore be determined by sacrificing a sub-sample for oven drying. The full sample must therefore include sufficient material for both dry-weight analysis, and the actual pesticide extraction and analysis.

As explained below, a new technique for obtaining filtered samples in the field is used (Sandstrom, 1995).

4.7.1 Pre-sampling preparation

Table 4-1 list the field equipment required to conduct this type of pesticide sampling. Pre-sampling preparation is as follows:

1) Check that pump batteries are charged
2) Fill:
    - One carboy and one bucket with *Liquinox* solution
    - One carboy and one bucket with hot tap water
    - One carboy and two buckets with de-ionized water
3) Dry filters to be used in a 100°C oven for 15 minutes. Cool for 5 minutes, label filter with a pencil, weigh and record filter weights.
4) Place ice pads in chests
5) Gather necessary field equipment

Table 4-1. Pesticide sampling field equipment

Field Equipment	
Benthic sediment sampler	60 mL amber glass, Teflon lid water sample containers
0.7 μm 142 mm glass fiber filters	125 mL amber glass, Teflon lid sediment sample containers
142mm Geotech aluminum filter holder	Ice chest with ice pads
Teflon sampling tube assemblies (9)	Stainless steel sediment scraper (spatula)
Sampling tube weight	Cleaning brush
Peristaltic Geotech Geopump Series II	Forceps
Pump battery, 12v DC	C-clamp vise grips w/steel pressing plates
25 L carboy containing Liquinox	Glass or stainless mixing spoon and bowl
25 L carboy containing tap water	Wash bottle with DI water
25 L carboy containing DI water	Rite-in-the-Rain field book

4.7.2 Sampling excursions

This protocol assumes that an excursion to the field shall be made, during which time a number of visits shall be made to a number of sites. A sample or samples shall be taken from each site. Depending on the aims of the work, samples may be taken directly, or filtered from the water column, or they may be taken from the benthos beneath a water column. The samples may then be analyzed at the CCoWS laboratory using ELISA techniques (Section 5.7) or sent to external laboratories for ELISA or GC/MS analysis.

4.7.3 General points relating to pesticide sampling excursions

Cleanliness shall be kept in mind at all times during the sampling excursion. This will prove challenging given the environmental conditions under which sampling occurs. However, every effort must be made to avoid the potential for sample cross-contamination. The aim is to measure pesticide concentrations in the order of parts per *trillion*, so a misplaced drop of water can be important.

4.7.4 Sample management and bottle labeling

Samples shall be assigned a unique Sample ID as follows:

Sample ID = Site Code + Date + Type + Bottle ID

- The Site Code shall follow the CCoWS convention described in Section 3.1.1.
- The Date shall be in the format: DD-MMM-YY, e.g. 12-May-02.
- The Type shall be "W", "S", or "B" for samples extracted from water, samples extracted from suspended sediment, and samples extracted from benthic sediment respectively.
- The Bottle ID is unique number assigned to each bottle in perpetuity (see below).

Example: "SAL-DAV, 20-Jul-02, W, P16" indicates a water sample taken on July 20, 2002 from the Salinas River at Davis Rd. in Pesticide Bottle 16.

Pesticide sample bottles are amber glass, with an opaque Teflon-lined plastic lid. In preparation for the time of first use, bottles to be analyzed in the CCoWS

laboratory shall be labeled with an ID code that is unique to the bottle in perpetuity (Prefix "P") (see Section □). Bottles to be analyzed by external laboratories may be obtained prior to sampling from these laboratories. These bottles shall also be labeled with a unique ID in a similar fashion to the CCoWS bottles (Prefix "EP"), however this ID should be retired once the results have been obtained from the external laboratory.

The samples shall be physically separated from other equipment. As each sample is taken, the sample ID and time shall be recorded, along with all additional information noted in Section 3.9.

4.7.5 Duplicate samples

For each excursion to eight or more sites, an additional sample shall be taken for the purposes of analysis at a laboratory other than the laboratory used for the majority of samples. This 'control' laboratory may also use different analytical techniques to those used for the majority of samples. For example, if the majority of samples are to be analyzed in the CCoWS laboratory using ELISA techniques, the additional samples could be sent to an external control laboratory for GC/MS analysis. These control samples shall be stored in a separate ice-filled cooler, and shall labeled with their own unique Sample ID.

4.7.6 Taking samples from the water column and from suspended sediments

1) Assemble filter unit, placing pre-weighed filter into holder with forceps, wet the filter with DI water. Use a fresh tubing assembly for each site.
2) Record filter and SS sample bottle #.
3) Lower sampler weight with tube down to the water and turn on the pump
4) Raise and lower the sampler weight through the vertical water column continuously to obtain an integrated SS sample.
5) During filtration, collect a water sample by placing a labeled sample bottle underneath the exit stream of the filter unit; do not fill to full, and cap. Record the container number and give it a sample name according to the naming convention described below. CARE SHALL ALWAYS BE TAKEN TO NOT CONTAMINATE THE INTERIOR OF SAMPLE BOTTLES WITH ANYTHING OTHER THAN INTENDED SAMPLE. Put sample on ice.
6) Experience with the filter sampler and differing SS loads will give some indication when enough of the SS sample has been acquired; typically the

exiting water stream will start to drip when the filter is near fully loaded (approx. 1 gram of sample). When enough sample has been obtained stop the pump.

7) Open the filtering unit and remove the sample and filter with FRESHLY GLOVED HANDS. Fold the filter in half, then into quarters with filtrate to the inside using forceps as much as possible. Place filter into pressing plates and use the C-clamp vise grips to squeeze the water from the filter and sample. Place filter into the jar and put sample on ice.
8) Now, CLEAN, CLEAN, CLEAN! Wash the filter unit and tubing weight in the five-gallon bucket of *Liquinox™*, rinse in warm tap water bucket, then final rinse in DI water bucket.

4.7.7 Taking benthic samples

1) Set the jaws in place on the sampler and lower through the water column, rinsing the sampler in local water a little before sending it to the bottom.
2) Quickly retrieve the sampler unit, getting the sampler out of the water column as quickly as possible/practical.
3) Carefully open the sampler and with a stainless steel spoon retrieve an aliquot of sample that, to the best of your ability, has not been in contact with either the jaws of the sampler or the water column. In other words, try to obtain the aliquot from the center of the larger sample. Place this sample in a glass or stainless bowl.
4) Obtain 3 such aliquots, sampling from the same location but separated by a couple meters.
5) Homogenize the 3 aliquots and from this sample take an aliquot and put into a labeled sediment jar. Record the sample number and name the sample. Put sample on ice.
6) Rinse all of the solid sediment material off the sampler in local water, using a cleaning brush if necessary
7) Now, CLEAN, CLEAN, CLEAN! Wash the bowl, spoon and sampler in the buckets as described above.
8) Take the sampler and rinse it once again in the fourth bucket, the final DI rinse for the benthic sampler ONLY. The unit is now ready for the next sampling site.

4.7.8 Steps to be taken in the field and laboratory at the conclusion of each field excursion

1) Obtain a sample of water from the benthic sampler second DI rinse. This will be used as a field blank to test the effectiveness of the sampler washing technique. Record the sample bottle id, give it a name and put it on ice.
2) On the final DI rinse of the SSC sampler, assemble the whole unit (pump, filter holder and tubing) with a fresh filter in place and run some DI water through the unit. Obtain a sample of this water. This will be used as a field blank to test the effectiveness of the filter unit/tubing assembly washing techniques. Record the sample bottle id, give it a name and put it on ice.
3) Place samples in the refrigerator to be kept until ELISA analysis.
4) Wash the Teflon tubing assemblies back at the lab by placing the tube in the *Liquinox™* carboy and running the solution through it by turning on the pump for approx. 30 sec. Do the same with warm tap water carboy and then DI carboy.
5) Dry off the equipment. Hang the Teflon hose to dry.
6) Fed-Ex the certified lab samples to the lab ASAP. Remember the chain of custody form.

4.8 Protocol for sampling pathogens

CCoWS monitors water bodies for the following pathogens:

- *E. coli*
- Total coliform
- Fecal coliform

When sampling for these pathogens, the following steps shall be taken:

- Sterile, sealed sampling containers with preservative shall be obtained from the external laboratory. These shall remain sealed until the sample is taken.
- The container shall be labeled and the ID shall be recorded in the field notebook along with the time of collection.
- Technician shall wear latex gloves to prevent contamination of the sampling container and for health safety.
- Remove seal from bottle.
- Insert the sample bottle just below the water surface with the mouth of the bottle facing upstream & fill bottle. Take caution not to disturb bottom sediment.
- The sample shall be placed into a cooler with ice.
- The sample shall be immediately delivered to the external laboratory with an accompanying chain-of-custody form after the sampling run is complete.

4.9 Protocol for collecting benthic macroinvertebrate samples

Benthic macroinvertebrate samples shall be collected according to sampling protocols described in Harrington and Born (2000). A California department of Fish and Game (CDFG) Scientific Collecting Permit should be obtained from the CDFG License and Revenue Branch prior to collecting any BMI specimens and the person whose name appears on the permit will be present during sampling.

A unique sample ID shall be given to the sample container and shall be recorded in the field book along with date and time of sample collection. Samples shall be transported immediately to the CCoWS laboratory following the monitoring run. Samples will be preserved according to the protocols described in Harrington and Born (2000). A California Bioassessment Worksheet will accompany each sample (Appendix M).

The following are protocols to be adhered to when filling out the CBW:

- Enter site location code, date and time of sample collection, name of monitoring group, sample identification numbers, and a brief site description.
- In the Crew Member Box, enter the names of each crewmember.
- Determine the geographic position using GPS.
- Record water temperature, salinity, pH, and dissolved oxygen in the Chemical Characteristics Box.
- Note the location of the laboratory where samples will be processed (i.e. CCoWS Laboratory @ CSUMB or Aquatic Biology Associates, Inc.).

5 Laboratory protocols

This section contains protocols relating to laboratory analyses, including:

- Sediment analysis
- Chemical water quality analysis
- Macro-invertebrate analysis

Training on laboratory safety procedures is provided by the Earth Systems Science and Policy (ESSP) laboratory staff at CSU Monterey Bay and is a requirement prior to laboratory use. Documentation of lab safety training is kept by the ESSP laboratory staff. It is CCoWS responsibility to assure that all technicians performing the following tests have attended a safety training session.

Technicians shall be familiar with the equipment and tests before analyzing samples on their own. This should include both training with the laboratory manager and/or an experienced technician and study of the instrument and procedure manuals. This training shall be documented and kept on file *Technician Training Tracking Sheet* (Appendix B).

A log of current samples within the refrigerator/freezer will be kept taped to the door of the cooler and updated as the status of samples changes. This form *Sample Storage Management Log* (Appendix A) will be saved to file when full. Nutrient sample preservation status will be recorded on the *Nutrient Sample Run Data* sheet (Appendix G).

5.1 Protocol for analyzing Suspended Solids (SSC)

The following SSC procedure is employed to determine the concentration of suspended sediment in a water sample. A filtration process is used, based on Woodward and Foster (1997). The procedure is summarized here.

1) Measure & record conductivity (uS/cm)
2) Measure & record transparency
3) Sample bottles are pre-weighed (to the nearest 0.01g) and assigned a container ID.
4) After the sample is obtained, the outside of the sample bottle is rinsed and dried, then weighed to the nearest 0.01g.
5) A small amount (literally a pinch) of sodium hexametaphosphate is added to the sample and shaken thoroughly. This helps suspend particles and keep them from flocculating.
6) Samples are first filtered through a 63-micron sieve to remove the sand component.
7) Pre-dried and pre-weighed (to the nearest .001g), disposable glass filters (filter size, 1.5 micron) are used to vacuum filter the water sample and the fine sediment component. The sand component is transferred to a disposable glass filter.
8) The filters containing the sand component and the fine sediment portion of the water sample are then dried for 2 hours at 100°C to evaporate any remaining water.
9) The filters are reweighed to determine the amount of sediment in the sample (to the mg).
10) The volume of the sample is determined from its weight and the density of water.
11) Concentrations of samples are recorded in mg/L.
12) All information shall be recorded on the *Lab Processing of SSC Water Samples* data sheet (Appendix H).

Estimated error of the results is dependent upon mass and volume of the sample. The error associated with a large sample (approximately one liter) with highly concentrated sediment will be approximately 2%. Small samples (approximately 1/4 liter) with small sediment concentrations can have errors near 100%. This large error in “clean” samples is not viewed as a problem, because a 100% error in small sediment concentrations has little affect on

estimated loads. Furthermore, most samples taken are large enough and "dirty" enough to keep errors low. See section 7.4 for an analysis of CCoWS SSC Analysis Procedures.

5.2 Protocol for analyzing turbidity

Turbidity samples are analyzed using a Hach 2100P portable turbidimeter, SM2130B. Samples are analyzed according to directions outlined in the factory manual. The protocols is as follows:

1) Fill sample cell with sample, cap the cell, taking care to handle cell by the top.
2) Wipe the cell with a soft, lint-free clot the remove water spots and fingerprints.
3) Apply thin film of silicone oil. Wipe with a soft cloth to obtain an even film over entire surface.
4) Place turbidimeter on a flat surface and turn on.
5) Insert sample cell in to instrument cell compartment so the diamond mark aligns with the raised orientation mark in front of the cell compartment. Close the lid.
6) Select automatic range. This measures turbidity from 0.01 to 1000 NTU.
7) Press: Read. The display will show the final turbidity in NTU after the lamp turns off.
8) All information is recorded on the *Lab Processing of SSC Water Samples* data sheet (Appendix H).

The scheduled calibration for the turbidimeter is once every three months according to manufacturer protocol. As a secondary accuracy check, *Gelex* factory standards are used before each series of measurements are taken. If the reported measurement is within the *Gelex* standard range, samples are then measured according to protocol. If out of range, the turbidimeter shall be calibrated prior to analysis of samples.

5.3 Protocol for analyzing transparency

Transparency is determined using a 60 cm clear tube with a secchi disk on the bottom. Each sample, after one minute of vigorous shaking, is poured into the tube and the tube is viewed from above. The samples are slowly released from a hose at the bottom of the tube back into the original container until the secchi disk at the bottom is first visible. The water level (cm) at the moment the secchi disk is first visible is the final reading. All information is recorded on the *Lab Processing of SSC Water Samples* data sheet (Appendix H).

If the transparency reading is < 5cm, dilute the sample for a more accurate measurement. Pour a small amount (~2-3cm) of sample into transparency tube, then fill the rest of the tube to ~50cm with clear water. The exact amounts are not important; what is important is to record the actual amount of sample (cm) used and the total final (sample + clear water (cm)) amount of sample. Then determine the transparency of that mixture. True transparency of the sample is then determined by: (sample * transparency)/total. Due to the dilution, this portion of sample is now contaminated and should NOT be returned to the original sample. For this reason, it is important to use as little of the original sample as possible that will still give a good turbidity reading. Experience will help here, but the dirtier the sample, the less one needs.

5.4 Protocol for analyzing bedload samples

All bedload samples are transferred into a cloth oven bag or tin for drying. Bedload samples are dried in an oven for 24 hours at 70°C. Samples are allowed to cool for two hours and then weighed for their total mass (g), which is later used to get an instantaneous bedload concentration.

Additionally, samples may be processed and analyzed to determine particle size distribution. The procedures for particle size analysis are as follows:

5.4.1 Dry or Wet Sieve

- Dry sample in oven for 24 hours at 70°C.
- Record dry weight of total sample.
- Dry sieve (using manual sieve shaker) or wet sieve sample using the U.S.A. standard sieve series.
- Weigh (may require drying if wet sieve method is used) and record the weight for each class size.
- Take a subsample of approximately 50 grams (up to 100 grams for more sandy samples) by repeatedly splitting all classes under 2mm.
- Record weight.

5.4.2 Dispersing Solution (5% solution of Sodium Hexametaphosphate)

- Weigh 50 grams of sodium hexametaphosphate.
- Add 1 liter of water and shake until dissolved.

5.4.3 Dispersion of Sample

- Add 250ml of distilled water and 100 ml of 5% dispersing solution to the 50-gram subsample.
- Thoroughly mix and allow sample to stand overnight

5.4.4 Hydrometer Procedure

- Shake dispersion solution and soil subsample for 5 minutes.
- Transfer sample to 1000ml-graduated cylinder.
- Fill to ~970 ml mark with distilled water.

- Shake (in up and down motion, not circular) for approximately 20 seconds.
- Record time and use remaining 30ml of water to rinse sides of cylinder.
- Take and record hydrometer readings at 40 seconds, 80 seconds, 4.5 minutes, 2.5 hours, and 24 hours
- Take and record temperature immediately after each hydrometer reading.
- Take blank reading (see calibration below) after every hydrometer reading.

5.4.5 Calibration of Hydrometer (Blank Value)

- Add 100ml of dispersing solution to cylinder and fill with DI to 1000ml mark.
- Mix and let stand until temperature is constant.
- Take and record temperature.
- Take and record hydrometer reading.

5.5 Protocol for Chemical Water Quality Analysis using a Spectrophotometer

This section describes the laboratory procedures used by CCoWS to analyze water quality constituents in water samples using a HACH Odyssey DR/2500 Spectrophotometer. This instrument is used by CCoWS for the analysis of dissolved nutrients, including oxidized nitrogen-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N) and orthophosphate (PO_4-P), but it can also be used for a wide variety of water quality constituents.

5.5.1 Sample handling

In general, samples will be handled according to the specifications of the test method.

For every sample run, one site will be randomly chosen as the QAQC site: all duplicate measurements and samples will be taken from this site, and all laboratory sample checks (section 5.5.2) will be run on these samples. This will ensure clarity and continuity in data management and reporting.

During sample collection, field duplicates will be taken to define the accuracy of the samples at representing the water body. At least one duplicate will be taken per sample run.

In all cases, the most accurate data will result from the immediate processing of the nutrient samples upon return to the lab. QA/QC samples to be sent to an outside lab for comparison should be sent immediately after sampling or no later than the following day. Should this prove impractical or impossible, the next best option is to refrigerate the sample to 4°C and process within 48 hours from the time they entered the lab.

If samples are not to be analyzed within 48 hours of collection, they should be frozen for later analysis. In the case of frozen samples, they should be analyzed within one month of collection.

Samples may have already been filtered as per field protocols of specific projects (except those samples going to an outside laboratory for analysis). If Orthophosphate will be analyzed for, the samples may be immediately filtered in

the field into properly labeled scintillation vials using syringe driven 0.45μm Millex filters. If samples are not filtered prior to freezing, then filtration will occur after thawing before analysis. All equipment is thoroughly washed with *Liquinox*™ between filtrations.

All samples should be placed in plastic *Ziploc* bags with the sample collection date/time and campaign title written on the bag. If samples are to be frozen, the date of initial freezing should also be noted on the bag. A log of current samples within the refrigerator/freezer will be kept taped to the door of the refrigerator/freezer and updated as the status of samples changes. This form *Sample Storage Management Log* (Appendix A) will be saved to file when full. Sample preservation status will be recorded on the *Nutrient Sample Run Data* sheet (Appendix G).

Samples shall be brought to room temperature before analysis. This may be done by thawing overnight or by a warm-water bath. However, if a bath is used care must be taken to not raise the sample temperature above room temperature at any time. Overnight thawing is preferred.

5.5.2 Quality Control: Sample Checks

In the laboratory, samples are grouped into batches, usually 10 – 20 samples per batch. Standard solutions, reagent or method blanks, bottle blanks, replicates, and spikes will be run with every batch of samples to assess the accuracy and precision of the laboratory method and techniques. Everything is documented on a 'Nutrient sample run data' (Appendix G). All analysis is done according the manufacturer's instructions and specifications for each individual analysis.

If a project has specific data quality objectives (DQOs), the QC Sample Checks shall be modified to meet any project's specific DQO's.

5.5.2.1 Reagent/Method Blanks

The manual for the spectrophotometer suggests running reagent blanks (or method blanks) to compensate for the contribution of the reagents to the final reading. The procedure is performed with RO (water purified by reverse osmosis) water in place of the sample. The reading of this RO water is then

recorded on the 'Nutrient sample run data' lab sheet (Appendix A) and zeroed out of the instrument.

5.5.2.2 Standard Solutions

The accuracy of the spectrophotometer will be checked against standard solutions of known concentrations. These standards are obtained from HACH (dated upon receipt) and include a low range, middle range, and high range concentrations (some dilution of stock standard solutions may be necessary to obtain the lower range standard). Table 5-1 lists the 3 methods CCoWS commonly uses and the standards that are used for each method. Standard solutions are run before any samples are processed. Accuracy will be assessed by the percent error between the known concentration of the standard, and the reading or measured value from the spectrophotometer. The acceptable % error for each method is presented in Table 5-1.

$$\%Error = \left| \frac{(MeasuredValue - KnownConcentration)}{KnownConcentration} \right| * 100$$

Should standards fall outside of this limit, the procedures will be rechecked, the date the standard was received will be checked (if the standard is older than the specific shelf life of the specific standard, then it is disposed of and a new standard is obtained) and the standard is processed again. Samples are not processed until the acceptable % Error has been achieved.

Note that once the program is exited from, the blank re-zeros and the value is lost. A new blank and new standard solutions must be run each time the instrument is turned on, each time the program is changed, and every time a sample run is performed.

Table 5-1 Summary of the test ranges, method descriptions, and standard solutions of commonly used analyses.

Constituent	HACH Method	Method Description	Test Range (mg/L)	Acceptable % Error	STANDARDS		
					Low	Mid	High
NO_3-N	10020	chromotropic acid method	0.2 - 30	10%	0.5	10	25
NH_3-N	10023	salicylate method; AmVer Test 'n Tube	0.02 - 2.50	4%	0.05	1	2.5
PO_4-P	8048	absorbic acid method; PhosVer 3 Test 'n Tube	0.06 - 5.00	4%	0.05	1	5

5.5.2.3 Bottle Blank

The bottle blank consists of RO water in a re-used, cleaned, and acid washed sample bottle. To ensure no contamination from the sample bottle, method blanks must not detect any nutrients. One bottle blank is run per batch of samples.

One sample (preferably one of the duplicates) is chosen as the QC sample. This sample will be used for both replication and spiking. Using the same sample for all QC will ensure clarity and continuity in data management and reporting.

5.5.2.4 Replicates

A replicate on at least one sample per batch, or 5% of samples will ensure precision. Replication is done by running the QC sample in the beginning of the sample run, and running the same sample from the same bottle again at the end of the sample run. Calculating the % difference between the replicates will assess precision:

$$\%Difference = \left| \frac{(R1 - R2)}{\overline{R1R2}} \right| * 100$$

Where R represents a replicate. The acceptable % difference is $\pm$25%.

5.5.2.5 Sample Spikes

Sample spikes will ensure the accuracy of laboratory results. At least one sample spike will be conducted per sample batch. Sample spikes are made with a 1:1 ratio of the QC sample and standard solution. The percent recovery from this spike will be used to assess the accuracy of the method and technique:

$$\%\,\mathrm{Recovery} = \frac{MeasuredSpikeValue}{ExpectedSpikeValue} * 100$$

Where the expected spike value is the average of the sample value and standard concentration. The acceptable % recovery for all analysis is 80% - 120 %.

5.5.3 Analysis with the Spectrophotometer

Technicians shall be familiar with the equipment and tests before analyzing samples on their own. This should include both training with an experienced technician and study of the instrument and procedure manuals. This training shall be documented and kept on file *Technician Training Tracking Sheet* (Appendix B).

Methods in commun use by CCoWS are listed in Table 5-1. Procedures for tests are detailed in the *HACH Odyssey* DR/2500 Spectrophotometer Procedure Manual (te/dk 04/01 2ed) under the above-mentioned methods. Procedures and instructions shall be followed step-by-step. Particular attention should be paid to the "Tips and Techniques" section at the beginning of each method.

In the Procedure Manual, the statement is made that this methods are technique-sensitive, that the color development depends upon shaking time and technique. Different verbs are used in different procedures to describe how to mix the sample with the regents. Below is description of how these verbs should be interpreted.

- "Invert": Hold the vial in the vertical position with the cap pointing up. Turn the vial upside down. Wait for all of the solution to flow down to the cap. Pause. Return the vial to an upright position, wait for all of the solution to flow to the bottom of the vial. This process equals one inversion. Repeat as many times as the method specifies.
- "Shake": Shake vigorously for the amount of time designated in the method instructions. Each sample shall be shaken consistently.
- "Mix" and "Swirl": Perform the "Invert" procedure until the contents of the test tube are visibly well mixed.

