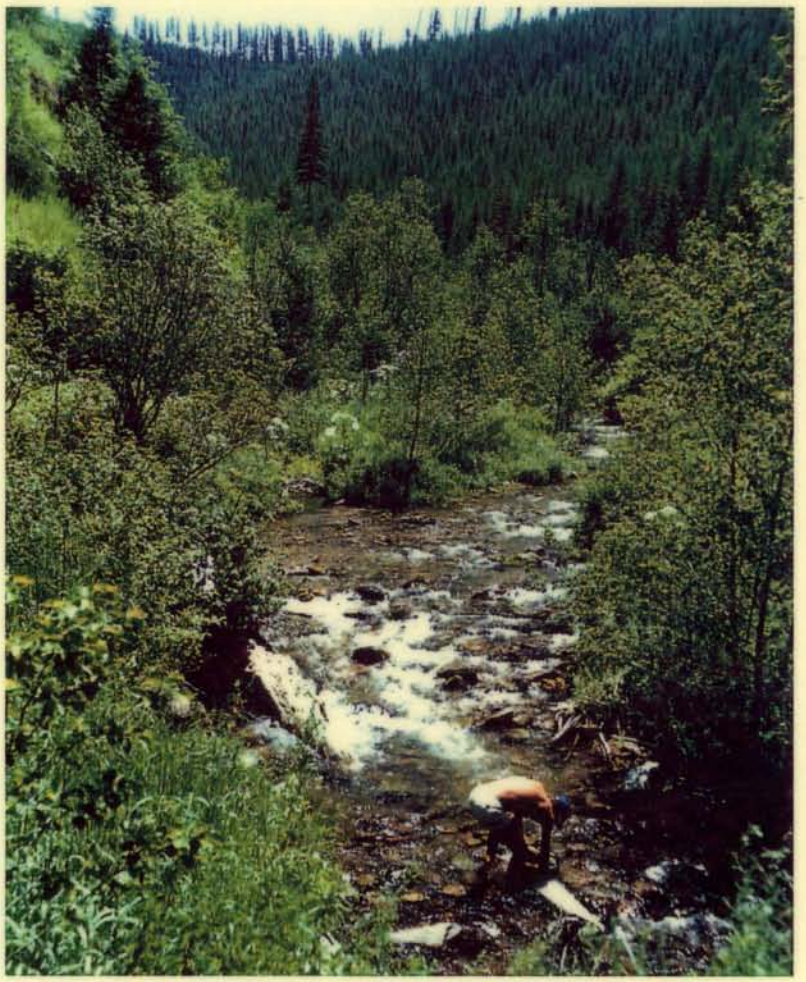
Idaho Streamwalk III

Learning How to Monitor Our Streams



Cinnamon Creek, Panhandle National Forest

by
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INTRODUCTION

This Streamwalk program was originally developed by EPA Region 10 in 1989. In 1991, the Idaho Streamwalk program was implemented by the Idaho Water Resources Research Institute, University of Idaho. The Idaho Streamwalk II and III field classes and companion instruction manual is the result of ongoing development of the Idaho program.

Streamwalk was developed as a basic screening tool to identify potential problem areas, and provide a standardized data collection method so that regional and trend comparisons can be made. As important, Idaho Streamwalk encourages citizen commitment to protect streams and educates people about the relationship between streams and watersheds. The data that the Streamwalk program gathers is housed in central databases located at the Idaho Water Resources Research Institute, University of Idaho and EPA, Region 10. Idaho Streamwalk has been included in the Project WET (Water Education for Teachers) curriculum.

Initiated in 1992, Streamwalk II was an 40-hour field and lab course which went beyond the basic Streamwalk program of monitoring only the physical characteristics of a stream. This course was developed as a more complete approach to stream monitoring and included chemical and biological techniques. Streamwalk III contains all of the original elements of the course, but has been improved to include more comprehensive information, as well as quality control and quality assessment measures.

The class requires a commitment of seven days to learn about various stream monitoring concepts and procedures. As a team, we monitor an impacted stream and compare it with a relatively unpolluted site in the area. This involves collecting data on habitat quality, water chemistry and instream biota.

In learning how to monitor a stream, the participant develops skills in observation, data collection, and analysis while becoming more knowledgeable about stream ecology.

INSTRUCTORS

Dr. Fred Rabe is a Professor Emeritus in Biological Sciences at the University of Idaho. Currently, he is involved in stream monitoring and classification of aquatic natural areas in Idaho and Montana.