Should the concentration of a sample fall under the range of the test, the data value will be reported as "non-detect". If the test indicates an over-range value, then a 3:1 dilution of the sample will be performed and the sample will be retested. The value that is read from this diluted sample is then multiplied by 4 to obtain the data value.

Used sample that has been processed with reagent is a regulated hazardous waste and disposed of according to CSUMB's Environmental Protection, Health & Safety Program (EPHS, 2005).

5.6 Protocol for Chemical Water Quality Analysis using a Digital Titrator

This section describes the laboratory procedures used by CCoWS to analyze water quality constituents in water samples using a HACH Digital Titrator Model 16900. This is a precision dispensing device fitted with compact cartridges that contain concentrated titrants. This instrument is used by CCoWS for the analysis of carbon dioxide (CO_2, method 8205), but it can also be used for a wide variety of water quality constituents.

A designated amount of sample is measured into an Erlenmeyer flask. The amount of solution that is dispensed into a sample by the titrator is measured in digits (or clicks of the delivery knob).

Concentration of the constituent is then calculated by the following equation:

Digits Required * Digit Multiplier = Sample Concentration

The digit multiplier is different for each individual analysis, and is provided in the in the procedure for each method.

The accuracy of the dispensed volume from the titrator is rated at ±1% or better for a titration of more than 100 digits. For titrations less than 100 digits, accuracy is ±1 digit.

5.6.1.1 Quality Control: Sample Checks

A method blank (RO water) will be performed with every batch of samples to be analyzed. One of the duplicate samples shall be replicated and the % difference between the two shall be calculated to ensure precision. As with the spectrophotometer, the acceptable % difference is ±25%. Standards and spikes are discussed in section 5.6.2.1.

5.6.2 CO_2

Samples taken for CO_2 analysis are collected in clean plastic bottles. Bottles are filled completely and tightly capped. One duplicate sample is collected per sample run. Samples shall be analyzed as soon as possible after collection, however if this not possible, samples shall be refrigerated at 4°C for no longer

than 24 hours. Samples that have been refrigerated should be warmed to room temperature for analysis.

For CO_2, phenolphthalien is added to the sample in an Erlenmeyer flask. Sodium hydroxide (NaOH) is titrated into the flask as it is simultaneously swirled. When the sample turns from colorless to a light pink color that persists for longer than 30 seconds, the number of digits on the titrator is recorded. This number is then multiplied by the digit multiplier to obtain the concentration of CO_2 (mg/L) in the sample.

The digit multiplier is determined by the amount of sample that is used for analysis. The volume of sample that is used depends on the expected concentration range. If the expected concentration is unknown, a smaller sample volume should be tried first to determine the approximate concentration. The procedure should then be repeated using the appropriate sample size.

The expected concentration range also determines the concentration of NaOH that is used as the titrant. A table summarizing these specifications is on page 49 of the instruction manual with the procedure, and is reproduced here in Table 5-2.

5.6.2.1 Standard Additions

The instruction manual recommends performing an accuracy check whenever interferences are suspected or to verify analytical technique. Standard Additions is a widely accepted technique for checking the validity of test results. It is also known as “spiking” and “known additions”, the technique adds a small amount of the constituent to an analyzed sample and the analysis is repeated. The increase in test results should equal the amount of standard that is added to the sample.

The volume of standard that is added to samples already analyzed for CO_2 depends on the concentration range that the sample value falls in (0.1 mL or 1.0 mL). The titration is resumed to the same end point. The required number of digits is recorded. This is repeated using 0.2 mL or 2.0 mL, and again using 0.3 mL or 3.0 mL. The same end point is used for each addition.

For CO_2, each addition of standard should require 50 additional digits of titrant. If the actual number of digits varies noticeably, the problem is cause by the reagents, the apparatus, the procedure, or an interfering substance. A trouble-shooting guide, called a 'Decision Tree' is outlined in Appendix A of the instruction manual. This process shall be followed step-by-step should any problems or uncertainties occur during analysis. The process involves replacing the sample water with DI water and performing multiple standard additions.

Table 5-2 Specifications for HACH method 8205 for CO_2 analysis using a digital titrator.

Range (mg/L as CO_2)	Sample Volume (mL)	Titration Cartridge (N NaOH)	Digit Multiplier
10 – 50	200	0.3636	0.1
20 – 100	100	0.3636	0.2
100 – 400	200	3.636	1.0
200 – 1000	100	3.636	2.0

5.7 Protocol for analyzing chlorpyrifos and diazinon pesticide samples using ELISA

The following section describes procedures of analyzing for the specific pesticides diazinon (D) and chlorpyrifos (C) collected as described in Section 4.7 using Enzyme Linked ImmunoSorbent Assays, or ELISA. The theory of this analysis is documented in Katznelson and Feng (1998). This analysis may be used for a wide variety of organic pesticides using the exact same method with test kits specific to the chemical of interest. The procedure presented here is an adaptation of the one in Katznelson and dfend (1998), with the exception of analysis on suspended sediment samples.

Water samples can be analyzed directly using ELISA technology; however, benthic and suspended sediment (SS) samples must first have any pesticide extracted using methanol. The two methods are distinct and must be treated separately throughout the entire procedure. Furthermore, extraction of pesticides from SS samples is a different procedure than extraction of sediment samples. Once extracted, SS and benthic samples can be analyzed concurrently using the same methods. Any single analysis (water or methanol extracted) of a field excursion is considered an ELISA 'run'.

Many pesticides, including D & C, hydrolyze. Therefore, analysis on water samples should be performed within a day of collection for most accurate results. Samples shall be kept refrigerated until analysis. Benthic and SS samples that have been extracted with methanol are quite stable and may be stored for weeks if kept in a cool (4°C), dark place (refrigerated).

Each batch of samples shall have incorporated into them the appropriate amount of QA/QC sample checks including:

- Field method blanks: 3 per field excursion
- Lab method blanks: 1 per run
- Sample replicates: at least 1 per run or 10% of samples
- Sample spikes: 1set per run
- Samples to be sent to outside lab: at least 1 per field excursion or 10% of samples

5.7.1 Equipment/materials

- Gloves, goggles, lab coat
- ELISA plate kit with all components
- High-Performance Liquid Chromatography (HPLC) water
- Methanol, Optima grade, *Fisher Scientific*
- 10 mL glass syringe w/pipette needle
- 10 mL glass syringe w/Luer-lock hub
- Syringe filters, teflon
- Parafilm
- Multi-channel pipette OR repeater pipette, with appropriate tips
- Reagent wells for multi-channel use
- 20 mL glass scintillation vials
- Test tubes (12x75mm) & rack
- 000 size rubber stoppers
- 20-200 µL pipette with tips
- 100-1000 µL pipette with tips
- Positive displacement micro-dispenser
- Mixer/vortexer
- EL301 strip reader, Bio-tek
- Sample press
- Laboratory blender
- Sample dehydrator

5.7.2 Initial Preparation

Samples to be analyzed, the necessary number of kit well strips, and reagents shall be brought to room temperature before performing the test. Unused well strips shall remain refrigerated. Benthic and SS samples take longer to warm and process, so should be started earlier. The maximum number of wells to be used at any one time shall be 36, or 3 strips.

The ideal scheduling of an entire ELISA excursion would be as follows:

- First day: collect field samples, store in refrigerator
- Second day: run ELISA analysis on water samples, perform sediment/SS extractions
- Third day: run ELISA analysis on extracted samples

There is potential to fill 36 separate micro-wells during an ELISA run. It is easy to get confused as to what samples are placed into which wells. An *ELISA Run Plan* (Appendix K) is a form to help organize samples to keep the technician on track and to help avoid confusion. Determine position of calibrators, samples, replicates, spikes, blanks, and controls using the *ELISA Run plan* (Appendix K) along with consideration of QA/QC samples. First runs of unknown samples are always undiluted. If, after the first run, a sample is deemed too concentrated, dilution procedures described later shall be followed.

5.7.3 Sample preparation

5.7.3.1 Water samples

Water samples are filtered in the field (see section 4.7.6) into an amber glass bottle and therefore are ready to place directly into the wells. Sample bottles shall be arranged in the pattern that they will fill the wells in to help avoid confusion. Samples that look murky or otherwise in need of filtering shall be filtered using a dedicated glass syringe and a syringe filter. The sample shall be delivered to a test tube labeled with the Bottle ID#. Equipment shall be cleaned between each sample preparation.

5.7.3.2 Methanol extraction of pesticides from suspended sediment samples

The sample is a filter with suspended sediment placed into a labeled amber glass bottle (Section 4.7.6). The sample shall be removed from the bottle, weighed and the weight recorded. It shall then be placed in a dehydrator for 2 hours. The sample shall be reweighed and weight again recorded. The sample shall then be cut into strips and placed into a lab blender with 5 mL of 100% methanol to homogenize and aerate. It shall be immediately returned to its sample bottle, covered and allowed to stand for 1 hour. Place sample into the press and squeeze the sample over a beaker to collect the methanol extract. Immediately pour the extract into a glass syringe with filter tip and dispense into a labeled (same as Bottle ID) scintillation vial. The sample is now extracted and ready for analysis. Carefully record all information on the *SSC & Benthic Methanol Extraction* plan (Appendix I). Clean all equipment used between each sample preparation.

5.7.3.3 Methanol extraction of pesticides from benthic samples

The sample is a grab of benthic material, homogenized and placed into an amber glass bottle (Section 4.7.7). After it has sat for some time (overnight), pour out excess overlaying water from the sample. Weigh out approximately 10 g of sample, record wet weight, and return to the original rinsed and dried sample bottle. Add 20 mL pure methanol (15.82 g weighed out) to sample bottle, shake vigorously but occasionally (every 5-10 min) for 30 minutes. Let stand for 1 hour. The methanol extract will rise to the top of the sample. Decant clean methanol off the top to a dedicated filtering syringe. Filter to a labeled (same as Bottle ID) scintillation vial. The sample is now extracted and ready for analysis. Discard waste sediment. Weigh out another portion of the sample in a drying tin, record weight, dry in oven at 100°C for 2 hours, cool for 5 minutes, and re-record weight. Record all information on the *SSC & Benthic Methanol Extraction* plan (Appendix I). Clean all equipment used between each sample preparation.

5.7.3.4 Dilution of Samples

If the first round of analysis shows that a particular sample is too concentrated to fall into the calibration curve (indicated by a relatively clear sample well after incubation and a flag from the ELISA Excel spreadsheet, described later), dilution of the sample will be necessary. Prepare sample dilutions as follows:

- Prepare 12 X 75 mm glass test tubes, 2 for each sample, by labeling the test tubes with the sample Bottle ID and dilution (25% or 6.25%)
- Dispense 300 µL HPLC water (for water sample) or 300 µL methanol (for extraction sample) in each tube
- Use serial dilutions of 25% at each step: transfer 100 µL of sample into the first (25%) tube with 300 µL HPLC water (or methanol) and mix well (pipetor pumping & vortex). Then, using the same tip, transfer 100 µL from first (25%) tube to the second (6.25%) tube and mix well with existing HPLC water (or methanol).
- Repeat ELISA routine.

The sample methanol extract for both SS & benthic samples must be diluted with HPLC water before being placed in the sample wells. As with the dilution for the calibrators, place 500 µL of HPLC water into as many test tubes as there are samples and label the tubes with the Bottle ID. Then, place 55 µL of sample

extract into the labeled tube with HPLC water and mix. This ratio of 55 µL of sample to 500 µL of HPLC water is maintained for all other QA/QC samples also (ie. method blanks, spikes, control, etc.)

5.7.4 Standards (calibrators & control) Preparation

5.7.4.1 Standards for ELISA analysis of water samples

To make the CALIBRATOR *STANDARD* for the calibrators:
Note: "D" stands for diazinon, "C" for chlorpyrifos.

Mix in clean 20 mL scintillation vial labeled "400 ng/L D", **OR** "1000 ng/L C":

- 10 mL HPLC water: (use dedicated syringe)
- 40 µL diazinon stock solution (100 ng/mL), **OR** 10 µL chlorpyrifos stock solution (1 ppm): (use micro-dispenser)
- Mix by vortex.

To make the *CONTROL* solutions:

Mix in clean 20 mL scintillation vial labeled "300 ng/L D", **OR** "500 ng/L C":

- 10 mL HPLC water: (use dedicated syringe)
- 30 µL diazinon stock solution (100 ng/mL), **OR** 5 µL chlorpyrifos stock solution (1 ppm)
- Mix by vortex.

This will create 300 ng/L D (500 ng/L C) *CONTROL* solutions to be used as controls and spike analytes.

Calibrators:

- Label 4 test tubes; "400 ng/L D (1000 ng/L C), 100 ng/L D (250 ng/L C), 25 ng/L D (62.5 ng/L C) and 0 ng/L D (0 ng/L C)"

- In the 400 ng/L D (600 ng/L C) tube, dispense 500 µL of 400 ng/L D (1000 ng/L C) from the vial

- Dispense 300 µL of HPLC water into each of the remaining tubes.

- Into the 100 ng/L D (250ng/L C) tube, dispense 100 µL of 400 ng/L D (1000 ng/L C) standard. Mix by pipette and vortex.

- In the 25 ng/L D (62.5 ng/L C) tube, dispense 100 µL of 100 ng/L D (250 ng/L C) standard. Mix by pipette and vortex.

- Put nothing in the 0 ng/L tube, except 300 µL HPLC water

- Place all tubes in their proper locations of tube holders according to the *ELISA Run Plan* (Appendix K).

5.7.4.2 Standards for the ELISA analysis of SS/benthic samples extracted using methanol

Methanol will evaporate readily and the volumes dispensed are crucial. Therefore, test tubes containing methanol must be covered with a rubber stopper when not being used. It is best to have two technicians at this stage, one dispensing, and one capping.

- Prep 4 test tubes labeled: 4,000 ppt D (10,000 ppt C); 1,000 ppt D (2,500 ppt C); 250 ppt D (625 ppt C), 0 ppt D or C.

- Prep 4 more test tubes labled: 400 ppt D (1,000 ppt C); 100 ppt D (250 ppt C); 25 ppt D (62.5 ppt C), 0 ppt D or C.

- In the 4,000 ppt D (10,000 ppt C) tube, add 1 mL methanol (0.791 g weighed out) and 40 µL D (10 µL C) stock solution, mix by vortex. This is the 4,000 ppt D (10,000 ppt C) standard.

- Add 300 µL of methanol to the other 3 test tubes.

- Take 100 µL of 4,000 ppt D (10,000 ppt C) standard and pipette into the 1,000 ppt D (2,500 ppt C) tube. Mix by pipette and vortex.

- Take 100 µL of 1,000 ppt D (2,500 ppt C) standard and pipette into the 250 ppt D (625 ppt C) tube. Mix by pipette and vortex.

- Put nothing but 300 µL methanol in the 0 ppt calibrator.

- Put 500 µL of HPLC water into each of the other tubes labeled: 400 ppt D (1,000 ppt C); 100 ppt D (250 ppt C); 25 ppt D (62.5 ppt C), 0 ppt D or C.

- Take 55 µL from each of the 4,000 ppt D (10,000 ppt C); 1,000 ppt D (2,500 ppt C); 250 ppt D (625 ppt C), 0 ppt D or C tubes and put into each of the respective 400 ppt D (1,000 ppt C); 100 ppt D (250 ppt C); 25 ppt D (62.5 ppt C), 0 ppt D or C tubes. Mix by pipette and vortex. These further diluted samples are the calibrators.

  To make a control solution, place 30 µL D (5 µL C) stock solution into a tube with 1 mL methanol (0.791g weighed out), mix by vortex. Then take 55 µL of that solution and dilute into 500 µL HPLC water, mix by vortex. This will make a 300 ng/L D, (500 ng/L C) control standard. This will be used as a QA/QC check for accuracy of the method. There shall be a control solution sample for each ELISA run.

Spikes:
The control standard can be used to spike a sample to be used as a QA/QC procedure for evaluation of extraction efficiency and as another measure of precision. Mix 100 µL of control standard with 100 µL of sample to create a spike. Comparisons are then made between the spike, original sample and the control. Spikes should be performed/analyzed at a frequency of about 1 in 20 real samples (1 per 3 strips).

5.7.5 Performing an ELISA run

Align calibrators, samples, control, spikes, and field/lab method blanks for rapid, efficient deployment to sample wells in the order of the *ELISA Run Plan* (Appendix K). Label the well rows.

Step 1: Note time. Pipette 100 µL of test solution into each well according to plan. Immediately add 100 µL of conjugate solution supplied in the kit to each well (using multi-channel or combitip repeater). Note time. Cover with parafilm, gently mix wells with circular motions on countertop and incubate in the incubator (room temp, 23°C) for 60 minutes beginning from the average of

the two before-noted times. Remove the samples from the incubator and gently mix with circular motions every 15 minutes.

Step 2: After 60 min, remove from incubator and remove parafilm. At this point all of the sample that is necessary is attached to the antibodies on the sides of the micro-wells. Pour out the rest of the sample from the wells into a waste container and rinse the wells with tap water 4-5 times. Tap out remaining water in wells & blot off water from strip undersides.

Step 3: Add 100 µL substrate solution supplied with the kit to each well (multi-channel or repeater), cover, mix & incubate for 30 minutes. This time can be increased slightly if color development is slow, or sooner if fast. At the end of incubation, add 100 µL stop solution supplied by the kit to each well (multi-channel or repeater), cover & mix.

Step 4: Remove parafilm from the wells. Insert well strips into the strip reader. Read strips at 450 nm within 30 minutes of stop solution addition. Print all readings from the plate reader ("data out"). Clean up.

Step 5: Enter ELISA information into the appropriate place on the ELISA Run Spreadsheet template. Double-check for errors and that the figures make sense.

Step 6: Address QA/QC samples & checks. Katznelson and Feng (1998) give a detailed account of quality checks and controls based on QA/QC samples and data from the regression model. We shall follow the procedures addressed in their report.

5.7.6 ELISA Run Spreadsheet template

Absorbance readings with corresponding well numbers are entered into an Excel spreadsheet specifically designed as a template for the ELISA analysis. An example of this sheet is presented in Appendix J. Using a regression curve established by the calibrators, absorbance readings are translated into concentrations of diazinon or chlorpyrifos in either ng/L for water samples or ng/kg for sediment samples. %Error, &Difference, and %Recovery will be calculated in the same way as described in Section 5.5.2.

5.8 Protocol for analyzing pathogen samples

At present, CCoWS does not analyze pathogen samples. Samples may be analyzed by the following state certified laboratories:

Monterey County Health Department Laboratory
1270 Natividad Rd.
Salinas, CA 93906
(831) 755-4516

Bio Vir Laboratories
685 Stone Road, Unit 6
Benicia, California 94510 -1126
1-800-GIARDIA (442-7342)
(707) 747 - 5906

The primary technique for coliform analysis will be Multiple Tube Fermentation (SM9221). Membrane Filtration may be a more appropriate method for coliform testing because it results in a direct colony count, but Multiple Tube Fermenation will be used for in order to allow for comparisons to the Basin Plan objectives (1994). Additional information on laboratory protocols can be obtained from the above address. All samples will be placed on ice and delivered immediately to the external laboratory with an accompanying chain-of-custody form.

5.9 Protocol for analyzing benthic macro-invertebrate (BMI) samples

CCoWS currently uses techniques adapted from following manual for the analysis of benthic macroinvertebrates:

Harrington, J. and M. Born. 2000. Measuring the Health of California Streams and Rivers, A Methods Manual for: Water Resource Professionals, Citizen Monitors, and Natural Resource Students. Sustainable Land Stewardship International Institute. Sacramento, CA.

Internal bioassessment validation (for accuracy and precision) will be conducted by another staff person completing re-identification on at least 10% of the samples. If time and resources permit, 100% of samples are validated. Accuracy and precision must be within ±5% difference (refer to procedures in section 5.9.1.2). Bioassessment validation will also be conducted externally on 10% of the samples by an independent laboratory, Aquatic Biology Associates (ABA, Inc.), located in Corvallis, Oregon.

Each step of the process followed by CCoWS is documented on a Chain of Custody (COC, Appendix L), a California Bioassessment Worksheet (CBW, Appendix M), laboratory bench sheets (Appendix N), and IDENTIFICATION EVALUATION sheet (Appendix O).

5.9.1 Laboratory methods

The three level-system has been adapted from Harrington and Born (2000) as follows:

1) Sample labels are made on small pieces of 3x5 note cards that include the site code, sample location, date, time, and samplers. These labels are placed inside the sample jars.
2) If the samples are not to be processed immediately, they shall be placed in a secure location for storage until they can be processed. The COC and CBW are placed in a secure location in a safe location.
3) Empty the contents of the sample jar into the #35 sieve, being sure all debris is rinsed from the jar to the sieve. Place the label back in the jar. Use water from the sink to rinse the sample without splashing debris out of the sieve.

4) After rinsing the sample, remove debris larger than ½ inch, green leaves, twigs, and rocks. Filamentous algae and skeletonized leaves will not be removed. This will be accomplished by rubbing the material underwater and inspecting it. The debris will then be discarded.
5) The material is then placed to one side in shallow a plastic tray. A small portion of the sample is moved to the middle of the tray where it is thoroughly scanned for any invertebrates present. After this small portion has been completely sorted and all specimens have been removed and placed in a plastic Petri dish, the sorted portion of the sample is then moved to the other side of the tray, and another small portion of the original sample is moved to the middle where it is sorted. This process is continued until the entire sample has been sorted. The remaining contents of the tray are put into a pint jar with the sample label (this label includes site code, date, and name of collectors) and enough 70% ethanol/glycerin solution to completely cover the contents.
    a. Note that the procedure in Harrington and Born suggests subsampling 100 organisms out of the sample. CCoWS has found that most samples may not contain 100 organisms. If there are not 100 organisms present in a sample, the procedure will continue with the all organisms present and a note shall be made for this sample on the benchsheet.
6) Fill in the lab number, sample identification number, and sample description on the benchsheet (Appendix xx).
7) The pitri dish with all the sorted BMI's from the sample is placed under a dissecting microscope. Each specimen is examined for distinguishing characteristics and tallied into taxonomic categories, identified according to various keys (Merritt and Cummins, 1996; Harrington and Born, 2000; McCafferty, 1998; Smith, 2001; Fitzpatrick, 1983; NAMC, 2001; APHA, 1998).
8) Specimens of the same order are put in a clean vile with ethanol/glycerin solution and the vial is put in a vial tray. A specimen label is made with the order name, location, collector, collection date, and identifier. This specimen label is then slipped under the plastic strip on the vial tray in front of that vial. The pitri dish is then searched for other BMI's of the same order and put into the same-labeled vial.
9) Continue until all BMI's are identified.
10) Vials labeled mayflies (order: *Ephemeroptera*), stoneflies (order: *Plecoptera*), caddisflies (order: *Trichoptera*), beetles (order: *Coleoptera*),

true flies (order: *Diptera*), hellagrammites (order: *Megaloptera*) true bugs (order: *Hemiptera*), and dragonflies and damselflies (order: *Odonata*) are emptied into individually into a clean pitri dish, being sure not to leave any specimens in the vial. Add ethanol/glycerin if necessary to the pitri dish in order to keep the specimens from drying out.

11) All specimens in the vial are identified to the family taxonomic level (the same keys are used).
12) Specimens from each family are placed in a separate clean vial with the ethanol/glycerin solution. The Sorting label from the vials that contained the specimens classified to the order taxonomic level is discarded, and another label is made with the taxonomic name of the identified specimen, the number of specimens in that family, collection date and time, site code, collection location, identification date, and name of identifier. The label is placed in each vile when complete.
13) Identification continues until all sorting vials are divided into the final taxonomic levels.
14) Samples and vials shall be stored.
15) Specimens may be photographed through the dissecting scope. Photos shall include documentation of each collection site and close-ups of the substrate when possible.

5.9.1.1 External Identification Validation

Bioassessment validation will be conducted by an independent laboratory that does not have a personal affiliation with CCoWS. One set of duplicate samples shall be collected sample per run and shall be sent to Aquatic Biology Associates, Inc. (ABA) for a QC check.

5.9.1.2 Internal CCoWS re-identification check procedure

1) Each black-topped vial that contains specimens of each identified organism, ethanol/glycerin mixture, & its Order & Family ID is assigned another ID (single capitol letter) by placing a small piece of 3x5 card with the letter written on it into the vial. These vials are then placed in a clear plastic strip and this strip is labeled with the site code.
2) One specimen from each black-topped vial is placed in its own 20mL scintillation vial (white topped) with ethanol/glycerin mixture. This specimen is labeled with a sharpie on the top of the lid with the corresponding single letter ID (but not the order & family ID).

3) These vials are then placed together separate from the black-topped vials. These will be the specimens that are re-identified.
4) The re-identifier then keys out each specimen and records Order & Family on the IDENTIFICATION EVALUATION sheet (Appendix O) next to the corresponding single letter ID.
5) This re-identification list is then compared to the Family & Order identification located in each black-topped vial containing the specimens using the single letter ID.
6) The 'AGREEMENT' field on the IDENTIFICATION EVALUATION sheet is checked if both identifiers agree on the Family & Order ID. It is left blank if the two identifiers disagree.
7) Both identifiers meet to discuss disagreements, and try to come to agreement on the classification of 100% f the organisms.

6 Protocols for Data Analysis

This following section contains protocols for data analysis including:

- Constructing of stage-discharge curves and rating tables
- Estimating total event fluxes from a number of samples
- Statistical analysis of BMI samples

6.1 Protocol for constructing stage-discharge curves and rating tables

After a collection of discharges at different stage levels is obtained, stage discharge curves are created for each site. It then becomes possible to only collect a discharge measurement at a given site for stages that have not been measured before, thus saving time.

Final discharge estimates are taken from a stage-discharge 'rating' curve hand-fitted to the discharge data for each site. This curve was of the form:

$$Discharge = Scale \times (Stage + Offset)^{Power}$$

Where *Scale*, *Offset* and *Power* are parameters fitted for each site.

Because individual measurement errors are likely to be smoothed by the curve we make the assumption that discharge estimates based on the curve are more accurate than actual measurements. This practice is also effectively followed by the USGS (although the USGS uses a more complex rating curve).

6.2 Protocol for estimating total event fluxes from a number of samples

The total flux of either water or some entrained constituent such as sediment is determined by numerical integration of a number of measurements or samples taken at discrete time intervals over the entire course of the event. Usually, the sampling interval is variable from sample to sample. Thus, the following procedure is used:

- List all samples taken during the event, including the samples immediately before and after the event.
- Assign a start time and end time for each sample within the event (excluding the samples immediately before and after the event). The start time for each sample is the mean of the time at which that sample was taken, and the time at which the previous sample was taken; and similarly for the end time for each sample.
- Compute the duration of time (seconds) to which each sample is assumed to apply as the difference between its end time and its start time.
- Multiply the duration by the flux for each sample (the flux being the water discharge in m^3/s, or the load of some water quality constituent such as sediment in kg/s).
- In the case of discharges, the instantaneous discharge for each sample may be either directly measured (see Section 4.1), or estimated by inputting a measured stage into a previously prepared stage-discharge curve or rating table (see Section 6.1).
- In the case of loads, the instantaneous load for each sample is the concentration of that sample (kg/m^3, perhaps converted from mg/L) multiplied by the discharge (m^3/s).
- Sum the duration-flux products over all samples to yield the total discharge (m^3) or load (kg or tonnes) for the event.

6.3 Protocols for BMI Data analysis

In order to describe the BMI samples that were collected and processed, it is necessary to statistically describe the data to assess the condition of the waterbody where the samples were gathered. This data is called a biological metric. It is something that defines a feature of the BMI population that changes in a predictable manner with an increase in human disturbance. There are many ways to use these biological metrics to describe the ecological makeup of BMI communities. Biological metrics are categorized in four distinct types:

1. Richnesss measures
2. Composition measures
3. Tolerance/Intolerance measures
4. Functional feeding groups

Data shall be evaluated statistically according to Harrington and Born (2000). The BMIs present in the samples may also be related to the tolerance values published for each family (Harrington and Born, 2000; Hilsenhoff, 1988). It should be noted that the procedure below might be modified to meet the objectives of individual projects. One of the biological metrics that may be used by CCoWS team is presented in the following protocol:

1) The total number of families listed for the following groups are counted: *Ephemeroptera, Plecoptera*, and *Trichoptera*. The number of each order is recorded on the front of the Laboratory Worksheet.
2) The number of taxa in the *Ephemeroptera, Plecoptera*, and *Trichoptera* groups are added together together to find the EPT Taxa value. This number is recordedon the front of the Laboratory Worksheet.
3) The number of organisms in the *Ephemeroptera, Plecoptera,* and *Trichoptera* orders are added together, this sum is divided by the total number of organisms in the sample, and multiplied by 100% to calculate the EPT index. This value is recorded on the front of the Laboratory Worksheet (Appendix P).
4) The number of organisms in the *Ephemeroptera, Plecoptera*, and *Trichoptera* orders that have a t-value (t-values are located Appendix Q) of 0-3 are added together and divided by the total number of organisms, then multiplied by 100% to find the Sensitive EPT Index. This value is recorded on the front of the Laboratory Worksheet.

5) The number of organisms in the *Hydropsychidae* family is divided by the total number of organisms and multiplied by 100% to find the Percent *Hydropsychidae*. This value is recorded on the front of the Laboratory Worksheet.
6) The number of organisms in the *Beatidae* family is divided by the total number of organisms and multiply by 100% to find the Percent *Baetidae*. This value is recorded on the front of the Laboratory Worksheet.
7) The t-value for each taxon is multiplied by the number of organisms in that taxon. These values are added together for all taxa and divide by the total number of organisms, being sure to subtract from the total number of organisms those that don't have a t-value. This will calculate Tolerance Value and will be recorded on the front of the Laboratory Worksheet.
8) The number of organisms with t-values of 0,1, or 2 is divided by the total number of organisms and multiplied by 100%, being sure to subtract from the total number of organisms those that don't have a t-value. This will calculate Percent Intolerant Organisms and will be recorded on the front of the Laboratory Worksheet.
9) The number of organisms with t-values of 8,9, or 10 is divided by the total number of organisms and multiplied by 100%, being sure to subtract from the total number of organisms those that don't have a t-value. This will calculate Percent Tolerant Organisms and will be recorded on the front of the Laboratory Worksheet.
10) The number of organisms for the most abundant taxa is divided by the total number of organisms and multiplied by 100% to calculate the Percent Dominant taxa. This value is recorded on the front of the Laboratory Worksheet.
11) The number of organisms with f-designations (f-designations are located next to each taxon on the Laboratory Worksheet) that relate to the functional feeding group are divided by the total number of organisms and multiplied by 100%, being sure to subtract from the total number of organisms those that don't have a t-value. This calculates Percent Collectors, Perfect Filterers, Percent Scrapers, Percent Predators, and Percent Shredders. Record the values on the front of the Laboratory Worksheet.

7 Methodological comparisons

This section contains the results of several methodological comparison exercises conducted in relation to the protocols described previously in the document. This includes:

- Comparison of various types of flow meters including calibration techniques
- Comparison of suspended sediment/turbidity measurement techniques
- Comparison of dissolved oxygen measurement techniques

7.1 Flow meter calibration and comparison

CCoWS uses several types of current meters (flow probes) for measuring stream velocity: *Gurley Precision Instruments* Price Type AA and Pygmy current meters, the *Global Water* flow probes (plastic propeller), or the most commonly used CCoWS manufactured flow probes (plastic propellor).

The specifications for *Global Water* flow probes and *Gurley Precision Instruments* current meters are summarized in Table 7-1 to Table 7-2.

Table 7-1. *Global Water* Flow Probe Specifications

Global Water Flow Probe Specifications	
Range	0.3 to 25 ft/sec (0.1 to 8 m/s)
Accuracy	0.1 ft/sec
Averaging	True digital running average; Readings taken once per second
Sensor Type	Protected Turbo-Prop propeller with electro-magnetic pickup

Table 7-2. *Gurley Precision Instruments* Current Meter Specifications

Gurley Precision Instruments Current Meter Specifications		
	Price Type AA	Pygmy Type
Accuracy	2%	2%
Minimum depth required		
Rod suspended	6 inches	3 inches
Dimensions		
Bucket open end diameter	2 inches	0.78 inches
Bucket wheel diameter	5 inches	2 inches
Operating Range		
Feet per second	0.2 to 25	0.05 to 3.0* 0.02 to 15.00
Meters per second	0.06 to 7.6	0.02 to 0.9* 0.02 to 4.57
*The range of the pygmy meter can be extended to 11 fps with the 611 hand counter (headphone model) and 15 fps with the Model 1100 flow indicator. However, the Price AA is recommended for velocities in this range.		

The *Global Water* and *Gurley Precision Instruments* current meters shall be maintained and calibrated according to instructions provided by the manufacturer. The ESSP laboratory/equipment staff at CSU Monterey Bay maintains all *Gurley Precision Instruments*, and the CCoWS field manager maintains all *Global Water* instruments as well as those constructed by CCoWS. Prior to each use of *Global Water* and CCoWS flow probes, the calibration function on the digital readout display should be checked. Single magnet probes should read "1603" and double magnet probes should read "2538".

Additional accuracy checks of all probes are also conducted regularly by CCoWS. These accuracy checks should be performed annually prior to the rainy season and anytime in which repairs have been made or problems have been detected. The procedures for flow probe accuracy checks are as follows:

- Calibration shall be conducted at a swimming pool.
- Along the edge of the pool, a fixed distance shall be determined and marked (approximately 8 to 10 meters).
- The flow probe shall be placed in the top 0.5 meter of the swimming pool while the operator walks along the edge recording the amount of time taken to travel the fixed distance.
- A wide range of velocities should be measured.
- At least 20 to 30 trials should be made.
- For each trial, the metered velocity (flow probe reading) as well as the actual reading (fixed distance traveled per time) shall be recorded and then compared.

For each current meter assessed, the average of all trials should be within 10% accuracy. If the % accuracy is greater than 10%, the calibration/accuracy check should be repeated to detect potential error in the calibration procedure. If the error is repeatedly high, then the current meter should be returned to the manufacturer for maintenance or repairs by CCoWS should be made. Potential sources of error in this pool type calibration could be flow probe computer malfunction, low battery power, loose parts, human reaction time with a stopwatch in the actual velocity measurement, and/or interferences in metered velocities due to possible currents in the pool created by the pump and filtration systems. However, these procedural interferences should be minimal.

The results of several comparisons are presented in Figures 7-1 to 7-2. For all types of flow probes, the accuracy was within 12%. The results indicate that at velocities ranging between 0.2 and 2, the current meters are least precise at measuring velocities at the lower and upper ends of that range, although all of the R^2 values were greater than 0.97. Accuracy has not been checked for velocities greater than 2 m/s.

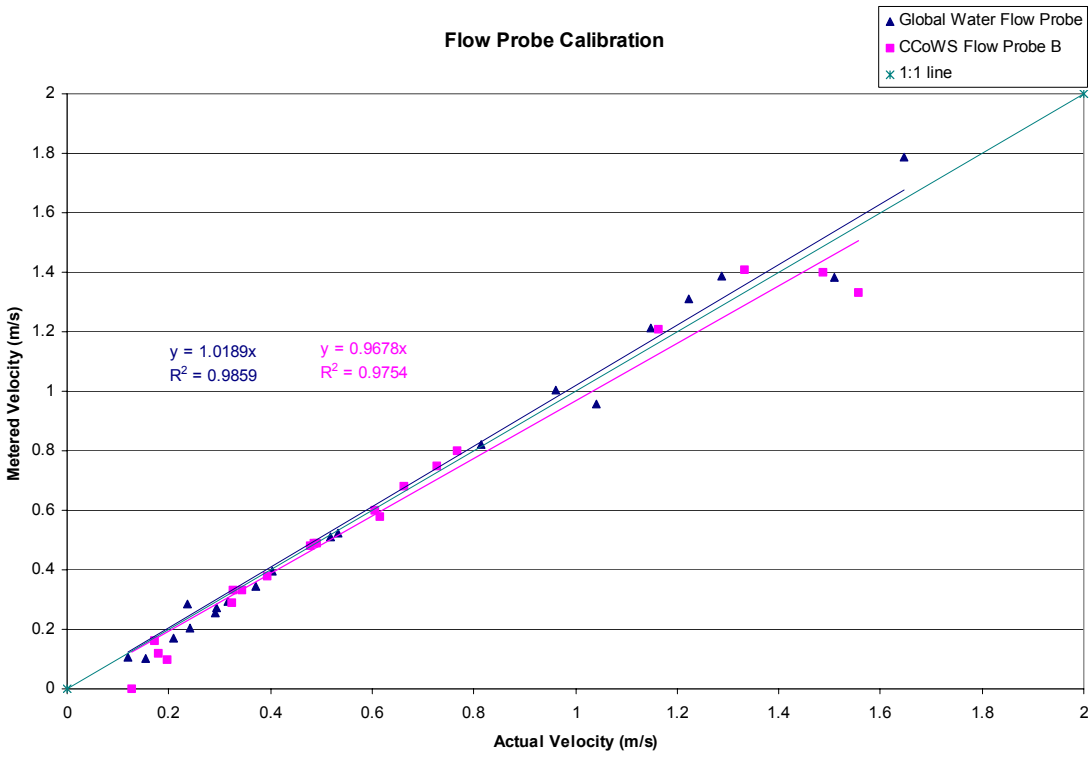
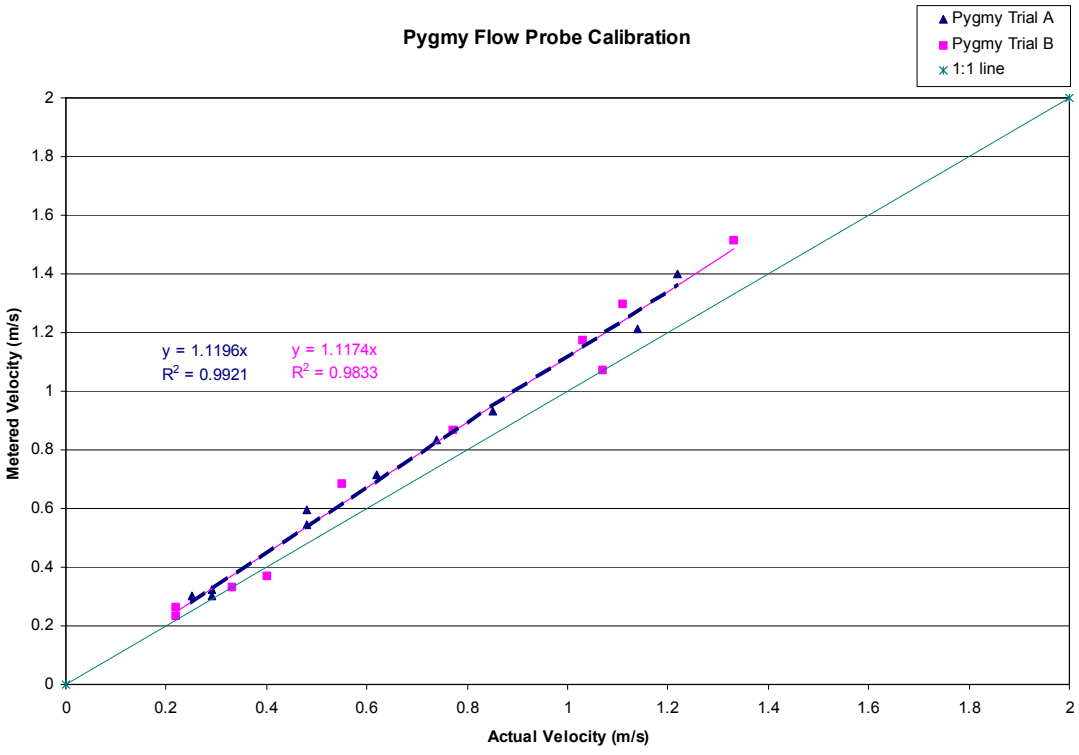


Figure 7-1. Results of CCoWS and Global Water flow probe calibration.



7.2 Comparison of results from sediment and turbidity analyses

7.2.1 Introduction

Four different laboratory methodologies were conducted on 20 different water samples to determine a correlation between each of the different methods for detecting a sample's turbidity. The following methodologies were used:

- Vacuum Filtering
- Imhoff Cone (Nalgene Inc.)
- Turbidity Tube
- NTU-Turbidimeter (*Hach 2100P*, Hach Inc.)

Twenty samples, collected at different times of the year, were taken at 8 different locations. Different locations, or water bodies, were chosen in order to cover a wider range of sediment concentrations and/or turbidity.

Often ranch managers or property owners use simple devices such as Imhoff Settling Cones or Turbidity Tubes to estimate the level of turbidity in their water. However, it is not efficient or economically feasible for them to run complete analysis on their water to detect suspended sediment concentrations. The main objective of this study was to see how closely related each of the four methodologies are for indicating how much suspended sediment is in a sample of the water column. In addition, this section seeks to see if one methodology performed on each sample can provided strong estimates about the others without actually having to perform them. For example, can a transparency reading from a Turbidity Tube reveal a strong estimate of suspended sediment concentration, or the samples turbidity?

7.2.2 Methods

The first of the four methodologies used on each sample was a Turbidity Tube. Each sample, after a minute of vigorous shaking, was poured into the tube. Some samples were diluted for better accuracy. The samples were slowly released from the tube into the original container until the secchi disk at the bottom of the tube was first visible. The water level at the moment the secchi disk is first visible is the final reading. This is a crude method of indicating the cloudiness or sediment concentration of a sample.

The second methodology used was a turbidity meter. The maximum range for the *Hach 2100P* is 1000 Nephlometeric Turbidity Unit (NTU). Several of the collected samples exceeded the 1000 NTU limit. Therefore, a dilution of these samples was necessary. A small representative sub-sample from each sample was taken for this analysis leaving the remainder of the sample intact. A turbidimeter measures the amount of light that is able to pass through a column of water. The more suspended particles in the water the higher the NTU value.

After completing each turbidity measurement, the remainder of each sample was weighed for its official volume. The sample weighing was done before the Imhoff Cone analysis because during the Imhoff Cone analysis, there is a tendency for fine particles to statically adhere to the walls of the cones. Therefore, to ensure that all of the sediment material is contained within the sample, a rinse is required, thus diluting the original sample. The samples could not be diluted without knowing their original volumes before vacuum filtering.

After being weighed, each sample was poured into an Imhoff Cone. The total volume was recorded. Measurements of all settleable material were recorded after twenty-four hours. The final readings of this analysis were a ratio of settleable solids to volume of water (L/L).

The final methodology used in this study was the vacuum filtering. Each sample was filtered through a 63 micron sand break (when needed), then both a coarse (2.4-6 μm) and fine (1.5 μm) grain filters. After sediment filtering, the samples are dried for two hours at 100°C and then weighed for their final total. This procedure measures the actual concentration, in mg/L, of suspended sediment in a water sample.

7.2.3 Results and Discussion

Final data from each of the different comparisons is listed in Table 7-3.

Table 7-3. Data results for each of the four methodologies.

Sample Source	Sample ID	Turbidity (NTU)	Imhoff Cone Ratio (L/L)	Transparency (cm)	Suspended Sediment (mg/L)
Irrigation runoff from a lettuce field in the Salinas Valley	IRR-JON	13770	0.016	0.22	9158
Irrigation runoff from a lettuce field in the Salinas Valley	IRR-JON	13740	0.015	0.28	8777
Chualar Creek at Chualar Creek Road	CHU-CHU	2935	0.0082	0.69	1804
Chualar Creek at Chualar Creek Road	CHU-CHU	3078	0.004	0.71	1754
Chualar Creek at Foletta Rd	CHU-FOL	2622	0.013	0.91	1649
Chualar Creek at Foletta Rd	CHU-FOL	2949	0.0069	0.63	1612
Agricultural drain at Foletta Rd	DRA-FOL	1368	0.0039	1.19	1077
Agricultural drain at Foletta Rd	DRA-FOL	1389	0.012	0.95	1081
Agricultural drain at Foletta Rd	DRA-FOL	1146	0.0072	1.41	879
Agricultural drain at Foletta Rd	DRA-FOL	1209	0.0086	1.51	834
Chualar Creek at Foletta Rd	CHU-FOL	920	0.000082	1.81	681
Chualar Creek at Foletta Rd	CHU-FOL	949	0.004	1.59	681
Chualar Creek at Chualar Creek Rd	CHU-CHU	497	0.003	2.44	451
Chualar Creek at Chualar Creek Rd	CHU-CHU	479	0.004	2.66	431
Agricultural drain at San Juan Grade Rd	DIT-SJU	152	0.0004	10.4	336
Agricultural drain at San Juan Grade Rd	DIT-SJU	184	0.0005	10.1	339
Salinas River at Chualar River Rd	SAL-CHU	33	0	26.2	53
Salinas River at Chualar River Rd	SAL-CHU	33	0	27	36
Gabilan Creek at Crazy Horse Rd	GAB-CRA	2.4	0	60	16
Gabilan Creek at Crazy Horse Rd	GAB-CRA	0	0	60	5

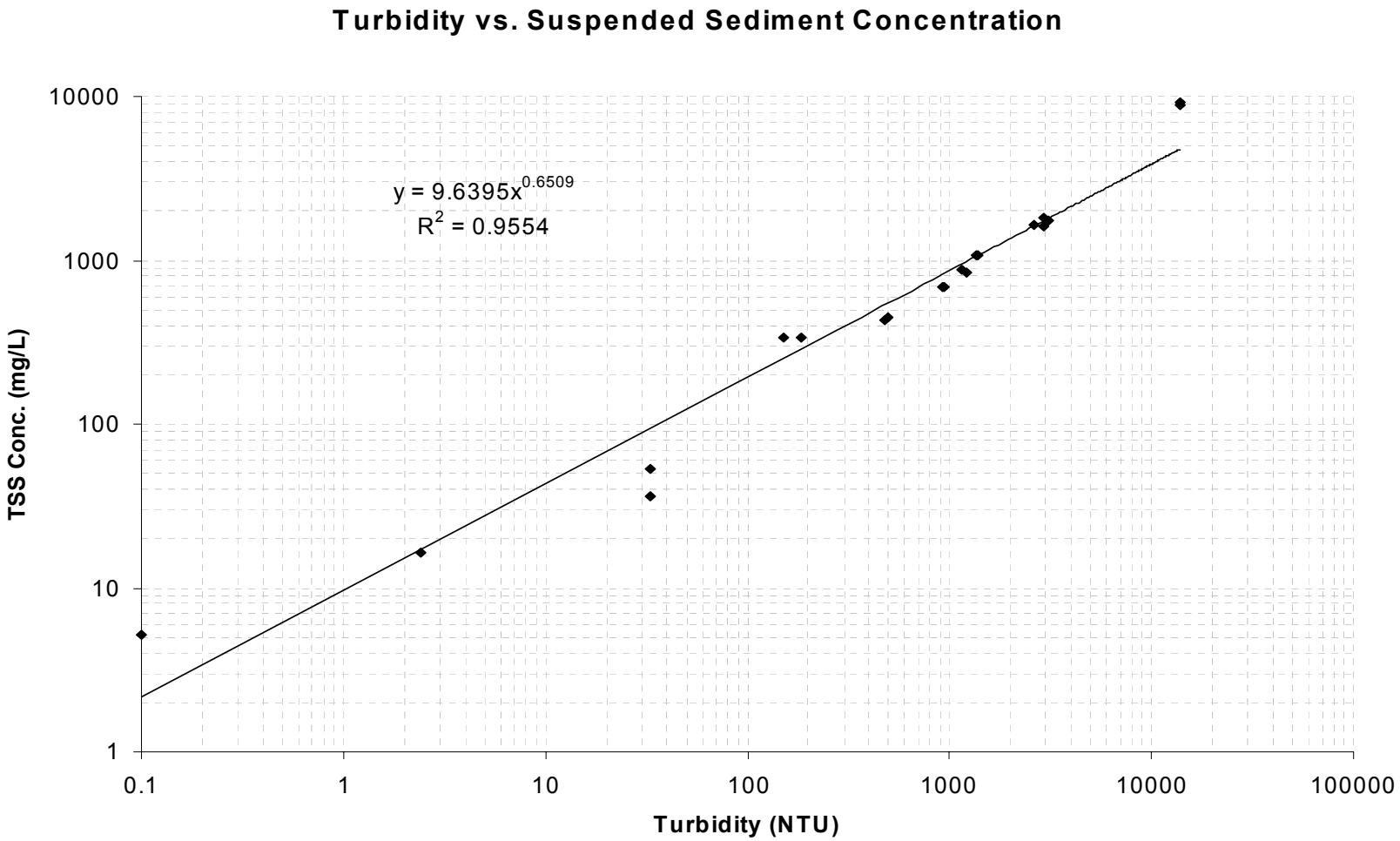


Figure 7-3. Turbidity vs. Suspended Sediment Concentration

Fig 7-3 suggests that there is a significant correlation between SSC concentration and the turbidity (NTU) measurements. Fig 7-4 suggests that there is strong a correlation between a sample's inverse transparency and its turbidity. In addition, the data suggests that a sample's inverse transparency is strongly correlated to the amount of suspended sediment—Fig 7-5.