Mr. Jody White is finishing a graduate degree in aquatic entomology at the University of Idaho and is also involved in stream monitoring for Northwest Management, Inc. in Moscow, Idaho.

Habitat Assessment

HABITAT ASSESSMENT

The purpose of habitat assessment is to describe current instream and riparian habitat conditions, which allows the investigator to relate physical characteristics to biotic conditions.

The objectives are to 1) measure selected instream variables which include depth, width, velocity, substrate, and 2) evaluate stream reach characteristics by utilizing a standard protocol for site description and comparison.

Measurement Concepts

The habitat assessment methodology is derived from information provided by EPA, *Rapid Bioassessment protocols for Use in Streams and Rivers* (Plafkin, et al 1989), Table 1, and from Idaho DEQ, *Protocols for Assessment of Biotic Integrity (Macroinvertebrates) for Wadable Idaho Streams* (Draft 1992). The various parameters are designed to evaluate specific weighted criteria for macroinvertebrates. Once a reach has been assessed, the investigator tallys scores and come up with a specific value. This value is compared either to a reference or control site. A ratio between the impacted reach studied and the reference or control site is calculated to determine degree of impact. Measured criteria include primary, secondary and tertiary parameters.

Primary parameters (Instream Habitat): Bottom Substrate, Embeddedness -- Scores range from 0-20 points. Primary parameters describe the micro-habitat which directly influences the macroinvertebrates.

Secondary parameters(Channel Morphology): Width/Depth Ratio, Pool/Riffle Ratio, Channel Alteration -- Scores range from 0-15 points. The secondary parameters evaluate the stability and characteristics of the stream channel.

Tertiary parameters (Riparian and Bank Structure): Lower Bank Stability, Bank Vegetative Protection, Canopy Cover, Riparian Zone Width -- Scores range from 0-10 points.

It is important to evaluate the secondary and tertiary parameters both on the reach and on the watershed upstream of the study site. The effects of upstream impacts are usually cumulative and influence the biological community.

Reference or Control Site: *Reference sites* represent the best habitat and water quality conditions attainable for the region or watershed. The term is used here to designate a site as similar as possible in a nearby drainage just outside the location

Table 1. Habitat Assessment for Small Streams

Stream: _____

Site: _____

Date: _____

Observor: _____

	Optimal	Suboptimal	Marginal	Poor
1. Bottom Substrate	16-20 Greater than 50% cobble, gravel, submerged logs, and other stable substrate	11-15 30-50% of the same	6-10 10-30% of the same	0-5 Less than 10% of the same
2. Embeddness	16-20 Gravel, cobble and boulders surrounded by 0-25% fine sediment	11-15 Substrate surrounded by 25-50% fine sediment	6-10 Substrate surrounded by 50-75% fine sediment	0-5 Substrate surrounded by > 75% fine sediment
3. Width/Depth Ratio	12-15 less than 7 overbank flows rare	8-11 8-15 overbank flows occasional	4-7 15-25 Overbank flows occasional	0-3 > 25 Peak flows not contained
4. Pool/Riffle, Run/Bend Ratio	12-15 5-7	8-11 7-15	4-7 15-25	0-3 >25
5. Channel Alteration	12-15 No channelization	8-11 25-50% channelization	4-7 50-75% channelization	0-3 >75% channelization

Table 1 (cont). Habitat Assessment for Small Streams

Stream: _____

Site: _____

Date: _____

Observor: _____

	Optimal	Suboptimal	Marginal	Poor
6. Lower Bank Stability	9-10 Lower bank stable No evidence of erosion or bank failure	6-8 Moderately stable Infrequent small areas of erosion mostly healed over	3-5 Moderately unstable Moderate frequency and size of erosional areas	0-2 Unstable Many eroded areas 'Raw'sites frequent
7. Bank Vegetative Protection	9-10 >90% of streambank surfaces covered by vegetation	6-8 70-89% streambank surfaces covered by vegetation	3-5 50-69 %covered by vegetation	0-2 Less than 50% covered by vegetation
8. Canopy Cover	9-10 Mixture of condiitons where some areas of water surface fully exposed to sunlight, and other receiving various degrees of filtered light	6-8 Covered by sparse canopy;entire water surface receiving filtered light	3-5 Completely covered by dense canopy OR nearly full sunlight reaching water surface	0-2 Lack of canopy, full sunlight reaching water surface
9. Riparian Zone Width	9-10 Width of zone at least 4 times width of stream	6-8 Width of zone at least 2 times width of stream	3-5 Width of zone at least as wide as stream	0-2 Little or no streamside cover

impacted. In some cases sites previously used as reference sites have been impaired and can no longer be considered as references. One alternative is to utilize historical data compiled on the once unimpacted reference stream. Another alternative is to choose a *control* site located upstream of the site monitored.

Bottom Substrate

Description: Bottom substrate is the instream organic and inorganic material which supports aquatic biota. Substrate types range from stable materials (cobbles, boulders, aquatic plants, large organic debris) to unstable materials (sand, silt, gravel, fine organics). Optimum conditions exist when a diversity of substrate types are present.

Examples: Boulders, cobbles, sand, silt, tree roots, submergent and emergent vegetation, logs, and undercut banks.

Significance: Diverse, stable habitat conditions allow for cover and feeding areas for a variety of aquatic organisms. Cobble sized particles are usually considered optimum habitat for healthy macroinvertebrate communities. Logs provide habitat for fish (i.e., cover and pools) and smaller organics serve as an energy source for macroinvertebrates. Also, aquatic vegetation is a stable source of cover and food for aquatic biota.

Methods

Observe substrate conditions along the assigned reach.

Bedrock	-	solid slab of rock
Boulders	-	greater than 10 inches in diameter
Cobbles	-	2-10 inches
Gravel	-	0.25 to 2 inches
Sand	-	up to 0.25 inches
Silt/mud/clay	-	fine particles

Estimate percent substrate composition at three locations in the study reach (bottom, middle and top).

At each location, record percent composition of bottom substrate from both estimated observations and measurements. A plastic ruler is provided.

In addition, note percentage of reach covered by aquatic plants, woody debris, and undercut banks if any or all of these habitat types exist.

Embeddedness

Description: Embeddedness measures the amount of fine sediments (usually < 0.25 inches) deposited around larger substrate. As embeddedness increases, the spaces around the larger substrate fill, the amount of living space for aquatic biota decreases, and gravel used for spawning are covered.

Examples: A 10 inch diameter cobble with only 5 inches showing above the stream bottom is considered 50 % embedded. A bottom covered only by fine sediment is considered 100 % embedded.

Significance: You would expect to observe more fines in pools (depositional habitats) and in sections of streams with lower gradients than on riffles (erosional habitats). Some invertebrate groups such as fly larvae, aquatic earthworms, clams and leeches are commonly found in depositional habitats. However, other groups of invertebrates require larger substrate for feeding and cover (e.g., mayflies, stoneflies, caddisflies). The greatest diversity is observed in erosional habitats.

Methods

Visually estimate the percent embeddedness of the reach. You must first calibrate your eye by measuring embedded substrate with your ruler and then ocularly averaging the total embeddedness for the study reach.

To calibrate your eye, pick a rock from the stream bottom (making sure you mark how deep it is embedded with you finger tip) and measure the total height and the embedded height of the rock.

Also, before you remove the rock, estimate the percent embeddedness. Compare your estimate with the measured value. Repeat several times until your estimates are consistent with your measurements.

Divide the embedded height by the total height to calculate percent embeddedness.

Width/Depth Ratio

Description: Stream channel depth is important in containing the streams discharge. As the width/depth ratio of streams change, so does habitat diversity and the capacity to contain floods. The width/depth ratio is one method we use to measure the present capacity of the stream and relate this measurement to known standards.

Significance: Sediment accumulations, bank destruction, impairment of riparian zones, and channelization of the stream all the width/depth ratios. As the stream widens, there is increased solar input which increases the water temperature. This can be detrimental to cold-tolerant species. Also, a shallow depth caused by sediment accumulation decreases the habitat available for colonization by aquatic organisms.


Measuring depth and width of stream

Methods

Measurements are taken at the top, middle and bottom of the reach.

Measure the stream width between the wetted banks with a tape.

A meter stick is used to measure depths at 1/4, 1/2 and 3/4 of the stream width. Divide the total of 3 depth measurements by 4 to take into consideration the depth of 0 where the water and stream banks meet.

Divide the wetted width by the mean depth for each location and average the three measurements.

Pool/Riffle, Run/Bend Ratio

Description: This is the difference in distance between riffles or runs divided by stream width.