The data results from the Imhoff analysis were not as significant. Fig 7-6 to Fig 7-8 illustrate that there is significant amounts of scatter among data points for the cleaner samples in all methodology comparisons.

Table 7-4 summarizes the conversion coefficients to convert from one methodology to another.

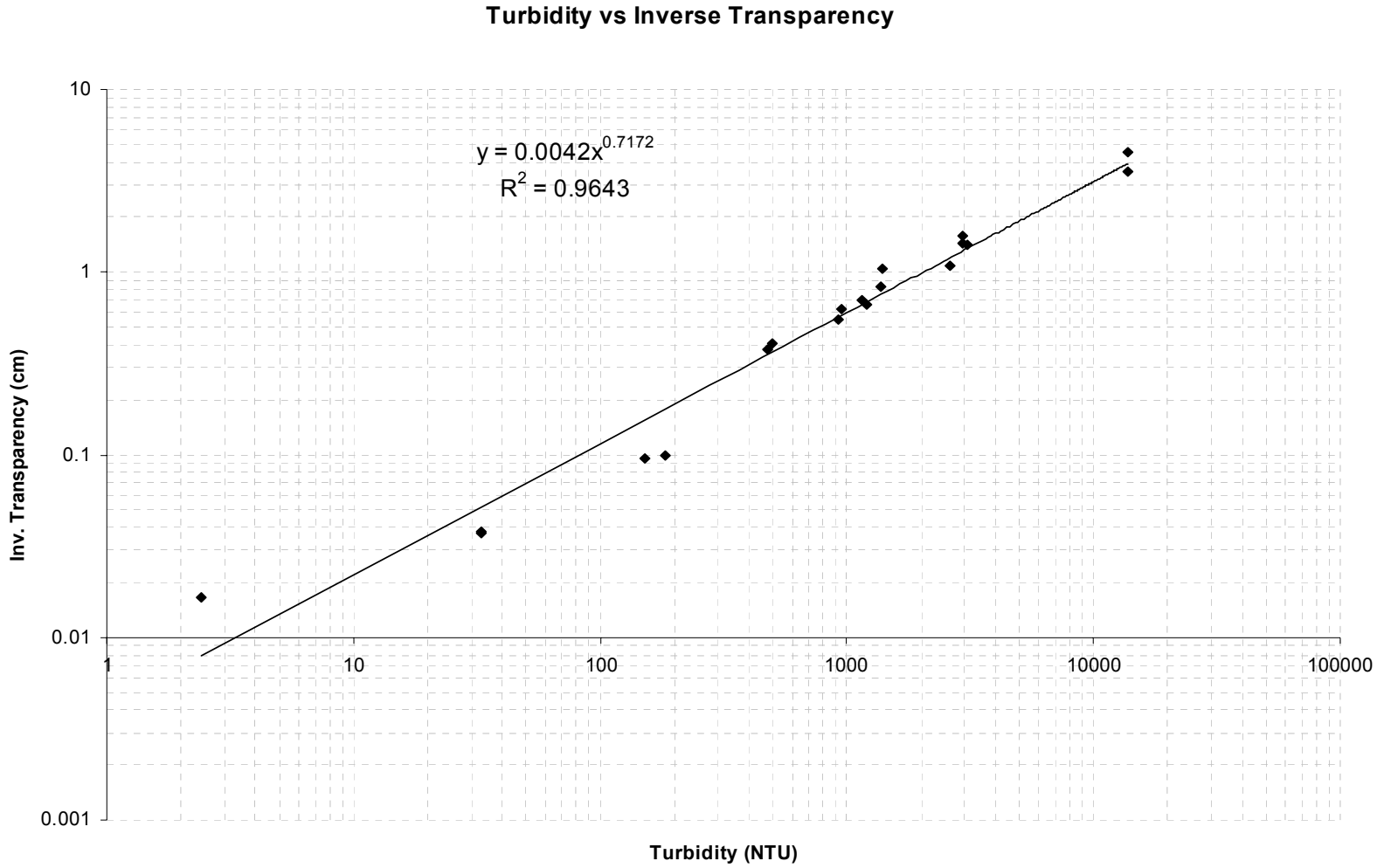


Figure 7-4. Inverse Transparency vs Turbidity

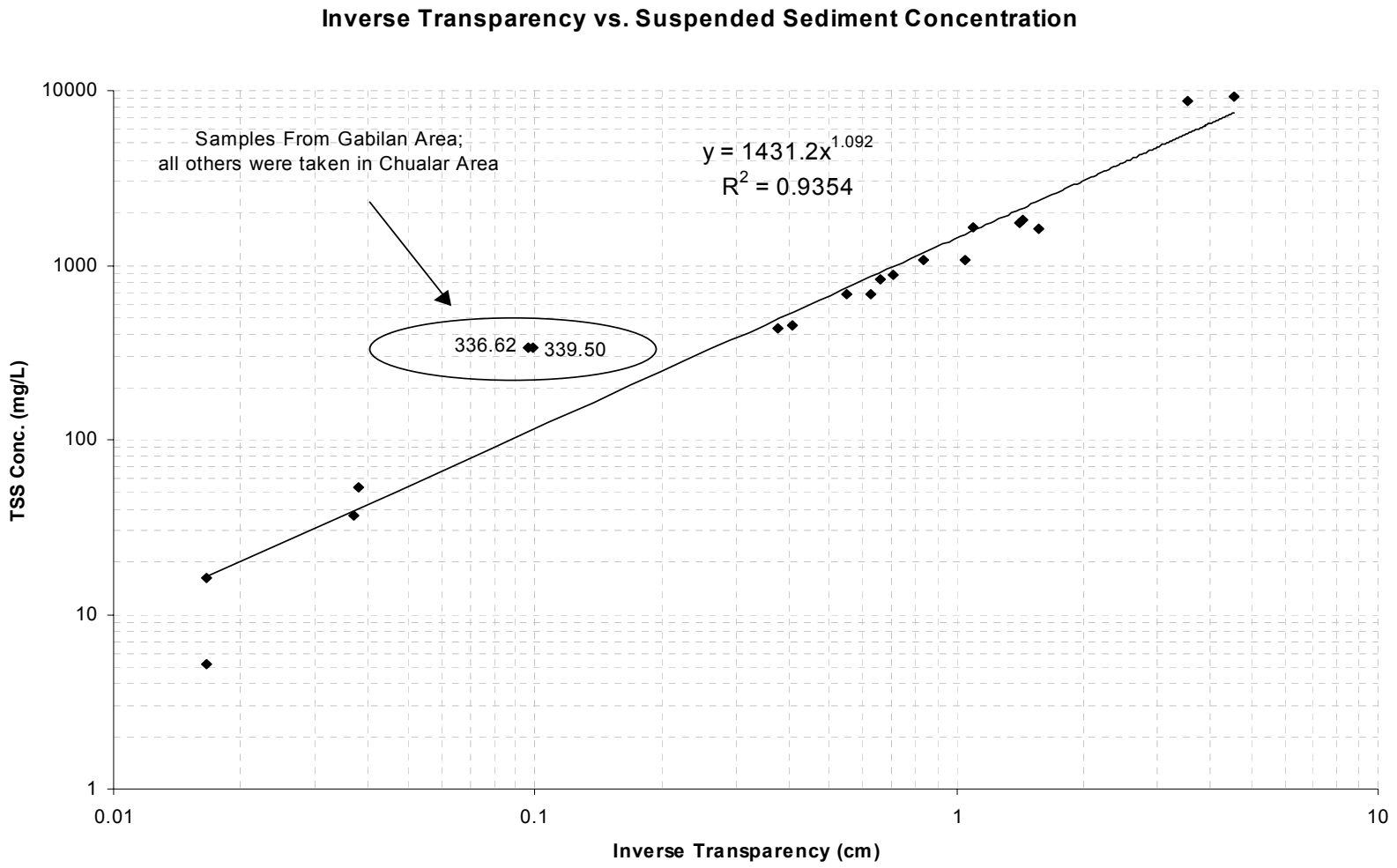


Figure 7-5. Inverse Transparency vs. Suspended Sediment Concentration

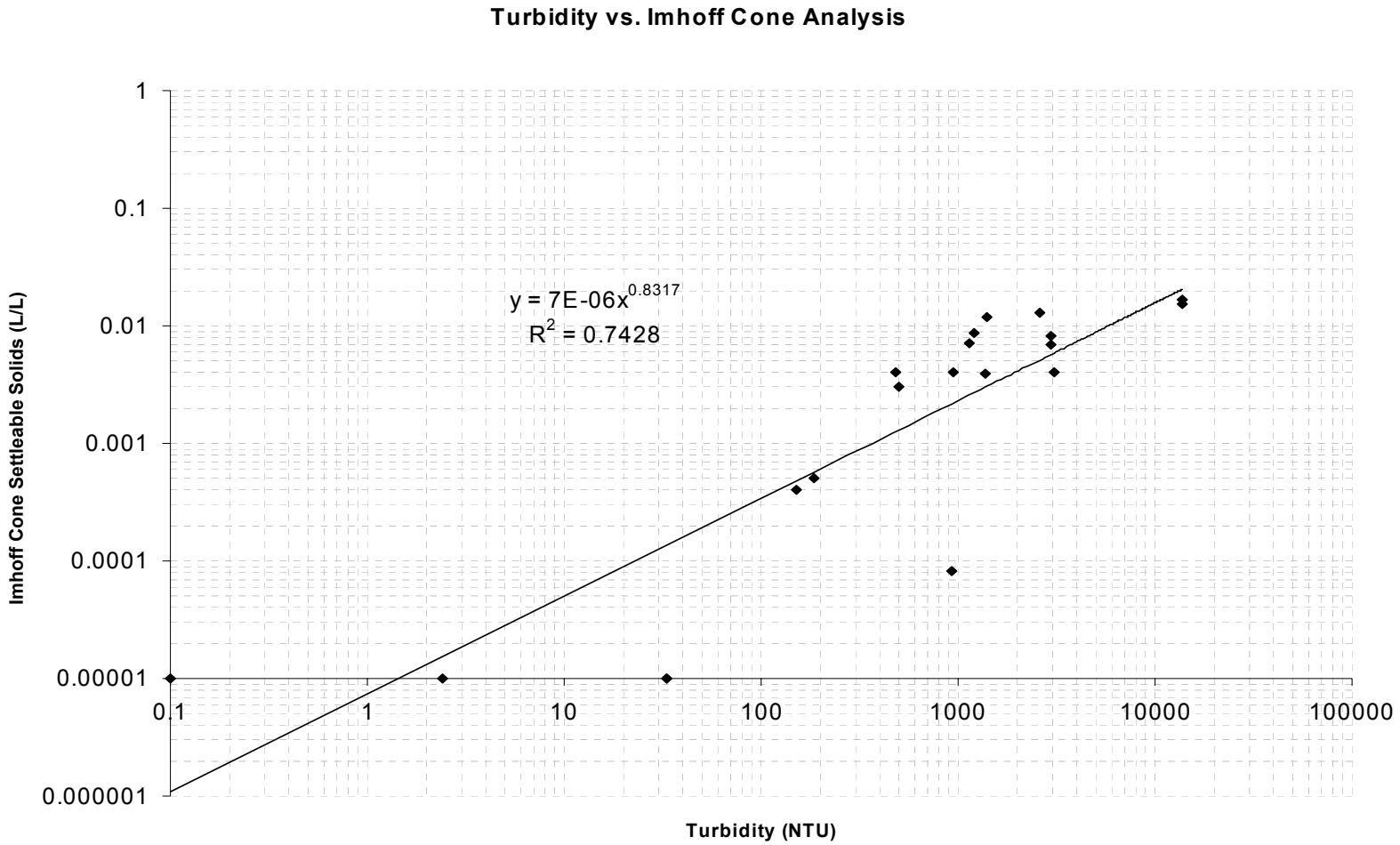


Figure 7-6. Turbidity vs. Imhoff Cone Analysis

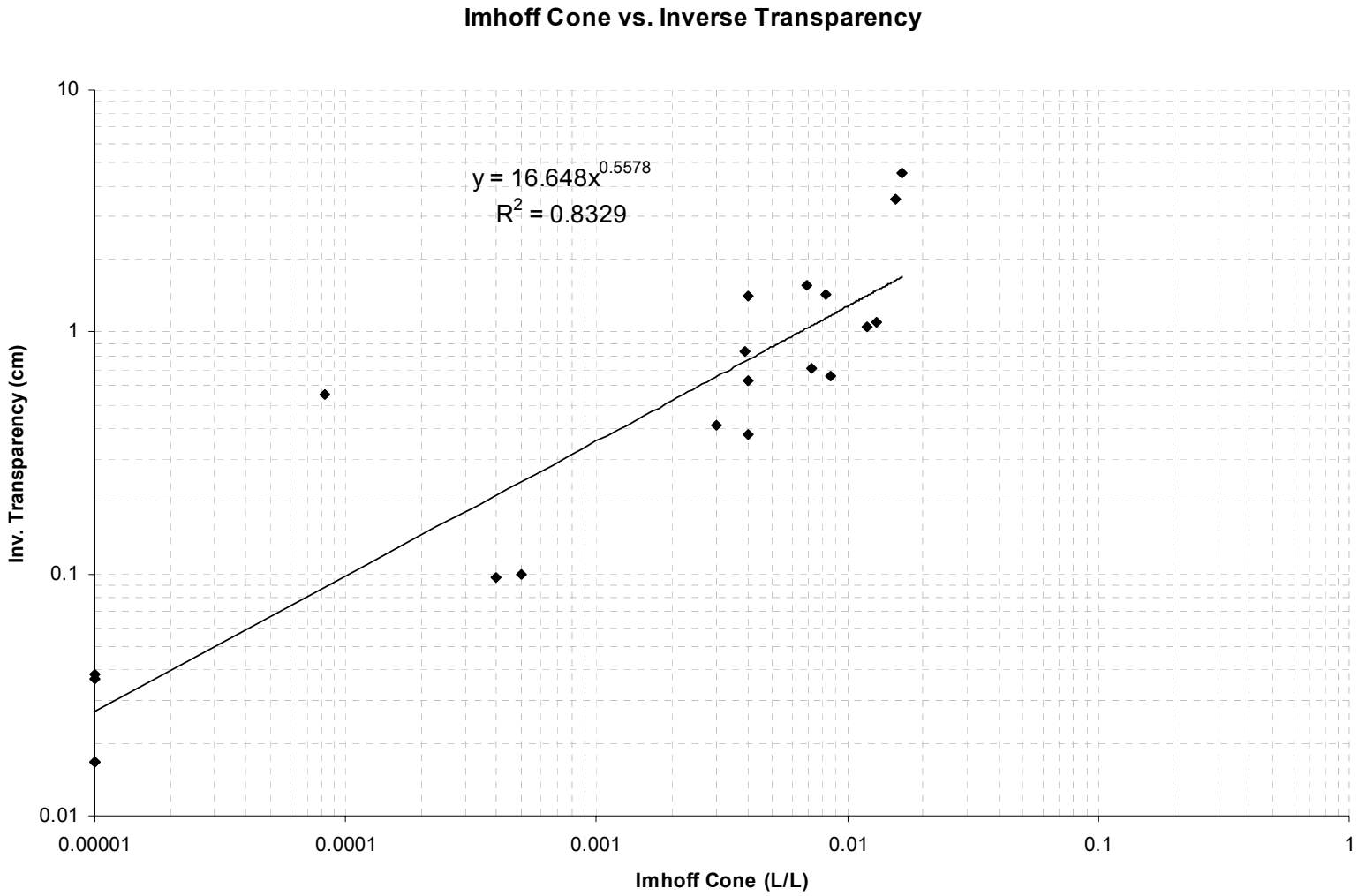


Figure 7-7. Imhoff Cone vs. Inverse Transparency

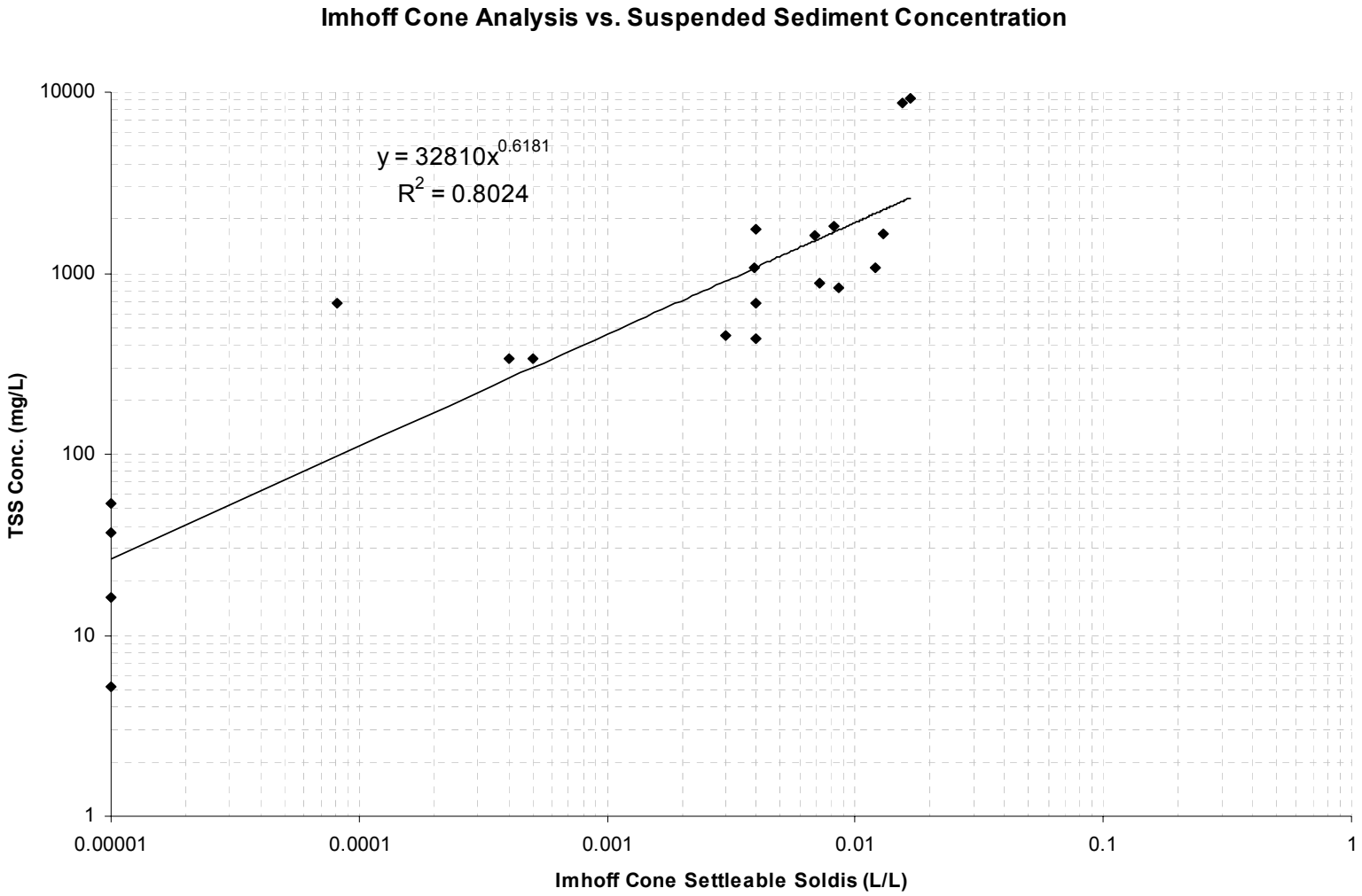


Figure 7-8. Imhoff Cone Analysis vs. Suspended Sediment Concentration

Table 7-4. Conversion coefficients and R^2 values for each of the methodology comparisons using a standard power function.

Methodologies	a	b	R^2
Turbidity vs. SSC	9.6395	0.6509	0.9554
Turbidity vs. Inv. Transparency	0.0042	0.7172	0.9643
Turbidity vs. Imhoff Cone	7E-06	0.8317	0.7428
Inv. Transparency vs. SSC	1431.2	1.092	0.9354
Imhoff Cone vs. Inv. Transparency	16.648	0.5578	0.8329
Imhoff Cone vs. SSC	32810	0.6181	0.8024

7.2.4 Conclusions

Four different methodologies were compared to see how effective each was at detecting the amount of suspended sediment in a field sample. Results of the study suggest that the Imhoff Cone analysis is the least accurate for estimating the suspended sediment concentration or the level of turbidity. Therefore, it appears that a transparency tube is the quickest and most economical method of detecting a reasonably accurate estimate of suspended sediment concentration and or turbidity.

7.3 Comparison of techniques for measuring dissolved oxygen

CCoWS generally uses the *YSI* 556 MPS to measure dissolved oxygen (DO) levels. Occasionally in agricultural areas, the *YSI* 556 MPS has recorded very high (super-saturated) DO levels in the region of 20 to 30 mg/L. This is consistent with observations of high algal abundance, and the inferred dominance of photosynthesis over respiration. The manufacturer's specifications for the *YSI* 556 MPS specify a maximum measurable dissolved oxygen concentration of 50 mg/L or approximately 500% saturation, depending on water temperature (Table 3-2).

In order to confirm the accuracy of the *YSI* 556 MPS when measuring high DO levels in local waters, CCoWS conducted a comparison using a *Hach* OX-2P DO meter, which incorporates a modified Winkler titration method. The manufacturer's specifications for the *Hach* OX-2P specify a maximum measurable dissolved oxygen concentration of 20 mg/L. Results of the comparison are summarized in Table 7-6. When possible, future tests will be conducted in waters with higher dissolved oxygen levels and using a different method that has the capability to measure concentrations greater than 20 mg/L.

Additionally, several replicate measurements were made using the *Hach* OX-2P. The results of those replications are presented in Table 7-6.

Table 7-6. *YSI* 556 MPS and *Hach* OX-2P Comparison

Date	YSI 556 MPS DO (mg/L)	Hach OX-2P Avg. DO (mg/L)	Difference (%)
31 Jul 02	11.96	12.50	4.5
15 Aug 02	16.50	15.75	4.5

Table 7-6. *Hach* OX-2P Replication Results

Date	Hach OX-2P DO (mg/L)						
	#1	#2	#3	#4	Average	St. Dev.	Coef. Of Variance (%)
31 Jul 02	12	13	-	-	12.5	0.71	5.7
15 Aug 02	16	16	15	16	15.75	0.5	3.2

7.4 Assessment of the CCoWS laboratory ability to measure total suspended solids (SSC)

7.4.1 Introduction

In order to assess the accuracy and precision of the lab analysis of Suspended Sediments (SSC) a recovery experiment was conducted in January 2003. The objective of the experiment was to measure the ability to recover both sand and silt/clay from SSC samples using CCoWS established laboratory procedures. The experiment also shows how the SSC concentration affects the accuracy and whether sand or silt/clay is more accurately measured.

7.4.2 Methods

Clean, dry DH48 sampling bottles were weighed and then filled approximately ¾ full with tap water and weighed again. Aluminum weighing trays containing course and fine filters were dried in the oven and then weighed. The sediment used in the experiment consisted of locally collected sand and silt that was dry sieved into two size classes, sand >63um and silt/clay <63um, in order to create samples with known amounts of sand and silt/clay. According to results of past SSC analysis an average of 27% sand and 73% silt/clay was measured; therefore, samples with approximately this ratio of sediments were created to mimic a typical sample.

In order to assess the accuracy of the procedure 9 different quantities of sediment ranging from 0-10 grams were used to create samples and 3 repetitions were made of each, totaling 27 samples. Table 7-7 illustrates the experiment design. Due to the small amounts of sediment used in the experiment, the amount of sand and silt/clay added to bottles only approximates the target numbers listed in the table. All of the weights were recorded so that after the samples were filtered the sediment content could be calculated and compared to the original amount added. The sand and/or silt was then added to the bottle of water and then weighed once more. No sand was added to the first four categories due to the difficulties of weighing small amounts of sand; only silt/clay was used in those samples. All measurements were recorded in the data sheet SSC_exp_data_entry_template.xls. Filters, trays

and sediment were weighed to the thousandth place; bottles were weighed to the hundredth place.