Examples: A *riffle* is a shallow, swiftly flowing stretch of water with surface agitation present but without the surface disturbance of a rapid. *Pools* are areas of the stream where water velocity is extremely reduced and would contain water even if no flow was present. *Runs* (or glides) are sections of stream with moderately low velocity without surface agitation. Depth is usually greater in runs than riffles but not as deep as pools. Often times, the difference between a pool and run is a value judgement. Runs are often located near the bend of a water course.

Significance: Bends and riffles are assumed to offer more diverse habitat than a run or a stream with uniform depth. Bends often exist in streams of low gradient that lack riffle areas and can offer suitable habitat due to the cutting action of water at the bend. Pools are used by fish for resting and cover and by macroinvertebrates adapted to burrowing in bottom sediments.

Methods

Measure width of the stream along the narrowest and widest length of the reach using a tape. Average these readings.

Pace off the distance between a number of riffles or bends and take an average of these distances.

Divide average distance between riffles or bends by the average stream width.

Channel Alteration

Description: Channel alteration occurs when the channel is straightened causing a decrease in the sinuosity of the stream. Sinuosity is the ratio of the length of channel to down valley distance or ratio between two point on a channel to the straight distance between these points. The term *meander* is used when channels have sinuosities of 1.5 or more.

Example: This often occurs where meandering streams tend to flood sometimes causing damage to crops, in with the construction of concrete embankments, and alongside roads.

Significance: Channelization results in increases in stream velocity and subsequent scouring of the stream bed. Alteration of channels may also cause deposition of materials on the inside of bends, below channel construction or where the gradient of the stream flattens out.

Methods

Estimate total channelization of the study reach: 25-50% channelization, 50-75%, or greater than 75%.

It is best to observe the stream from a high point. If that is not available, walk the stream to make your observations.

Lower Bank Stability

Description: This area exists from the normal high water line to the edge of the water during low flow in the summer. The upper bank covers the break in the general slope of the surrounding land to the normal high water line. Terrestrial shrubs and trees usually cover this zone.

Examples: Poor lower bank stability is observed by the amount of bare bank lacking protection from emergent vegetation, rocks or woody debris.

Significance: Poor bank stability adds sediment to a stream. It is an indicator of channel bank cutting which is related to high stream energy and lack of vegetative covering.

Methods

Initially, become familiar with examples of poor, marginal, sub-optimal and optimal lower bank stability by studying slides and pictures.

Rank the condition of the lower bank in the study reach accordingly.

Bank Vegetative Potential

Description: Bank vegetation is the amount of plant growth rooted along the stream bank which is a measure of bank stability. The opposite measurement is the amount of exposed soil in the upper bank. Bedrock and boulders also provide bank protection even if vegetation is not present.

Examples: A good vegetative protection zone is provided by alder, willow, and other trees and shrubs.

Significance: Root systems of higher plants are responsible for holding bank soil in place. Banks that are covered by plant growth are assumed to be stable features of the stream ecosystem and indirectly affects instream habitat characteristics.

Methods

Familiarize yourself with the range of conditions expected. Walk the stream reach and make notes on the amount of bank that has bare soil or poor vegetation covering.

Give an average for the site by percentage.

Canopy Cover

Description: Heavy shrub cover forming a partial canopy over the stream provides a good example of shading.

Examples: A good example of stream shading is when heavy shrub cover exists along the stream.

Significance: Canopy cover helps modify the water temperature by decreasing the amount of direct sunlight that reaches the surface. Vegetation hanging directly over or into the water provides habitat and cover for aquatic insects and fish. This vegetative growth contributes *detritus* or coarse particulate organic matter to the stream which serves as a source of energy for some invertebrate (e.g., shredders).

Methods

Walk the study reach making notes of the amount of canopy cover. Average your sightings and record.

Riparian Zone Width

Description: The riparian zone is an area between the stream and adjacent upland characterized by distinctive higher plants and soil types. Riparian zones can range from 0 meters to several hundred meters wide. The actual size depends on the stream size, geology, vegetation characteristics and stream morphology.

Significance: Riparian zones provide protection and cover to stream organisms and filter out sediment, toxic materials and nutrients. It also is a source of particulate material to benthic invertebrates inhabiting the stream. Fallen trees and root wads provide cover for the stream biota.

Methods

Measure the width of the riparian zone in at least three places along the study reach.

Record, as a function of stream size, the appropriate category on the evaluation sheet. Observe whether the riparian area is four or two times the width of the stream or if there no stream cover.