Table 7-7. Approximate amounts (g) of sediment added to the sample

Total wt (g)	Sand wt (g) 27%	Silt/Clay wt (g) 73%
0	0	0
0.005	0	0.005
0.01	0	0.01
0.05	0	0.05
0.1	0.027	0.073
0.5	0.135	0.365
1	0.27	0.73
5	1.35	3.65
10	2.7	7.3

Once the samples were made and their weights recorded, they were treated as a normal sample and filtered. Each sample was thoroughly shaken and vacuum filtered according to the vacuum filtering protocol. After the filtering process each filter with accumulated sediments was placed in a weighing tray, dried in the oven and then weighed. SSC concentrations were determined using the weight of recovered sediment and the initial weight of water added to each bottle. Volume of water was determined by estimating a density of 1000g/L. It was determined that using 998.23g/L for the density of water resulted in no difference.

7.4.3 Results/Discussion

In order to analyze and discuss our ability to measure a wide variety of sediment concentrations the results were broken into three ranges of concentrations: low, medium and high; as well as three sediment size classes: sand, silt/clay and total sediment. The silt/clay and sand concentrations are listed separately, but are components of the total sediment. The low range concentrations, 0-50 mg/L, consist of the samples that have from 0-0.01g of sediment added; the

medium range, 100-1500 mg/L, consists of those with 0.05-0.5g added; and the high range, 2000 – 30,000 mg/L, include samples that have 1.0-10.0g of sediment added.

The results varied a great deal, the percent error decreased as the concentrations increased (Table 7-8). To more clearly express the details of our accuracy, initial and measured SSC, absolute error of SSC and percent of sediment recovered were determined and reported. Graphs were also created to show initial SSC concentrations vs. measured SSC concentrations as compared to a 1:1 line.

Table 7-8. Percent Error for each range of concentration and size class

Range of Sediment Concentrations (mg/L)	% Error SSC Sand	% Error SSC Silt/Clay	% Error SSC
0-50mg/L	NA	5.12%	28.57%
100-1500mg/L	-2.78%	-10.01%	-1.61%
2500-27000mg/L	3.62%	-1.49%	0.63%
All Concentrations	1.15%	-2.66%	7.38%

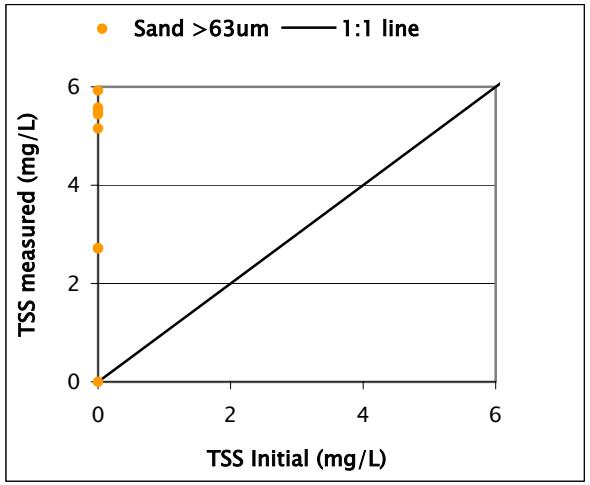
The measurements of the low range concentrations were the least accurate of the data. 105.12% of the added silt/clay was recovered and 128% of the total sediment added was recovered. Percent recovery of sand is indeterminable because no sand was added; however, an average of 4.28mg/L was measured resulting in a high percent recovery for total sediment (Table 7-9). This may be due to silt/clay or sand from previous runs getting stuck in the sand break, washed onto the sand filter and then falsely weighed as sand. Figure 7-9 illustrates the lack of accuracy in the results of the low range concentrations.

According to the data representing the medium and high ranges, the accuracy of the results improved as the concentration of sediment increased (Figure 7-10to 7-11). The data from the medium range shows an average of 89.99% recovery of silt/clay, 97.22% recovery of sand, and 98.39% recovery of total sediment (Table 7-9). In the high range of concentrations the accuracy increases still further. The results show an average percent recovery of 98.51% for silt/clay, 103.62% for sand and 100.63% for total sediments. These data are

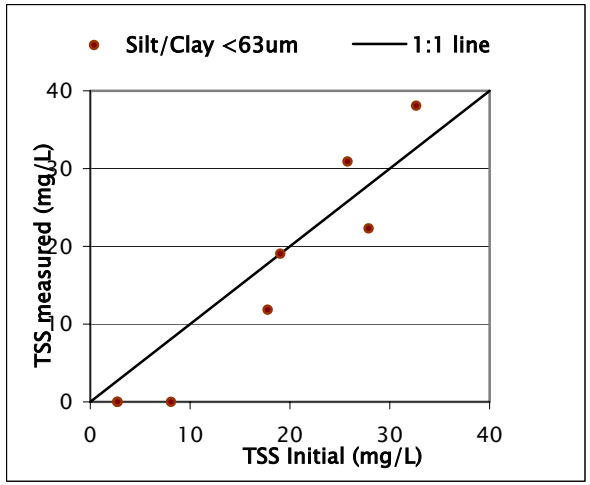
illustrated in Table 7-9 . The graphs in Figure 7-11 show the increase in accuracy.

7.4.4 Conclusions

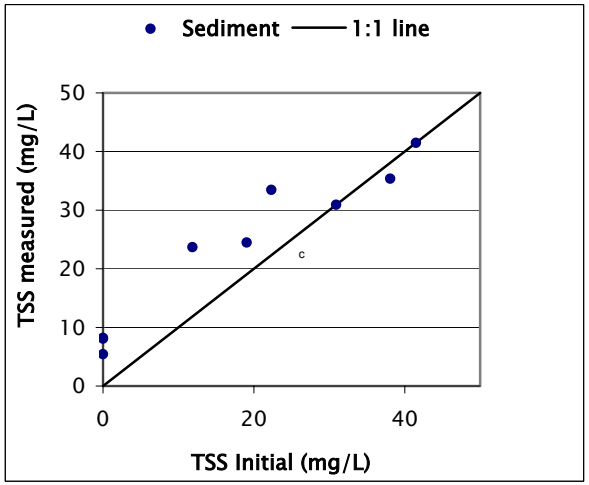
The results indicate that the methods that are currently being used to measure SSC are most accurate at measuring concentrations ranging from 2000-30,000 mg/L, while concentrations ranging from 100 – 1,500 were measured accurately as well. The lower concentrations ranging from 0-50 mg/L were least accurate. Past data indicates that 96% of the SSC measured in the CCoWS laboratory measures above 100 mg/L; therefore, the SSC analysis procedures currently practiced are suitable.



a) Initial vs. measured concentrations of sand 0-6 mg/L

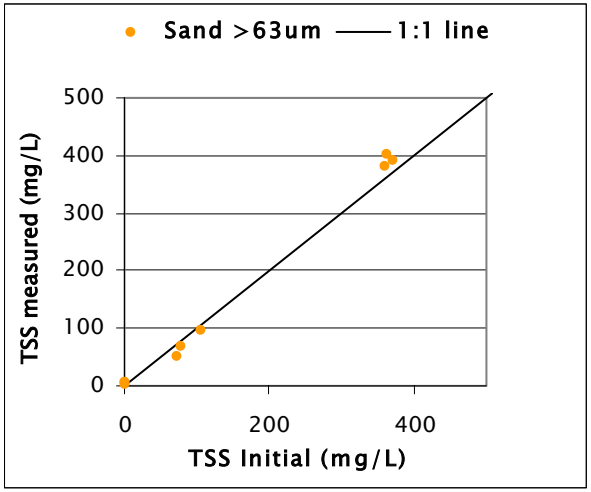


b) Initial SSC vs. measured SSC concentrations of silt/clay 0-40 mg/L

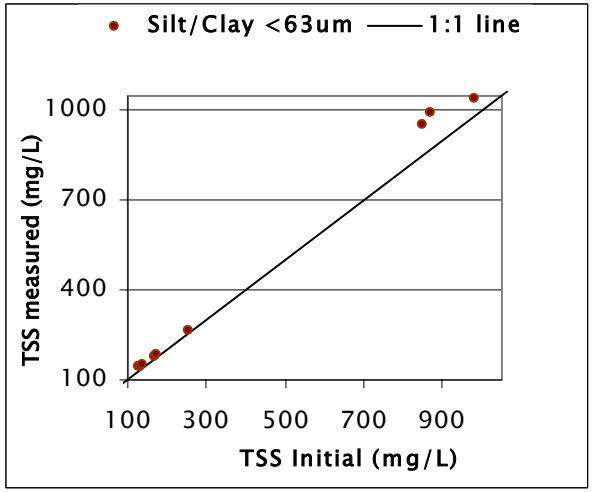


c) Initial SSC vs. measured SSC concentrations of total sediment 0-50 mg/L

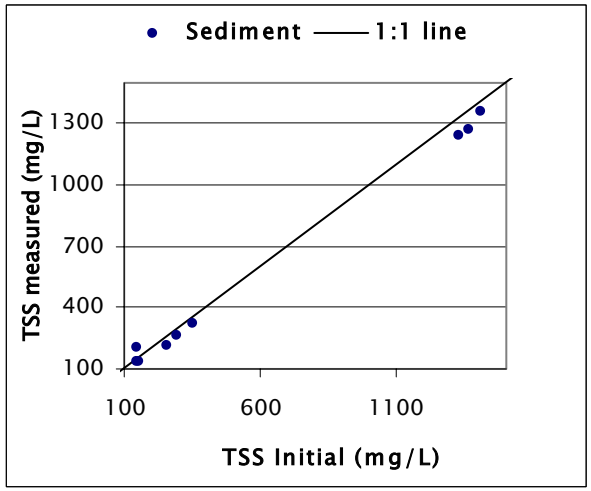
Figure 7-9. Graphs showing initial vs. measured concentrations in the low range.



a) Initial vs. measured concentrations of sand 0-500 mg/L

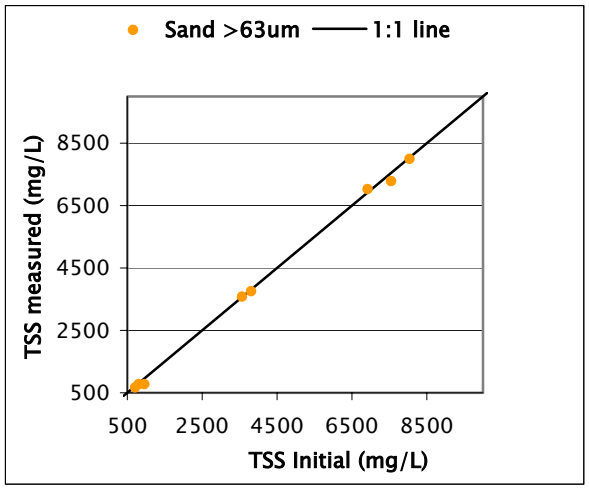


b) Initial SSC vs. measured SSC concentrations of silt/clay 100-1050 mg/L

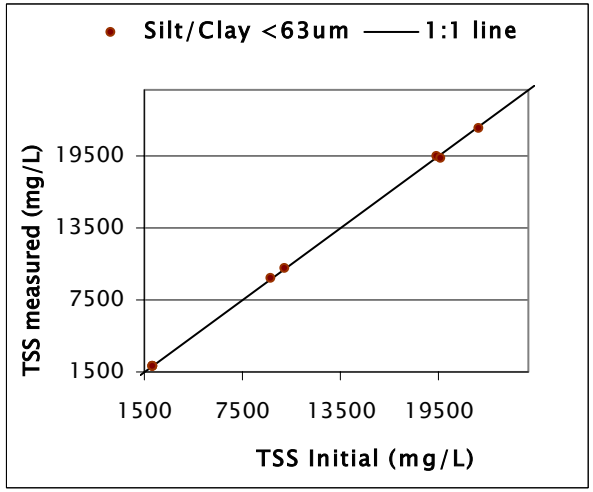


c) Initial SSC vs. measured SSC concentrations of total sediment 100-1500 mg/L

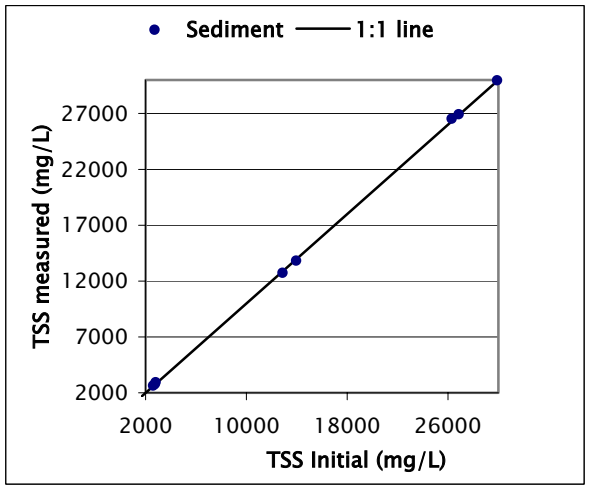
Figure 7-10. Graphs showing initial vs. measured concentrations in the medium range.



a) Initial vs. measured concentrations of sand 500–10,000 mg/L



b) Initial SSC vs. measured SSC concentrations of silt/clay 1,500–25,000 mg/L



c) Initial SSC vs. measured SSC concentrations of total sediment 2,000–30,000 mg/L

Figure 7-11. Graphs showing initial vs. measured concentrations in the high range.

Table 7-9 Initial and Measured Suspended Sediments, Absolute Error, and % Recovered

	Silt/Clay <63um				Sand >63um				Total Sediment			
	Initial TSS<63um Silt/Clay (mg/L)	Measured TSS<63um Silt/Clay (mg/L)	Absolute Error TSS Silt/Clay (mg/L)	%Silt/Clay Recovered	Initial TSS>63um Sand (mg/L)	Measured TSS>63um Sand (mg/L)	Absolute Error TSS Sand (mg/L)	% Sand Recovered	Initial Total Suspended Solids (mg/L)	Measured Total Suspended Solids (mg/L)	Absolute Error TSS (mg/L)	Total % Recovered
Low Range of Suspended Sediments	0.00	2.71	2.71	NA *	0.00	2.71	2.71	NA *	0.00	5.43	5.43	NA *
	0.00	2.74	2.74	NA *	0.00	5.47	5.47	NA *	0.00	8.21	8.21	NA *
	0.00	8.09	8.09	NA *	0.00	0.00	0.00	NA *	0.00	8.09	8.09	NA *
	19.05	19.05	0.00	100.00%	0.00	5.44	5.44	NA *	19.05	24.49	5.44	128.57%
	22.31	27.89	5.58	125.00%	0.00	5.58	5.58	NA *	22.31	33.47	11.16	150.00%
	11.85	17.77	5.92	150.00%	0.00	5.92	5.92	NA *	11.85	23.70	11.85	200.00%
	30.91	25.76	-5.15	83.33%	0.00	5.15	5.15	NA *	30.91	30.91	0.00	100.00%
	41.50	35.96	-5.53	86.67%	0.00	5.53	5.53	NA *	41.50	41.50	0.00	100.00%
	38.08	32.64	-5.44	85.71%	0.00	2.72	2.72	NA *	38.08	35.36	-2.72	92.86%
Average	18.19	19.18	0.99	105.12%	0.00	4.28	4.28	NA *	18.19	23.46	5.27	128.57%
Medium Range of Suspended Sediments	146.63	123.63	-23.00	84.31%	0.00	2.88	2.88	NA *	146.63	204.13	57.50	139.22%
	147.02	130.69	-16.34	88.89%	0.00	8.17	8.17	NA *	147.02	138.86	-8.17	94.44%
	151.11	134.32	-16.79	88.89%	0.00	8.40	8.40	NA *	151.11	142.72	-8.40	94.44%
	267.19	251.47	-15.72	94.12%	78.58	70.73	-7.86	90.00%	345.77	322.20	-23.58	93.18%
	181.62	165.59	-16.03	91.18%	72.11	53.42	-18.70	74.07%	253.73	219.01	-34.72	86.32%
	184.00	171.04	-12.96	92.96%	103.66	98.48	-5.18	95.00%	287.65	269.51	-18.14	93.69%
	958.85	848.21	-110.64	88.46%	368.79	392.50	23.71	106.43%	1327.64	1240.71	-86.93	93.45%
	994.77	868.41	-126.36	87.30%	362.96	403.29	40.33	111.11%	1357.73	1271.69	-86.03	93.66%
	1043.25	978.89	-64.37	93.83%	359.37	383.51	24.14	106.72%	1402.63	1362.40	-40.23	97.13%
Average	452.72	408.03	-44.69	89.99%	149.50	157.93	8.43	97.22%	602.21	574.58	-27.63	98.39%

	Silt/Clay <63um				Sand >63um				Total Sediment			
	Initial TSS<63um Silt/Clay (mg/L)	Measured TSS<63um Silt/Clay (mg/L)	Absolute Error TSS Silt/Clay (mg/L)	%Silt/Clay Recovered	Initial TSS>63um Sand (mg/L)	Measured TSS>63um Sand (mg/L)	Absolute Error TSS Sand (mg/L)	% Sand Recovered	Initial Total Suspended Solids (mg/L)	Measured Total Suspended Solids (mg/L)	Absolute Error TSS (mg/L)	Total % Recovered
High Range of Suspended Sediments	1930.73	1933.41	2.68	100.14%	669.46	709.63	40.17	106.00%	2600.19	2643.04	42.85	101.65%
	2021.83	1983.93	-37.89	98.13%	776.79	955.43	178.64	123.00%	2798.62	2939.36	140.74	105.03%
	1959.36	1964.66	5.30	100.27%	779.50	803.36	23.86	103.06%	2738.86	2768.03	29.17	101.06%
	10187.47	10020.28	-167.19	98.36%	3756.21	3809.16	52.94	101.41%	13943.68	13829.44	-114.25	99.18%
	9290.82	9171.77	-119.05	98.72%	3584.34	3563.64	-20.70	99.42%	12875.16	12735.41	-139.75	98.91%
	19565.30	19384.06	-181.23	99.07%	7286.68	7545.21	258.53	103.55%	26851.98	26929.27	77.29	100.29%
	21900.85	21930.79	29.95	100.14%	7999.06	8038.00	38.93	100.49%	29899.91	29968.79	68.88	100.23%
	19263.37	19613.56	350.20	101.82%	7027.60	6919.65	-107.95	98.46%	26290.97	26533.21	242.24	100.92%
Average	9619.16	9601.17	-17.99	98.51%	3558.79	3612.29	53.50	103.62%	13177.95	13213.46	35.50	100.63%

7.5 Comparison of Nutrient Analysis Methods

The following section describes an experiment that was completed to ensure the quality of nutrient data obtained with the HACH spectrophotometer (Section 5.5). Since the completion of this experiment (2002), the test methods used by CCoWS have changed (partly as a result of this experiment), and this experiment has yet to be replicated with the updated analytical methods.

7.5.1 Introduction

The use of HACH brand standards, reagents, equipment and techniques for use in determining levels of nutrients within environmental samples has been investigated. Of particular interest has been nitrogen in the forms of oxidized nitrogen and ammonia and phosphorus in the form of phosphate.

The experiment described below was designed to address the following data quality concerns:

- Can CCoWS technicians achieving levels of accuracy and precision in a laboratory setting using standards of known concentrations and deionized (DI) water as stated in the procedure manual?
- How do nutrient values obtained with the HACH spectrophotometer compare to the results achieved by an outside, accredited laboratory?
- Are nutrient values influenced by the use of freezing for preservation? If so, how?

7.5.2 Laboratory Precision

Using these HACH methods, CCoWS has analyzed *standard solutions* and has come to the following conclusions:

- Nitrate – Method 8192, Cadmium Reduction, Low Range (.01 to .5 mg/L NO_3-N):
  - CCoWS has not been able to produce the accuracy or precision stated achievable by the method. The creation of our own user program as outlined by the HACH Odyssey Procedure Manual is currently being investigating.

- Nitrate – Method 8039, Cadmium Reduction, High Range (0.3 to 30.0 mg/L NO_3-N):
    - HACH claims a precision of 20% of the true value of a 10mg/L standard in the 95% Confidence Limits of Distribution. CCoWS has obtained 28%.
- Ammonia – Method 10023, Salicylate, Low Range (0.02 to 2.50 mg/L NH_3-N):
    - HACH claims a precision of 4% of the true value of a 1 mg/L standard in the 95% Confidence Limits of Distribution. CCoWS has achieved this.
- Ammonia – Method 10031, Salicylate, High Range (0.4 to 50.0 mg/L NH_3-N):
    - HACH claims a precision of 10% of the true value of a 10-mg/L standard in the 95% Confidence Limits of Distribution. CCoWS has achieved this.
- Orthophosphate – Method 8048, Phosver3, (0.06 to 5.00 mg/L PO_4^{3-} or 0.02 to 1.6 mg/L P):
    - HACH claims a precision of 4% of the true value of a 3-mg/L standard in the 95% Confidence Limits of Distribution. CCoWS has achieved this, using a 1-mg/L standard.

7.5.3 Methods

The analytical methods of the HACH spectrophotometer were compared to the analytical methods used by the Monterey County Health Department (referred to as the 'MoCo'). Table 7-10 lists the laboratory methods that were used.

Table 7-10 Analytical methods that were compared.

Constituent	HACH Method #	MoCo Method #
NO_3-N	8039	EPA350.3
NH_3-N	10023	EPA 300
PO_4-P	8048	EPA 365.2

7.5.3.1 Standard Samples

Four clean, never-been-used sample bottles obtained from the Monterey County Health Department were filled with standard solutions (obtained from HACH) diluted with deionized (DI) water. These standard samples are treated as controls by which assess the County's accuracy. Once made, the standard samples were immediately placed in a cooler with ice. These standards created in the following way:

- **Nitrate**: 50mL of 100mg/L NO_3-N standard to 450mL RO water (10mg/L)
- **Ammonia**: 50mL of 100mg/L NH_3-N standard to 450mL RO water (10mg/L)
- **Orthophosphate**: 50mL of 50mg/L PO_4-P standard to 450mL RO water (1.6 mg/L PO_4-P)
- **Cocktail**: 50mL each of the above standards to 350mL RO water (10, 10, 1.6 mg/L, respectively)

Table 7-11 shows the value of the created standard, MoCo's measured value, and the percent difference between the two using MoCo as the reference value. Percent differences range from 0 – 2.9%. Of note is the 0.1mg/L NH_3-N

Table 7-11 Standard values, county values and % difference

	NO_3-N	NH_3-N	PO_4-P
Created Standard Values (mg/L): theoretical value			
Nitrate	10.0	0.0	0.0
Ammonia	0.0	10.0	0.0
Phosphate	0.0	0.0	1.6
Cocktail	10.0	10.0	1.6
Value from MoCo lab			
Nitrate	9.7	nd	nd
Ammonia	nd	10.0	nd
Phosphate	nd	0.1	1.6
Cocktail	9.9	10.1	1.6
% Difference between theoretical value and value measured by MoCo lab			
Nitrate	-2.9	0.0	0.0
Ammonia	0.0	0.0	0.0
Phosphate	0.0	n/a	-0.6
Cocktail	-0.6	1.0	-0.6

reported by the lab in the CHU-P sample, giving an undefined percent difference for this standard.

7.5.3.2 Field Duplicates

CCoWS visited two sites for the collection of samples: one site on Chualar Creek and one on Gabilan Creek at Crazy Horse Road. These sites were selected as being representative of nutrient impacted water. Both sites had flowing water, but Chualar Creek is suspected of being total agricultural run-off, as a quick trip to an upstream section of the watershed revealed no running water coming in from above land-use. The water in Gabilan Creek appeared "dirty".

At each site, a five-liter bucket was rinsed three times before a full bucket of sample was retrieved. This sample was stirred thoroughly with a stainless-steel spoon to homogenize the sample. From this, five sub-samples (duplicates) were obtained by lowering each of five clean, never-been-used sample bottles obtained from the Monterey County Health Department into the homogenized sample. Ten more sub-samples were obtained using CCoWS clean, nalgene sample bottles.

All sub-samples were labeled and/or recorded and immediately placed into a cooler with ice. Samples from Chualar and Gabilan to be delivered to the county lab for analysis were labeled as CHU-001A, B…E, and GAB-A, B…E. [One more sample of Gabilan Creek at Herbert Road (GAB-F) was taken as we noticed that there was water flowing here, downstream from Crazy Horse. (Note: this sample was not taken as part of the experiment, but rather out of curiosity as this section of Gabilan Creek is rarely seen flowing except for exceptional storm events.)] A total of 15 samples were delivered to MoCo lab for the analysis of nitrate, ammonia and orthophosphate.

Upon return to the CCoWS wet-lab, all sub-samples were filtered and each sample was then returned to its original collection container. Filtration equipment exposed to the sample was washed in warm Liquinox detergent, rinsed in warm water and final rinsed with RO water before use on the next sample. After filtration, five sub-samples from each site were placed in the freezer for a preservation time of one month. The other five sub-samples were placed in the refrigerator overnight at <4°C for analysis the following day.

After samples were allowed to come to room temperature, analyses were performed on them according to the HACH methods mentioned previously. Please review the referenced documents for specific details. Due to the current inability to replicate LR NO3-N accuracy and precision statistics, LR nitrate testing was not performed on the fresh samples. However, a LR program is intended use for analysis of the frozen samples. Due to the demonstrated high variability in sample values of past tests for nitrate, CCoWS samples were analyzed twice with one sample analyzed a total of three times.

Chular Nitrate Comparison

Values obtained from Chular samples ranged from a low of 6.3mg/L to a high of 20.4, with the average at 16.6 (σ = 5.5). MoCo values ranged from 41.3 to 41.8, averaging 41.6 (σ = 0.2). CCoWS obtained mean value was 60% less than the MoCo mean value. The individual values and statistics can be seen in Table 7-12.

Table 7-12. Results of Chualar Nitrate Comparison

fresh sample #	CCOWS NO_3-N value	MoCo sample #	MoCo value (NO_3-N)
2656	12.5	CHU-001A	41.3
2656	16.3	CHU-001B	41.8
2667	11.7	CHU-001C	41.8
2667	19.3	CHU-001D	41.6
2677	6.3	CHU-001E	41.6
2677	19.7		
2665	20		
2665	20.4		
2686	11.5		
2686	19.9		
2686	25.3		
mean	16.6		41.6
stdev	5.5		0.2
2 stdev	11.0		0.4
95%CI	5.6		41.2
	27.6		42.0
% Difference from mean (95%CI)	66.2		0.9
% Difference CCoWS from MoCo			60

Gabilan Nitrate Comparison

The results from the analysis of oxidized nitrogen for the Gabilan sites was less useful, as CCoWS reported values indicate non-detect levels. There may have been detectable amounts using a lower range test, but at the time of this analysis a reliable low-range test was not available. MoCo reported a value of 0.9mg/L very precisely ($\sigma = 0$). Gabilan at Herbert Road demonstrated twice the nitrate level as Crazy Horse. CCoWS measurement at Herbert was also below the tests detection limit. The individual values and statistics can be seen in Table 7-13.

8 References

American Public Health Association, American Water Works Association, Water Environment Federation, 1998. Standard methods for the examination of water and wastewater (20th edition). Washington, DC: American Public Health Association.

Environmental Protection, Health & Safety Program. (EPHS) 2005. Hazardous Waste Management Program of CSUMB. Available at: http://ephs.csumb.edu/site/Documents/cpd/haz_waste_plan.pdf

Fitzpatrick, J.F. 1983. How to Know the Freshwater Crustacea. McGraw-Hill. Boston. Pp 223.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual (3rd edition). California Department of Fish and Game: Inland Fisheries Division.

Gordon, N. D., T. A. McMahon, B.L. Finlayson. Stream hydrology: an introduction for ecologists. John Wiley & Sons Ltd., 526pp.

Harrington, J. and M. Born. 2000. Measuring the Health of California Streams and Rivers, A Methods Manual for: Water Resource Professionals, Citizen Monitors, and Natural Resource Students. Sustainable Land Stewardship International Institute. Sacramento, CA.

Katznelson, R. and A. Feng. 1998. ELISA measurement of diazinon in water and sediment: principles and operating procedures. Alameda County Flood Control and Water Conservation District, California.

McCafferty, W.P. 1998. Aquatic Entimology: the Fishermen's and Ecologists' Illustrated Guide to Insects and Their Relatives. Jones and Bartlett Publishers. Sudbury, Massachusetts. Pp 426.

Merritt, R.W., and Cummins, K.W. editors. 1996. An Introduction to the Aquatic Insects of North.America, 3rd edition, Kendall/Hunt Publishing Co. Dubi uque, Iowa. Pp 754.

National Aquatic Monitoring Center (NAMC), a.k.a. The Buglab. 2001. A Pictoral Guise to the Orders of aquatic Invertibrates. Department of Fisheries ans Wildlife. Utah State University. Logan, Utah. www.usu.edu/buglab

Rosgen, D. and L. Silvey. 1998. Field guide for stream classification. Wildland Hydrology, 193pp.

Sandstrom, M. 1995. Filtration of water-sediment samples for the determination of organic compounds. USGS Water-Resources Investigations Report 95-4105. Denver, Colorado.

Smith, D.G. 2001. Pennak's Freshwater Invertibrates of the United States, 4th edition. John Wiley and Sons, Inc. New York. Pp 615.

Woodward, J. and I. Foster. 1997. Erosion and suspended sediment transfer in river catchments. Geography 82:4, pp. 353-376.

Appendix A

Sample Storage Management Log

Campaign	# of samples	Date collected	Date/time stored	initial	frozen? (y/n)	Date frozen	initial	Date thawed	initial

Appendix B

Technician Training Tracking Sheet

Technique	Trainee (print)	Trainee (signature)	Trainer (print)	Trainer (signature)	Date

Appendix C

Earth Systems Science & Policy
California State University, Monterey Bay
Accident/Incident Report Form

Date of Incident:_____ **Time** of Incident:_____
Location Where Incident Occurred: _____
_____

Identity of any involved persons:
Name _____ _____
Address _____ _____
_____ _____
_____ _____
Contact Info _____ _____

Identity of any witnesses:
Name _____ _____
Contact Info _____

Description of Incident: _____
_____
_____
_____
_____
_____
_____
_____

Actions Taken: _____
_____
_____
_____
_____
_____

Name of Person Completing Report _____Date_____

Staff/Faculty Signature _____Date_____

Supervisor Signature _____Date_____

Appendix D

CCoWS Stream Reconnaissance Data Sheet

Reach #:_____ **Stream Name:**_____

Start Location:_____ **Team:**_____

Date:_____ **Start Time:**_____ **Slope:**_____ **Water Present:** (Y/N)

Water Temp:_____ (°C) **Surface Velocity:**_____ (m/s) **Avg. Water Depth**:_____(m)

Rosgen Stream Type: _____ **Stream Type Notes**:_____
_____
_____

Estimated Channel Width:_____ (m) **Estimated Channel Depth**:_____ (m)

Measured Low Flow Width:_____ (m) **Measured Low Flow Depth**:_____ (m)

Small Pool Count (length < 4m): _____

Medium Pool Count (length 4 to 10m):_____

Large Pool Count (length >10m):_____

LWD Count: _____

Surface Substrate Composition:

	Gravel_____ (%)
Bedrock _____ (%)	Sand _____(%)
Boulder _____ (%)	Silt _____(%)
Cobble _____ (%)	Clay _____(%)

Overhead Cover: _____ (%) ***check all plant species on back

Land Use: Left_____ Right_____

Bank Erosion: Left (Y/N) Right (Y/N) **Litter:** Left (Y/N) Right (Y/N) Channel (Y/N)

Rip-Rap: Left (Y/N) Right (Y/N) **Ag/Urban Drains:** Left (Y/N) Right (Y/N)

Fish: (Y/N) list species _____

Reptiles: (Y/N) list species _____

Amphibians: (Y/N) list species _____

Mammals: (Y/N) list species _____

Crustaceans: **(Y/N) list species** _____

GPS Points and Descriptions: _____

Plant Species List

_____Alder
_____Anise
_____Arundo
_____Burmuda grass
_____Buckeye
_____Buckwheat
_____Cape ivy
_____Cat tail
_____Cocklebur
_____Cottonwood
_____Coyote brush
_____Cypress
_____Dogwood
_____Eucalyptus
_____Ferns
_____Grasses
_____Gray pine
_____HemLock
_____Jimson weed
_____Madrone
_____Manzanita
_____Maple
_____Mint
_____Monterey pine
_____Mugwort
_____Mule fat
_____Mustard
_____Nettle
_____Oak
_____Oat
_____Pampas grass
_____Pepper tree
_____Pineapple weed
_____Poison Oak
_____Rushes/Reeds
_____Rush rose
_____Sage
_____Salt bush
_____Sedges
_____Seep Willow
_____Sword grass
_____Sycamore
_____Tamarix
_____Thistle
_____Tree tobacco
_____Watercress
_____Wild berry
_____Willow
_____Yerba

Other species:_____

Dominant Species (List 1):_____

Write all additional notes in field book!!!!!!!!!!

Appendix E

CCoWS Habitat Assessment Data Sheet

Stream:_____
Location:_____
Province ID:_____Reach ID:_____
Team:_____
Date:_____Start time:_____End time:_____
Start GPS ID:_____End GPS ID:_____
Observations:_____
_____

Transect ID:_____Start time:_____
Habitat type:_____(Pool, Glide, Run, Riffle)
If pool, downstream riffle crest thalweg water depth:_____(cm)
Thalweg Surface Water Temp:_____(°C) Thalweg Surface Velocity:_____(m/s)
Transect Width:_____(m)
Fish Sightings:_____
_____

Point ID (#)	Particle Size (mm)	Overhead Veg. Cover (yes/no)	Water Depth (cm)	Total Depth (cm)
Thalweg				
1				
2				
3				
4				
5				
6				
7				
8				
9				

Instream Shelter Components:

____1 to 5 boulders ____>6 boulders ____root mass
____single root wad ____LWD >12"diam, 6'long ____SWD <12" diam
____LWD + SWD ____undercut bank <12in. ____undercut bank >12in.
____bedrock ledge ____bubble curtain ____branches near water
____limited submersed vegetation ____extensive submersed vegetation
____undercut bank <12in. + root mass ____LWD + boulders + root wads
____≥3 LWD + SWD ____≥3 boulders + LWD + SWD
____undercut bank >12" + root mass or LWD ____b. curtain + LWD or boulders

Appendix F

CCoWS Population Assessment Data Sheet

Stream:_____
Location:_____
Province ID:_____Reach ID:_____
Team:_____
Date:_____Start time:_____End time:_____
Observation Method: _____Stream Bank _____Underwater _____Combination
Surface Water Temperature:_____ (°C)

Species Code	Size Class	Count

Notes:_____
_____
_____
_____
_____
_____

Salinas River Basin Fish List & Codes:

Code	Common Name	Scientific Name
LP	Pacific lamprey	*Lampetra tridentate*
RCH	California roach	*Hesperoleucus symmetricus*
HCH	Hitch	*Lavinia exilicauda*
BLK	Sacramento blackfish	*Orthodon microlepidotus*
PM-S	Sacramento pikeminnow	*Ptychocheilus grandis*
DC	Speckled dace	*Rhinichthys osculus*
SKR-S	Sacramento sucker	*Catostomus occidentalis*
RT	Rainbow trout/steelhead	*Oncorhynchus mykiss*
STB	Threespine stickleback	*Gasterosteus aculeatus*
PSCP	Prickly sculpin	*Cottus asper*
CSCP	Coastrange sculpin	*Cottus aleuticus*
RSCP	Riffle sculpin	*Cottus gulosus*
TP	Tule perch	*Hysterocarpus traski*
GSH	Goldfish	*Carassius auratus*
CP	Carp	*Cyprinus carpio*
BLB	Black bullhead	*Ameirus melas*
GAM	Mosquitofish	*Gambusia affinis*
WHB	White bass	*Morone chrysops*
GSF	Green sunfish	*Lepomis cyanellus*
BG	Bluegill	*Lepomis macrochirus*
LMB	Largemouth bass	*Micropterus salmoides*
BCR	Black crappie	*Pomoxis nigromaculatus*

Appendix G

Nutrient Sample Run Data

Nutrient Test Type:				
Campaign:				
Date/Time of Collection:				
Field Book #:				
Date of Preservation:				
Test Date:				
Analysts:				
Analysis Method:				
Detection Limit:				

Blank Value:	

Calibrators *			
	#1	#2	#3
Standard Value:			
Measured Value:			
** % difference:			

Spike		% Recovery ***		**Replicates**	
sample # spiked:				sample ID	Value (mg/L)
sample original value:					
standard & amount added:					
expected spike value:					
actual spike value:					

* Standards that should be used for calibrators (mg/L):				** Acceptable % difference
	#1	#2	#3	
NO3-N (method10020 HR):	0.5	10	25	10%
NH3-N (method 10023 LR):	0.5	1	2.5	4%
PO4 (method 8048):	0.5	1	5	4%

** % difference = absolute value [(measured value - standard value) / standard value]

*** 1:1 ratio of QAQC sample and a standard

expected spike value = average of sample value & spike concentration

% recovery = measured spike value / expected spike value * 100

Acceptible values: 80 - 120% (SWAMP Requirements)

see 'nutrient_QAQC_calculation_template.xls' (on the CCoWS server at :\admin\lab+field\Templates_Forms\nutrient_templates) for QAQC calculations.

Sample ID	Value (mg/L)	Code*	Notes:		
* codes: S = sample, R = replicate, D = duplicate, SPK = spike, FB = field blank, DIL = dilution					

Appendix H

Lab Processing of Water Samples- Suspended Sediment Concentrations (SSC)									**DATE:**	**TECHNICIAN:**
Pre vacuum						Sand		Coarse Filters		Fine Filters
Sample ID	**Bottle #**	**TDS (uS)**	**Transp (cm)**	**Turb (NTU)**	**Bottle's (w/sample) wt (g)**	**Sand Filter ID**	Sand Filter wt	**934-AH (1.5 um) Filter ID**	sample wt w/tin (g)	**GF/F (0.7 um) Filter ID**

Appendix I

Campaign:

Sample Date:

Processing Date:

Technician:

Note: weights in grams, volumes in mL

Field Filtration, TSS							Benthic wet:dry ratio				Benthic extraction		
sample #	site	filter #	filter wt, dry	filter wt, wet w/sample	filter wt, dry w/sample	volume of methanol added (mL)	tin#	tin wt	tin w/wet wt	tin w/dry wt	wt of sample (go for 10)	wt of methanol (go for 15.82)	volume of methanol

Appendix J

Kit Lot #: **2D1035** Vendor: **SDI** Operator: **koz/larson** Elisa date: **13-Jun-02**

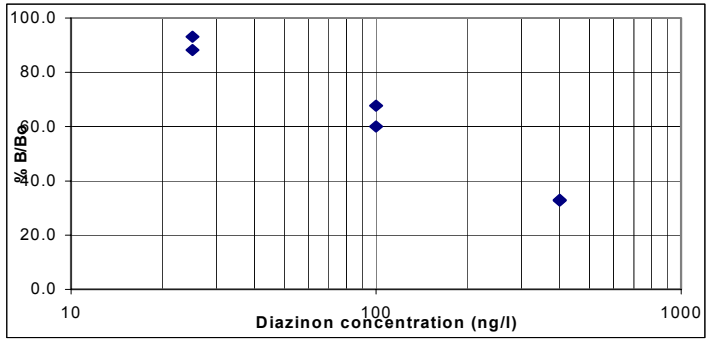
expiration date **Feb-03** Sample date: **n/a**

CALIBRATION CURVE for **Diazinon** in **Water**

calibrator #	**CLP** conc. added (ng/l)	well #	Absorb-ance at 450 nm	Avera ge Bo	% B/ Bo	Log ng/l added	Log ng/l by curve	Conc. by curve (ng/l)	% CV	%error value to stated
Zero	0	**A1**	**1.167**	1.203					4.18	
Zero	0	**C9**	**1.238**							
1	25	**A2**	**1.061**		88.2	1.4	1.5	29.1	3.83	16.3
1	25	**C10**	**1.120**		93.1	1.4	1.4	23.0		-8.1
2	100	**A3**	**0.722**		60.0	2.0	2.1	112.4	8.47	12.4
2	100	**C11**	**0.814**		67.7	2.0	1.9	77.9		-22.1
3	400	**A4**	**0.394**		32.8	2.6	2.6	416.0	0.54	4.0
3	400	**C12**	**0.397**		33.0	2.6	2.6	411.1		2.8
Lab Control	300	**B3&C2**	**0.484**		40.2		2.5	291.1		-3.0

number of calibrator pairs with %CV exceeding 15%: 0

Sample ID	sample conc. in well	well	Absorba nce at 450 nm	B/Bo	Log ng/l	DZN in test tube	Flag*	DZN in orig. sample	Sample ID
	(%)	(#)		(%)		(ng/l)		(ng/l)	
7	**100%**	**A5**	**0.577**	48.0	2.3	200		**200**	7
20	**100%**	**A6**	**0.570**	47.4	2.3	206		**206**	20
11	**100%**	**A7**	**0.584**	48.6	2.3	195		**195**	11
9	**100%**	**A8**	**0.570**	47.4	2.3	206		**206**	9
23	**100%**	**A9**	**0.537**	44.7	2.4	235		**235**	23
22	**100%**	**A10**	**0.566**	47.1	2.3	209		**209**	22
13	**100%**	**A11**	**0.473**	39.3	2.5	304		**304**	13
24	**100%**	**A12**	**0.508**	42.2	2.4	264		**264**	24
15	**100%**	**B1**	**0.584**	48.6	2.3	195		**195**	15
18	**100%**	**B2**	**0.595**	49.5	2.3	187		**187**	18
7	**100%**	**B4**	**0.589**	49.0	2.3	191		**191**	7
20	**100%**	**B5**	**0.590**	49.1	2.3	190		**190**	20
11	**100%**	**B6**	**0.583**	48.5	2.3	196		**196**	11
9	**100%**	**B7**	**0.589**	49.0	2.3	191		**191**	9
23	**100%**	**B8**	**0.566**	47.1	2.3	209		**209**	23
22	**100%**	**B9**	**0.585**	48.6	2.3	194		**194**	22
13	**100%**	**B10**	**0.537**	44.7	2.4	235		**235**	13
24	**100%**	**B11**	**0.512**	42.6	2.4	260		**260**	24
15	**100%**	**B12**	**0.588**	48.9	2.3	192		**192**	15
18	**100%**	**C1**	**0.537**	44.7	2.4	235		**235**	18
7	**100%**	**C3**	**0.597**	49.6	2.3	185		**185**	7
11	**100%**	**C4**	**0.559**	46.5	2.3	215		**215**	11
23	**100%**	**C5**	**0.578**	48.1	2.3	200		**200**	23
13	**100%**	**C6**	**0.552**	45.9	2.3	221		**221**	13
24	**100%**	**C7**	**0.580**	48.2	2.3	198		**198**	24
18	**100%**	**C8**	**0.615**	51.1	2.2	172		**172**	18



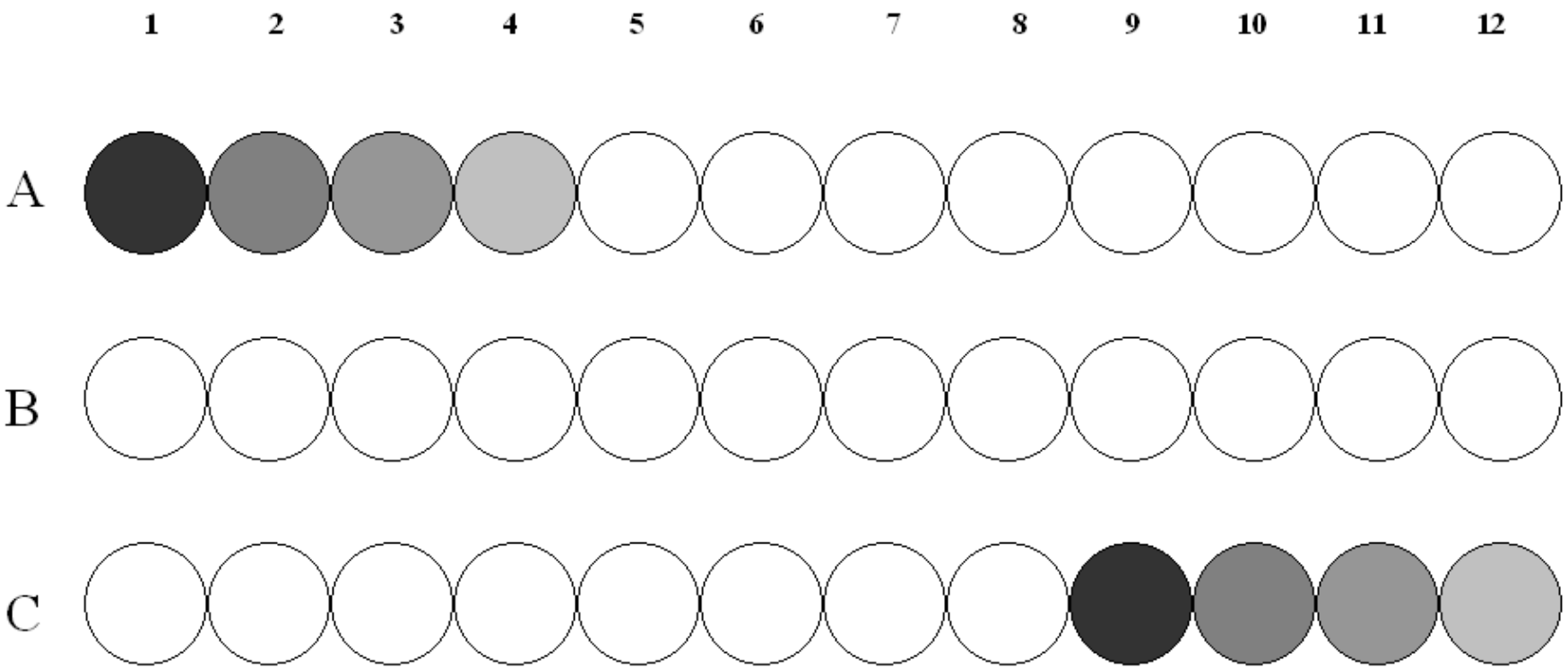
r^2 = 0.99 Slope -48.00 Intercept 158.5 **QA/QC date:**

sample replicates	**mean B/Bo**	**mean sample value**	mean treatment value
7	48.9	192.1	
20	48.2	198.1	
11	47.8	201.8	
9	48.2	198.5	1st batch
23	46.6	214.2	200.94
22	47.9	201.7	
13	43.3	251.0	
24	44.4	238.6	
15	48.7	193.4	2nd batch
18	48.4	196.2	216.18

***OoR** = out of range of calibration curve, using either replicate of lowest and highest calibrators; L,H indicates whether beyond low or high end of curve

Appendix K

ELISA Run Plan



ROOM TEMP		Circle one:	Diazanon	Chlorpyrifos	**Incubation**	TEMP		calibrators	**R** = replicate **SP** = spike
LOT #		Circle one:	water	methanol	Start time		(60min)	0	**C** = control **D** = dilution
DATE			**Pipette timing**		End time			25/62.5	**MB** = method blank (filtered)
Name			Start time		Start time		(30min)	100/250	**FFB** = filtered field bank
Name			End time		End time			400/1000	**RFB** = rinsed field blank

Appendix L

CCoWS Lab Chain of Custody Form for BMIs											
sample information					preservation		lab identification			photographs	
sample ID	sample location	sample type	date collected	sampled by (initials)	date preserved (ethanol & glycerin)	preserved by (initials)	beginning lab date (sorting)	ending lab date (identification complete)	lab tech initials	photos taken?	photo file name

Appendix M

CALIFORNIADEPARTMENTOFFISHANDGAME *WATERPOLLUTIONCONTROLLABORATORY*
AQUATICBIOASSESSMENTLABORATORY *REVISIONDATE–MAY,1999*

CALIFORNIABIOASSESSMENTWORKSHEET

WATERSHED/STREAM:_____ DATE/TIME:_____ _____

COMPANY/AGENCY:_____ SAMPLEID#:_____

SITEDESCRIPTION:_____

SAMPLINGCREW

_____

_____

_____

SITEINFORMATION

GPSCoordinates

Latitude: _____

Longitude: _____

Elevation: _____

Ecoregion: _____

COMMENTS:

_____

_____

_____

_____

_____

CHEMICALCHARACTERISTICS

WaterTemperature: _____

SpecificConductance: _____

pH: _____

DissolvedOxygen: _____

Bioassessment Laboratory Information:

_____

_____

_____

_____

_____

SENDACOPYOFTHISFORMTO:
DFG/WPCL
2005NimbusRoad
Rancho Cordova,CA95670
(916)358-2858
*website:*www.dfg.ca.gov/cabw/cabwhome.html

RIFFLE/REACHCHARACTERISTICS

PointSourceSamplingDesign

RiffleLength: _____

Transect1: _____

Transect2: _____

Transect3: _____

(recordPhysical/Habitat CharacteristcsinRiffle1column)

Non-PointSourceSamplingDesign

ReachLength: _____

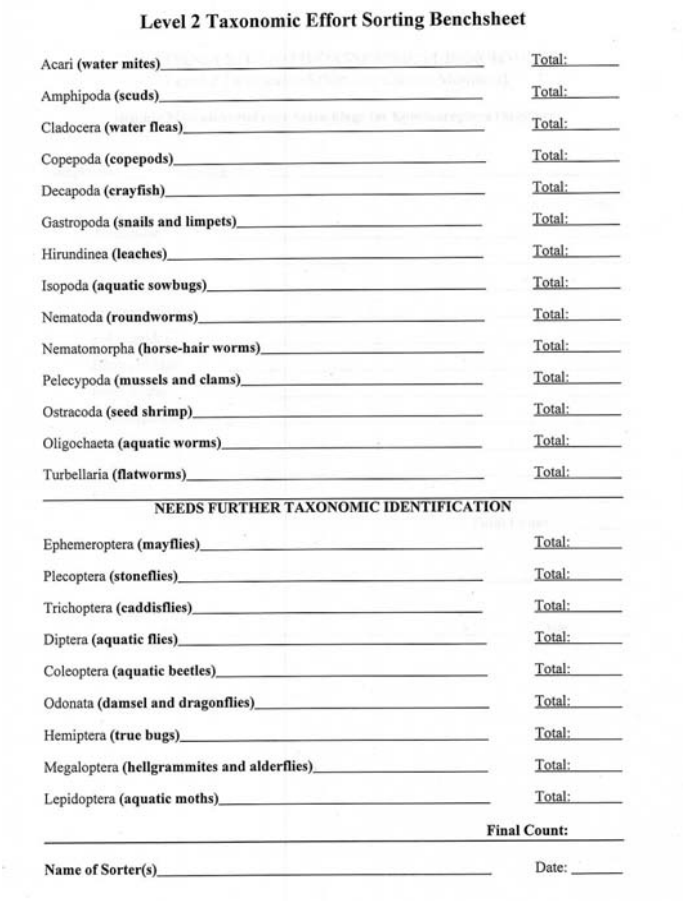
PhysicalHabitatQualityScore: _____

Physical/HabitatCharacteristics

	Riffle1	Riffle2	Riffle3
RiffleLength:			
TransectLocation:			
Avg.RiffleWidth :			
Avg.RiffleDepth:			
Riffle Velocity:			
%CanopyCover:			
SubstrateComplexity:			
Embeddedness:			
SubstrateComposition :			
Fines(<0.1"):			
Gravel(0.1-2"):			
Cobble(2-10"):			
Boulder(>10") :			
Bedrock(solid):			
SubstrateConsolidation :			
PercentGradient:			

Image scanned from Harrington and Born, 2000.

Appendix N



Level 2 Taxonomic Effort Sorting Benchsheet

Acari **(water mites)** Total:
Amphipoda **(scuds)** Total:
Cladocera **(water fleas)** Total:
Copepoda **(copepods)** Total:
Decapoda **(crayfish)** Total:
Gastropoda **(snails and limpets)** Total:
Hirundinea **(leaches)** Total:
Isopoda **(aquatic sowbugs)** Total:
Nematoda **(roundworms)** Total:
Nematomorpha **(horse-hair worms)** Total:
Pelecypoda **(mussels and clams)** Total:
Ostracoda **(seed shrimp)** Total:
Oligochaeta **(aquatic worms)** Total:
Turbellaria **(flatworms)** Total:

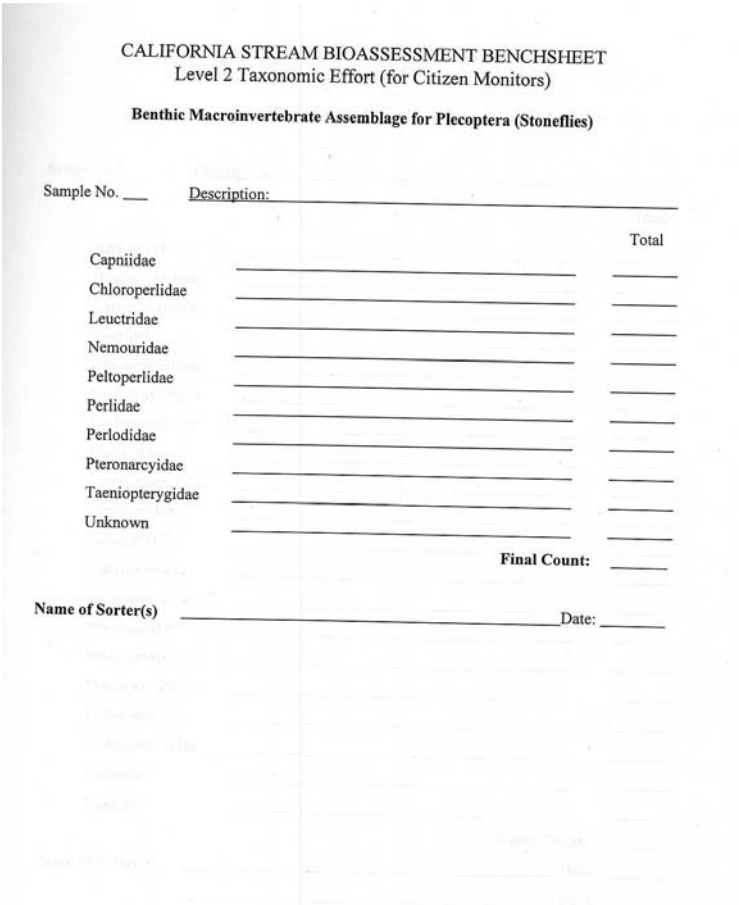
NEEDS FURTHER TAXONOMIC IDENTIFICATION

Ephemeroptera **(mayflies)** Total:
Plecoptera **(stoneflies)** Total:
Trichoptera **(caddisflies)** Total:
Diptera **(aquatic flies)** Total:
Coleoptera **(aquatic beetles)** Total:
Odonata **(damsel and dragonflies)** Total:
Hemiptera **(true bugs)** Total:
Megaloptera **(hellgrammites and alderflies)** Total:
Lepidoptera **(aquatic moths)** Total:

Final Count:

Name of Sorter(s) Date:

Sorting benchsheet scanned from Harrington and Born, 2000.



CALIFORNIA STREAM BIOASSESSMENT BENCHSHEET
Level 2 Taxonomic Effort (for Citizen Monitors)

Benthic Macroinvertebrate Assemblage for Plecoptera (Stoneflies)

Sample No. ___ Description:

Total

Capniidae
Chloroperlidae
Leuctridae
Nemouridae
Peltoperlidae
Perlidae
Perlodidae
Pteronarcyidae
Taeniopterygidae
Unknown

Final Count:

Name of Sorter(s) Date:

Image scanned from Harrington and Born, 2000

CALIFORNIA STREAM BIOASSESSMENT BENCHSHEET
Level 2 Taxonomic Effort (for Citizen Monitors)

Benthic Macroinvertebrate Assemblage for Ephemeroptera (Mayflies)

Sample No. ___ Description: _____

		Total
Ameletidae	_____	_____
Baetidae	_____	_____
Caenidae	_____	_____
Ephemerellidae	_____	_____
Ephemeridae	_____	_____
Heptageniidae	_____	_____
Isonychiidae	_____	_____
Leptohyphidae	_____	_____
Leptophlebiidae	_____	_____
Siphlonuridae	_____	_____
Unknown	_____	_____
	Final Count:	_____

Name of Sorter(s) _____ Date: _____

_____ Date: _____

Image scanned from Harrington and Born, 2000.

CALIFORNIA STREAM BIOASSESSMENT BENCHSHEET
Level 2 Identification (for Citizen Monitors)

Benthic Macroinvertebrate Assemblage for Trichoptera (Caddisflies)

Sample No. ___ Description: _____

		Total
Arctopsychidae	_____	_____
Brachycentridae	_____	_____
Calamoceratidae	_____	_____
Goeridae	_____	_____
Glossosomatidae	_____	_____
Helicopsychidae	_____	_____
Hydropsychidae	_____	_____
Hydroptilidae	_____	_____
Lepidostomatidae	_____	_____
Leptoceridae	_____	_____
Limnephilidae	_____	_____
Odontoceridae	_____	_____
Philopotamidae	_____	_____
Phryganeidae	_____	_____
Polycentropodidae	_____	_____
Psychomyiidae	_____	_____
Rhyacophilidae	_____	_____
Sericostomatidae	_____	_____
Uenoidae	_____	_____
Unknown	_____	_____
	Final Count:	_____

Name of Sorter(s) _____ Date: _____

_____ Date: _____

Image scanned from Harrington and Born, 2000.

CALIFORNIA STREAM BIOASSESSMENT BENCHSHEET
Level 2 Taxonomic Effort (for Citizen Monitors)

Benthic Macroinvertebrate Assemblage for Other Orders of Insects

Sample No. ___ Description: _____

		Total
Diptera		
	Athericidae	
	Blephariceridae	
	Ceratopogonidae	
	Chironomidae	
	Deuterophlebiidae	
	Dixidae	
	Empididae	
	Ephydridae	
	Psychodidae	
	Simuliidae	
	Stratiomyidae	
	Tabanidae	
	Tipulidae	
	Unknown	
Coleoptera (Water Beetles)		
	Amphizoidae	
	Dryopidae	
	Dytiscidae	
	Elmidae	
	Gyrinidae	
	Haliplidae	
	Helophoridae	
	Hydraenidae	
	Hydrophilidae	

Image scanned from Harrington and Born, 2000.

	Psephenidae	
Odonata (Dragonflies and Damselflies)		
	Aeshnidae	
	Calopterygidae	
	Coenagrionidae	
	Cordulegastridae	
	Corduliidae	
	Gomphidae	
	Lestidae	
	Libellulidae	
	Unknown	
Hemiptera (dragonflies and damselflies)		
	Belostomatidae	
	Corixidae	
	Naucoridae	
Megaloptera (hellgrammites and alderflies)		
	Corydalidae	
	Sialidae	
Lepidoptera (aquatic moths)		
	Pyralidae	

Final Count: _____

Name of Sorter(s) _____ Date: _____

_____ Date: _____

Image scanned from Harrington and Born, 2000.

Appendix O

INTERNAL CCoWS INVERTIBRATE IDENTIFICATION EVALUATION

Site name:	
Sample date:	
Preservation date:	
Origonal identification completed by:	
Origonal identification completion date:	
Re-Identification completed by:	
Re-identification completion date:	

AGREEMENT *	ID	ORDER	FAMILY	NOTES/DISTINGUISHING CHARACTERISTICS
	A			
	B			
	C			
	D			
	E			
	F			
	G			
	H			
	I			
	J			
	K			
	L			
	M			
	N			
	O			
	P			
	Q			
	R			
	S			
	T			
	U			
	V			
	W			
	X			
	Y			
	Z			

* AGREEMENT: check if both identifications agree, leave blank if disagree.

Appendix P

CALIFORNIA DEPARTMENT OF FISH AND GAME *WATER POLLUTION CONTROL LABORATORY*
AQUATIC BIOASSESSMENT LABORATORY *REVISION DATE - MAY, 199*

LABORATORY WORKSHEET - LEVEL 2 TAXONOMIC EFFORT

WATERSHED/STREAM: _____ DATE/TIME: _____
MONITORING GROUP: _____ SAMPLE ID NUMBER: _____
SITE DESCRIPTION: _____

Biological Metrics	Description	Sample Value
Richness Measures		
Taxa Richness	Total number of individual taxa	
Ephemeroptera Taxa	Number of mayfly families	
Plecoptera Taxa	Number of stonefly families	
Trichoptera Taxa	Number of caddisfly families	
EPT Taxa	Number of families in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	
Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with Tolerance Values of 0 through 3	
Percent Hydropsychidae	Percent of organisms in the caddisfly family Hydropsychidae	
Percent Baetidae	Percent of organisms in the mayfly family Baetidae	
Tolerance/Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values)	
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	
Percent Dominant Taxa	Percent composition of the single most abundant taxon	
Functional Feeding Groups		
Percent Collectors (CG)	Percent of macrobenthos that collect or gather fine particulate matter	
Percent Filterers (FC)	Percent of macrobenthos that filter fine particulate matter	
Percent Scrapers (SC)	Percent of macrobenthos that graze upon periphyton	
Percent Predators (P)	Percent of macrobenthos that feed on other organisms	
Percent Shredders (SH)	Percent of macrobenthos that shreds coarse particulate matter	
Abundance	Number of organisms in the total sample	

Image scanned from Harrington and Born, 2000.

Appendix Q

LEVEL 2 TAXONOMIC EFFORT WORKSHEET (for Citizen Monitors)

Benthic Macroinvertebrate Assemblage

Organisms	t-value	f-desig	Number
Non-Insects			
Acari (water mites)	5	P	____
Amphipoda (scuds)	4	CG	____
Cladocera (water fleas)	8	FC	____
Copepoda (copepods)	8	CG	____
Decapoda (crayfish)	6	CG	____
Gastrpoda (snails)	7	SC	____
Hirudinea (leeches)	10	P	____
Isopoda (sowbug)	8	SH	____
Nematoda (roundworms)	5	CG	____
Nematomorpha (horsehair)	-	-	____
Pelecypoda (mussels & clams)	8	FC	____
Oligochaeta (aquatic worms)	8	CG	____
Ostracoda (seed shrimp)	8	CG	____
Tubellaria (flatworms)	4	P	____
Unknown			____
E= Ephemeroptera (mayflies)			
Ameletidae	0	CG	____
Baetidae	4	CG	____
Caenidae	7	CG	____
Ephemerellidae	1	SC	____
Ephemeridae	4	SC	____
Heptageniidae	4	SC	____
Isonychiidae	2	FC	____
Leptohyphidae	4	CG	____
Leptophlebiidae	2	SC	____
Siphlonuridae	7	CG	____
Unknown			____
P= Plecoptera (stoneflies)			
Capniidae	1	SH	____
Chloroperlidae	1	SH	____
Leuctridae	0	SH	____
Nemouridae	2	SH	____
Peltoperlidae	0	SH	____
Perlidae	1	P	____
Perlodidae	2	P	____
Pteronarcyidae	0	SH	____
Taeniopterygidae	2	SH	____
Unknown			____
T= Trichoptera (caddisflies)			
Arctopsychinae	2	FC	____
Brachycentridae	3	CG	____
Calamoceratidae	2	SH	____
Glossosomatidae	0	SC	____
Goeridae	1	SC	____
Helicopsychidae	3	SC	____
Hydropsychidae	4	FC	____
Hydroptilidae	4	-	____
Lepidostomatidae	1	SH	____
Leptoceridae	4	CG	____
Limnephilidae	4	SH	____
Odontoceridae	0	SH	____
Philopotamidae	3	FC	____
Phryganeidae	4	SH	____
Polycentropodidae	6	FC	____
Psychomyiidae	2	CG	____
Rhyacophilidae	0	P	____
Sericostomatidae	3	SH	____
Uenoidae	0	SC	____
Unknown			____
Diptera (aquatic flies)			
Athericidae	2	P	____
Blephariceridae	0	SC	____
Ceratopogonidae	6	P	____
Chironomidae	6	CG	____
Deuterophlebiidae	0	SC	____
Dixidae	2	CG	____
Empididae	6	P	____
Ephydridae	6	CG	____
Psychodidae	10	CG	____
Simuliidae	6	FC	____
Stratiomyidae	8	CG	____
Tabanidae	8	P	____
Tipulidae	3	SH	____
Unknown			____
Coleoptera (aquatic beetles)			
Amphizoidae (A)	1	P	____
Dryopidae (A)	5	SH	____
Dytiscidae (A,L)	5	P	____
Elmidae (A,L)	4	CG	____
Gyrinidae (L)	5	P	____
Haliplidae (A,L)	5	SH	____
Helophoridae (A)	5	SH	____
Hydraenidae (A)	-	-	____
Hydrophilidae (A,L)	5	P	____
Psephenidae (L)	4	SC	____
Unknown			____
Odonata (dragonflies and damselflies)			
Aeshnidae	3	P	____
Calopterygidae	5	P	____
Coenagrionidae	9	P	____
Cordulegastridae	3	P	____
Corduliidae	5	P	____
Gomphidae	4	P	____
Lestidae	9	P	____
Libellulidae	9	P	____
Unknown			____
Hemiptera (true bugs)			
Belostomatidae	8	P	____
Corixidae	8	CG	____
Naucoridae	8	P	____
Megaloptera (hellgrammites and alderflies)			
Corydalidae	0	P	____
Sialidae	4	P	____
Lepidoptera (aquatic moths)			
Pyralidae	5	SC	____

Total Number of Organisms ____

Subsampling Data

Number of Possible Subsampling Grids ____

Number of Organisms in Grids:

____ ____ ____ ____ ____ ____ ____

Total Number of Organisms in Subsample: ____

Project Advisor

Name: _____

Address: _____

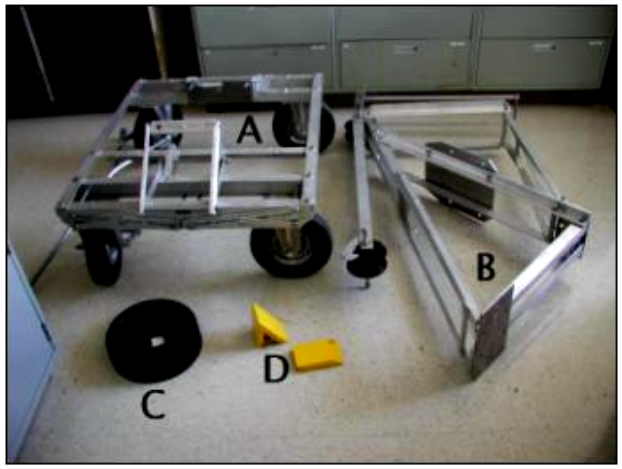
_____

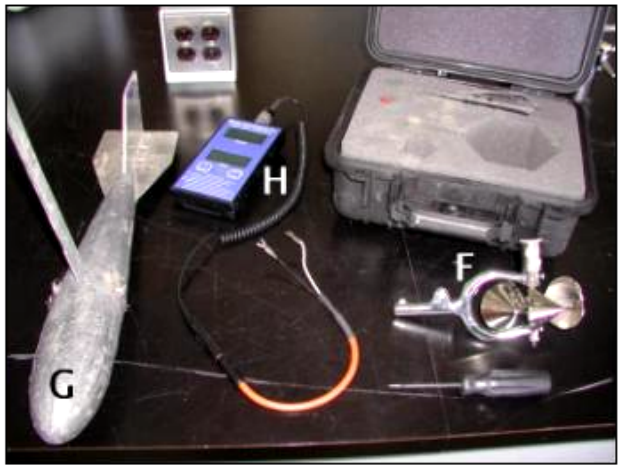
Phone/e-mail: _____

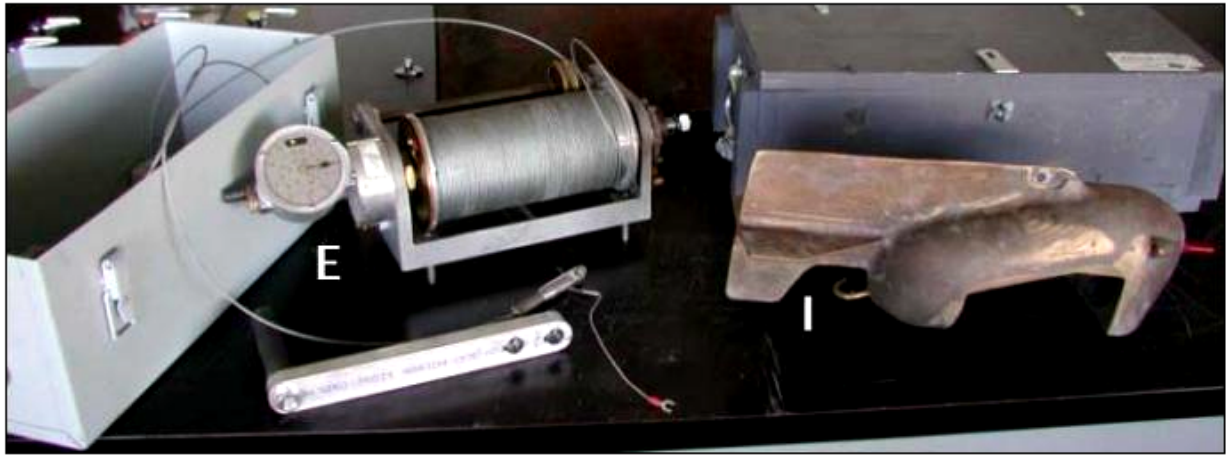
Appendix R

EQUIPMENT:

(A) 4-wheel truck (& handle)
(B) Crane
(C) Counter weights
(D) Wheel chocks
(E) Sounding reel and line
(F) Pygmy current meter
(cleaned and oiled)
(G) Fish sounding weight
& hanger bar
(H) Counter-timer (Aquapulse)
& pigtail wire
(I) DH76 & adapter








crane
current meter
sounding reel
counter-timer
fish sounding weight &
hanger bar
weights
4-wheel truck
DH76
SLOW

ASSEMBLY (refer to diagrams on pages 169 - 175):

Crane

1. Attach flat piece of the crane to the flat piece of the truck as shown.
2. Secure two wing nuts.
3. Attach smallest flat piece (in the joint) of the crane to the free limb of the truck as shown.
4. Secure one wing nut.
5. Hook the bottom-most limb of crane to the piece next to the first spool specified in the diagram as shown.
6. Hook the top-most limb of crane to the piece next top the second spool specified in the diagram as shown.

Sounding reel

7. Place sounding reel on the largest flat piece of the crane as shown.
8. Secure with four wing nuts. Attach winch handle (not shown in diagram). Run sounding line from reel over the spool at the top of the crane, and then over the spool at the end of the crane. Make sure the line is running over the spindle on the reel.

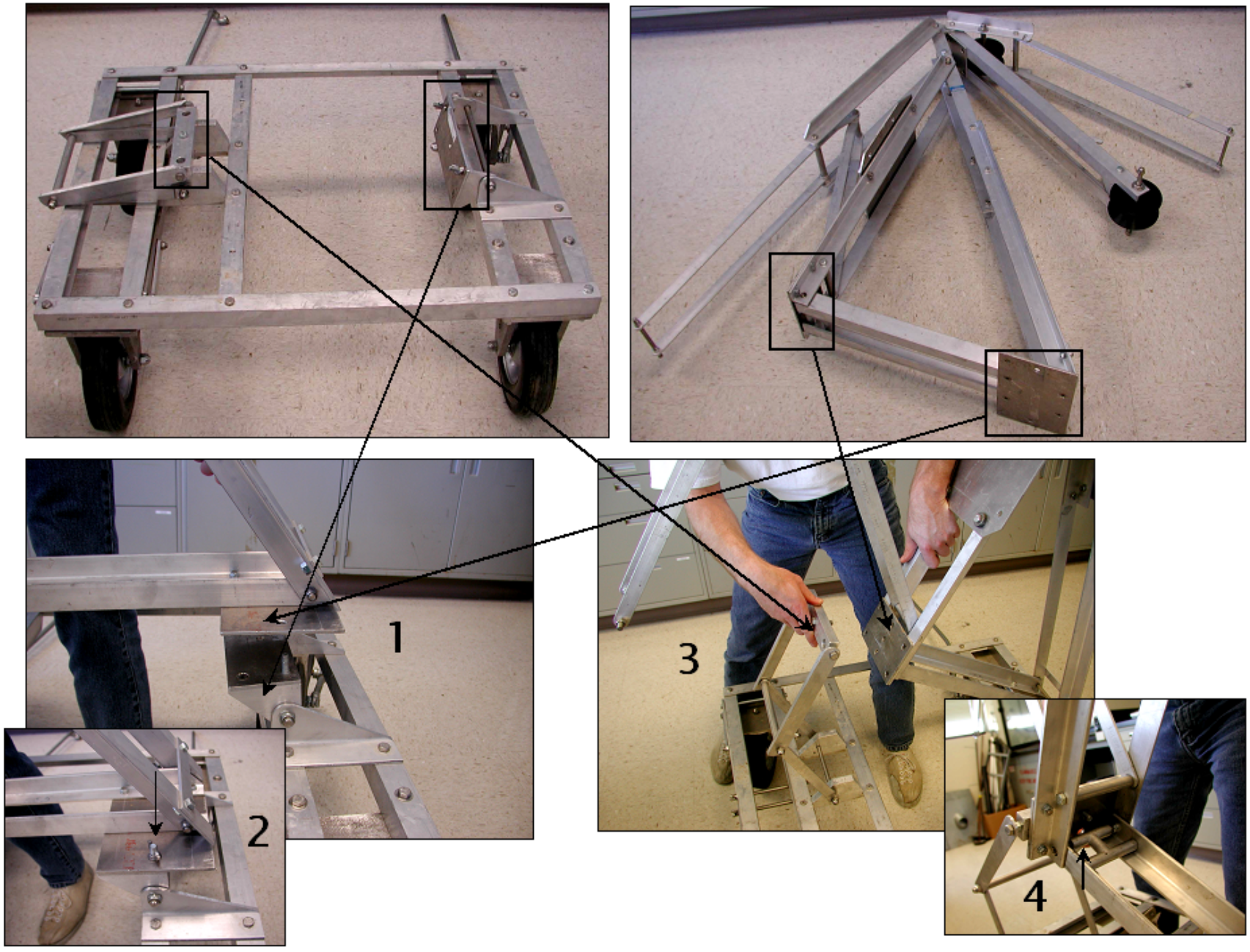
Counter-timer

9. Attach pigtails to the sounding reel as shown.
10. Connect stereo jack on the counter-timer to the other end of the pigtail as shown.

Pygmy/current meter (see also manufacturer's diagram for part names & specifications)

11. Align two tailpieces and slide together as shown.
12. Turn lever to lock the two tailpieces together as shown.
13. Connect tailpiece to the yoke of the pygmy meter (secure with a screw). The balance weight of the tailpiece should be on the bottom of the tailpieces and the contact chamber attached to the yoke above the buckets should be on the top as shown.
14. Connect this pygmy meter to the hanger bar on the fish (with a screw) as shown.
15. Connect the top of the hanger bar to the end of the sounding line with the cotter pin.
16. Attach sounding line cable to a binding post on the contact chamber as shown. Single-contact binding post (1) counts 1 revolution; the penta-contact binding post counts 5 revolutions and should be used for very large flows.

* The DH76 is attached to the end of the sounding line the same way the hanger bar is, with the cotter pin. *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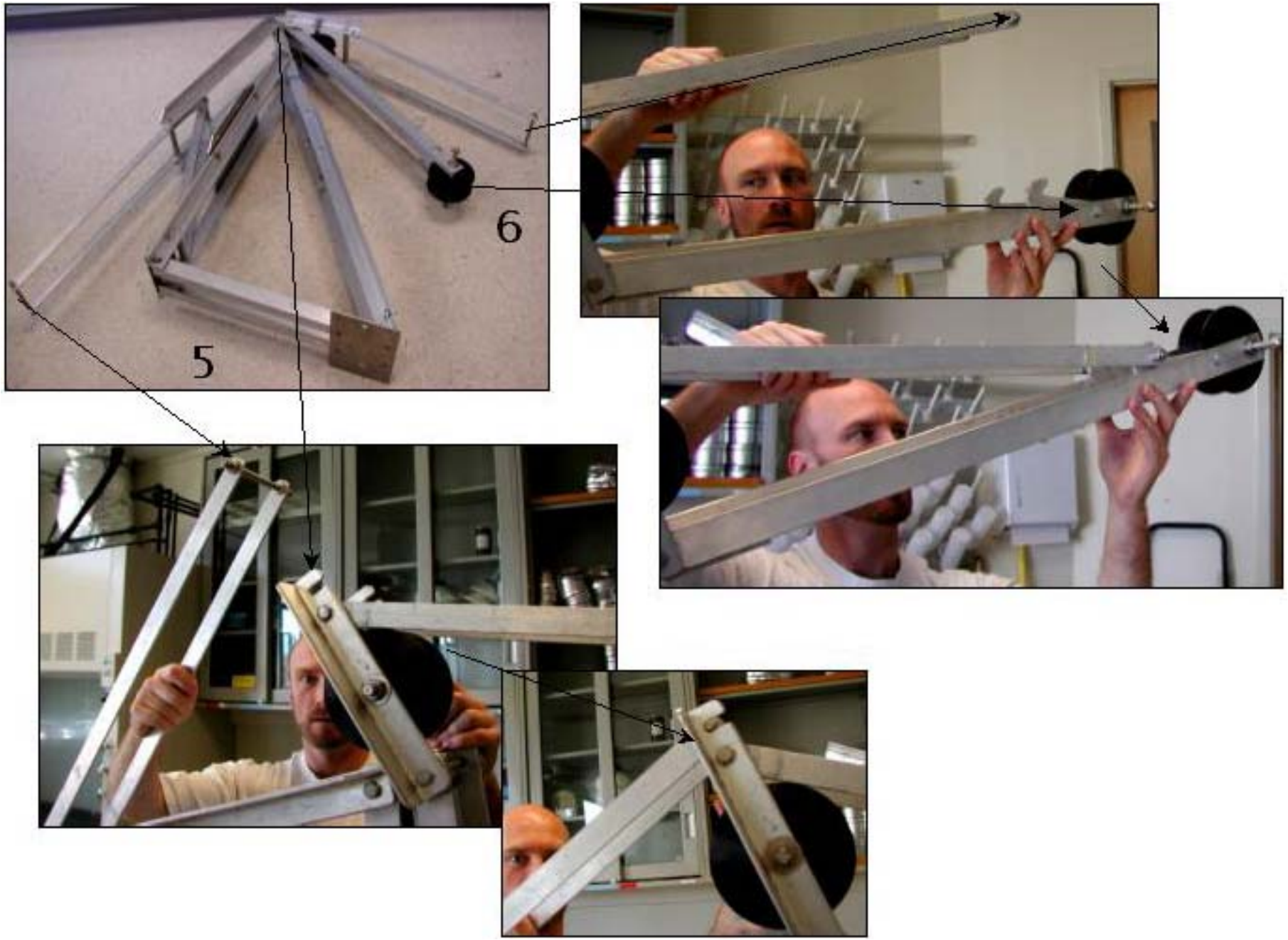
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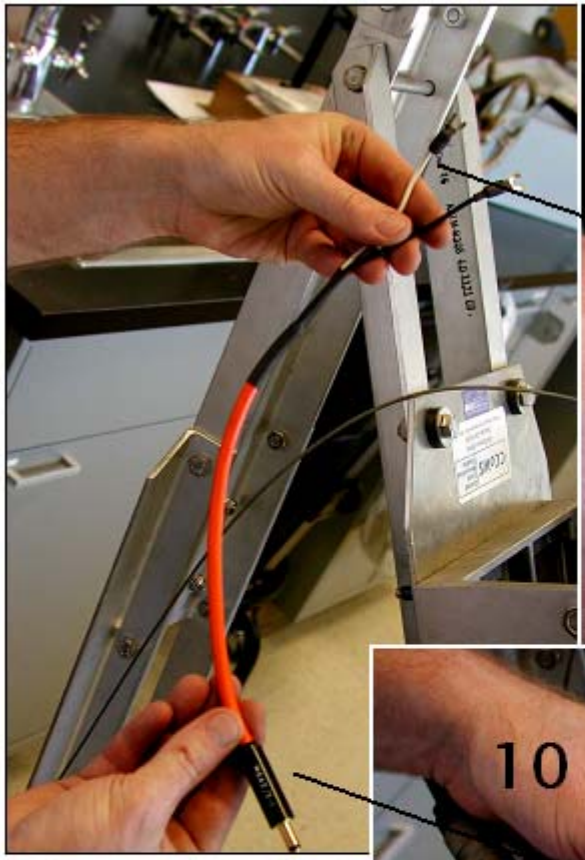

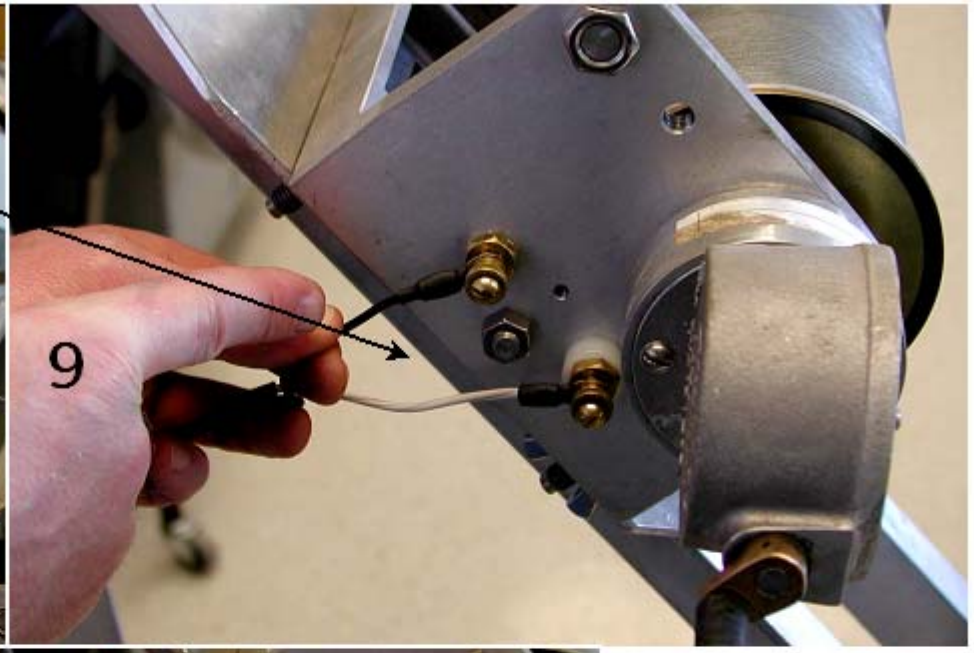
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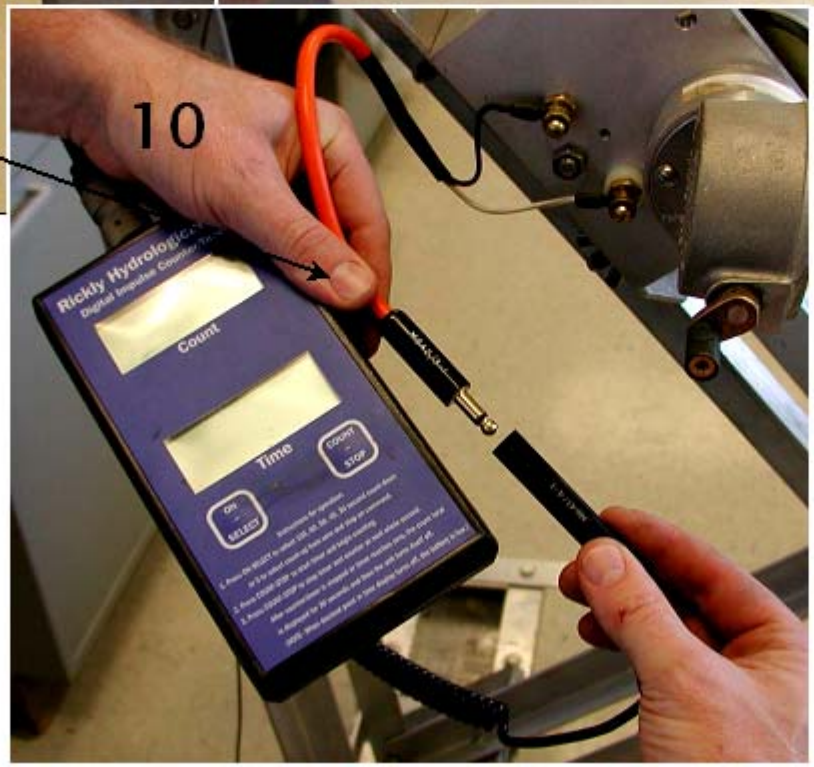
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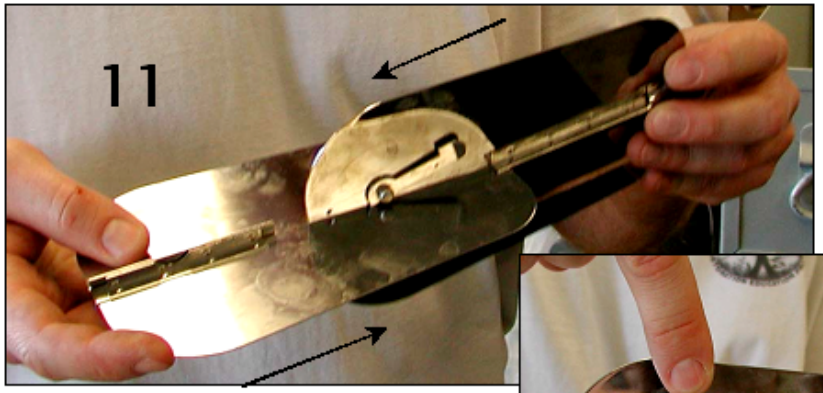
Rickly Hydrological
Digital Impulse Counter
Count
Time
COUNT
STOP
ON
SELECT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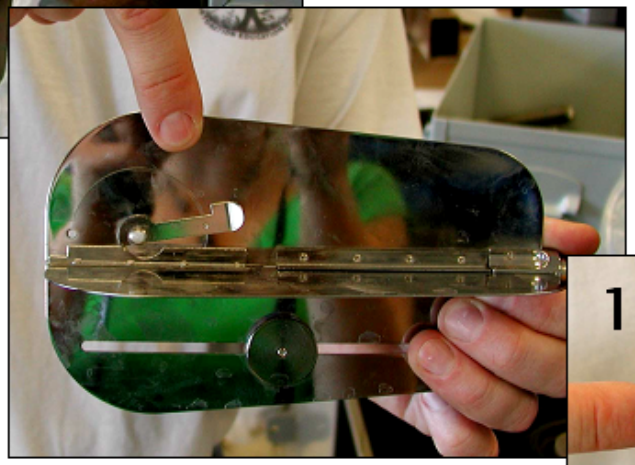


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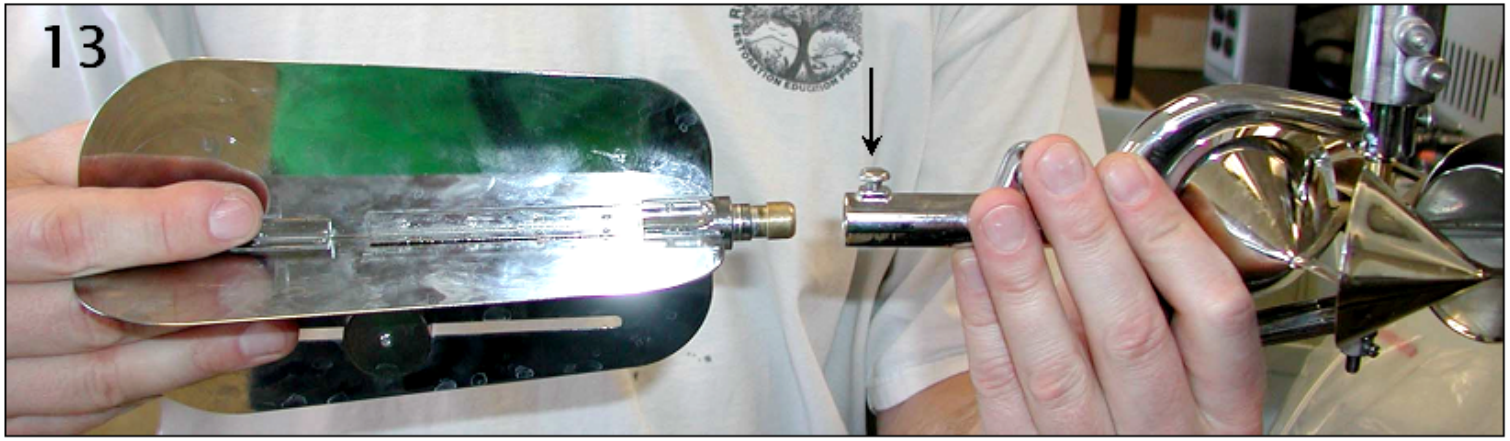
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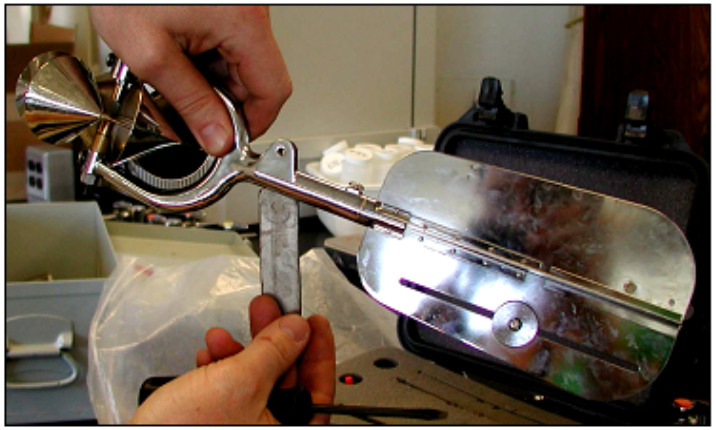

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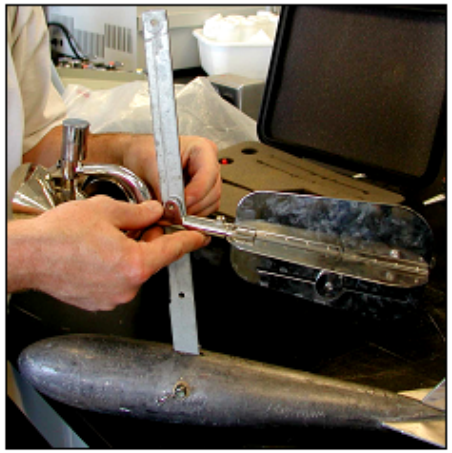

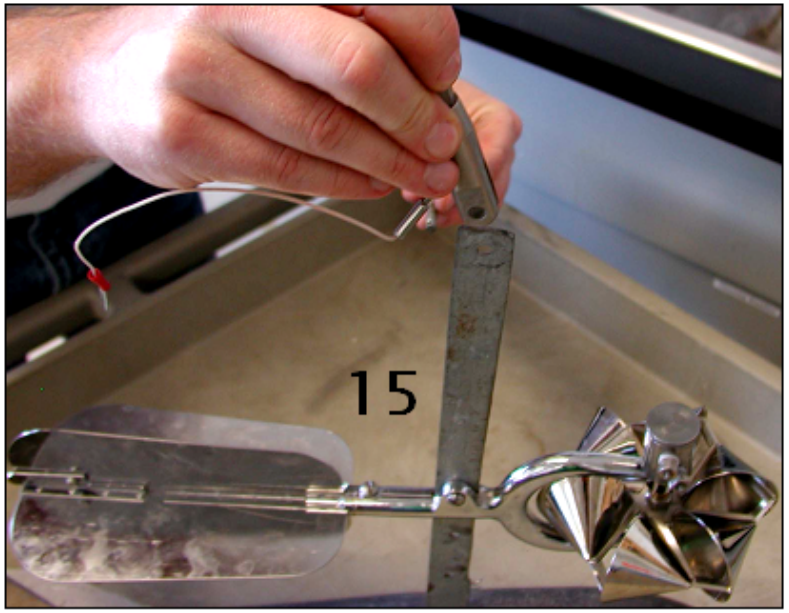

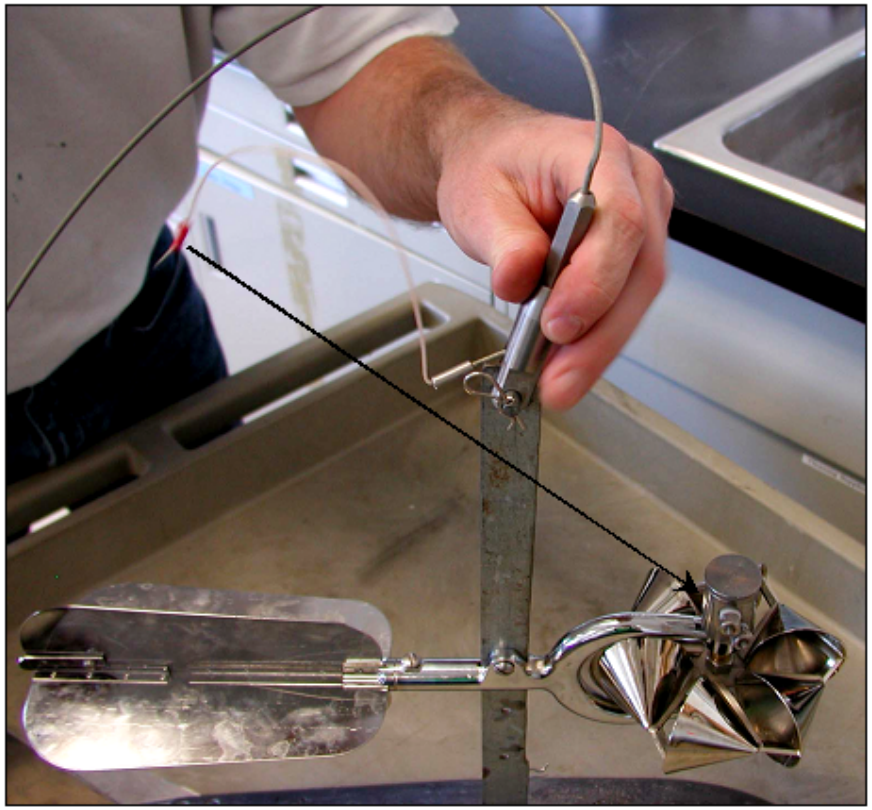

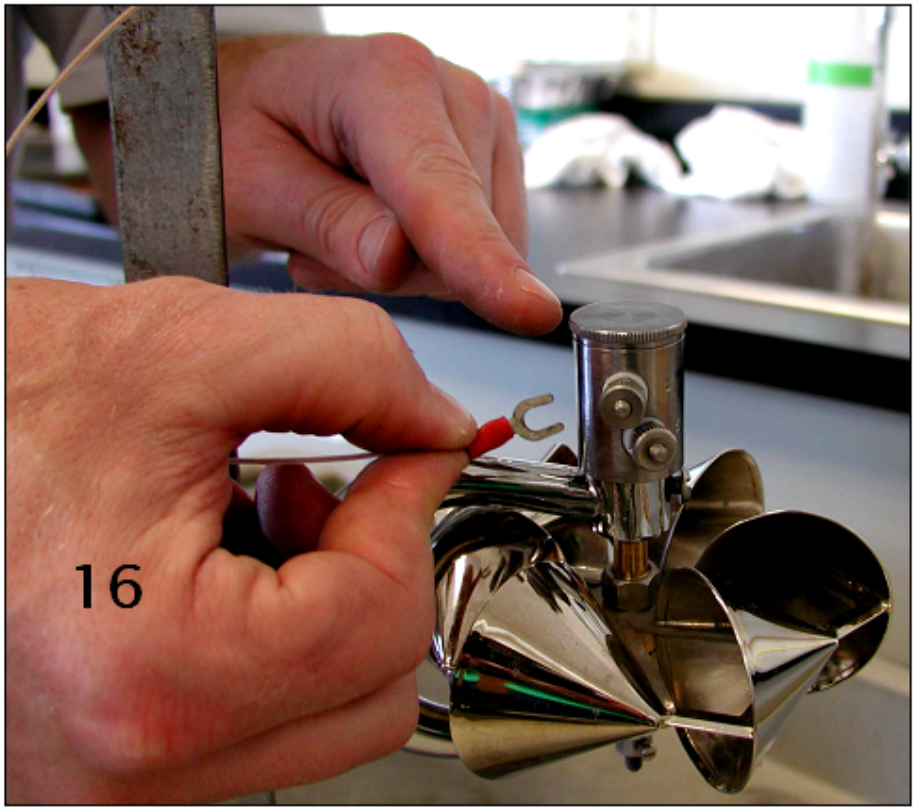
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