Measuring stream velocity by the float method

Velocity/Depth

Description: The combination of velocity and depth has a significant effect on the distribution and composition of the aquatic biota within a stream. This parameter is not being used in the habitat assessment but rather as a descriptor.

Examples:

1. slow, shallow-velocity less than 0.3 m/s, average depth is less than 0.5m.
2. slow, deep-velocity less than 0.3 m/s, average depth more than 0.5m
3. fast, shallow-velocity more than 0.3 m/s, average depth less than 0.5m
4. fast, deep-velocity more than 0.3 m/s, average depth more than 0.5m.

Methods

Velocity is estimated by the float method and depth is measured by using a meter stick.

Measure the width of the stream along the narrowest and widest sections of the reach using a tape. Average these readings.

Measure the water depth at 1/4, 1/2 and 3/4 of the stream width at the narrowest and widest length of the reach. Divide the total of three measurements by four to take into consideration the depths of zero at where the water and stream banks meet. Average the readings of the narrow and wide sites.

Discharge: Select a straight stretch of stream riffle or run and pace off about 100 feet. Obtain a float such as a brightly colored orange, tennis ball, or leaf if the channel is shallow. Record time required for float to cover measured distance. Repeat three times and take average.

$$D = \frac{WDLa}{T}$$

Where

D	=	discharge in cubic feet per second (cfs) or meters per second (mps).
W	=	average width of stream stretch in feet or meters.
D	=	average depth of stream stretch in feet or meters
L	=	length of stream stretch in feet or meters.
T	=	average time in seconds for float to cover stream stretch
a	=	constant-0.8 for rocky bottom, 0.9 for smooth bottom.

Use a digital current meter if available because it will give the best results.

Table 2. Physical Habitat Measurements

Stream: _____

Site: _____

Date: _____

Observor: _____

	Measurement 1	Measurement 2	Measurement 3	Average
Width (ft)				
Depth (ft)				
Substrate (%)				
Bedrock				
Boulders (> 10 in)				
Cobble (2-10 in)				
Gravel (0.25-2 in)				
Sand (< 0.25 in)				
Silt				
Organics %				
Velocity				
Gradient				
Dishcarge (cfs)				

COMMENTS:

Table 3. Habitat Assessment Form

Stream: _____

Site: _____

Date: _____

Observor: _____

	Optimal	Suboptimal	Marginal	Poor	Notes
PRIMARY	(20-16)	(15-11)	(10-6)	(5-0)	
Bottom Substrate					
Embeddedness					
SECONDARY	(15-12)	(11-8)	(7-4)	(3-0)	
Width/Depth Ratio					
Pool/Riffle Run/Bend					
Channel Alteration					
TERTIARY	(10-9)	(8-6)	(5-3)	(2-0)	
Lower Bank Stability					
Bank Veg. Protection					
Canopy Cover					
Riparian Zone Width					

COMMENTS:

Equipment

Hip boots or old footwear (depending on time of year)
Meter stick
Tape
Current meter or float
Field book
Field forms
Pencils
Clipboards
Watch with chronograph or second hand
Camera (optional)
Clinometer
Ruler (mm)
Stakes
Pack

Notes

Water Chemistry

WATER CHEMISTRY

The objective of this module is to collect, analyze, and compare chemical information from different sites.

Many of the methods used are adapted from Mitchell and Stapp (1991).

Nine different tests of water chemistry are made at each station sampled. Some readings are conducted in the field, others in the lab.

Results are recorded in a field book and later transferred to a Class Data Water Summary chart. Next, "Q" values are determined and listed on a Water Quality Index (WQI) table. Weighing factors are applied to each test result. The total score is compared to predetermined Water Quality Index values and rated Excellent, Good, Medium, Bad, and Very Bad.

Alkalinity and conductivity are measured in the field but not used in the Water Quality Index.

There is space on the WQI table to make remarks concerning stream conditions along the reach studied. These might include such things as garbage/junk in stream, pipes actively discharging material, foam or oil, and algae scum on surface.

In order to save time and guarantee more accurate results, some of the tests are run by a professional water testing lab.

Information concerning methods relating to chemical analysis are somewhat brief in this module, mainly due to time restraints and background experience of the participants.

Temperature

Description: Temperature is one of the most important environmental characteristics in a stream. It varies from site to site. A temperature taken in a stream located in a wide open valley is expected to differ from one situated in a narrow canyon. Riparian vegetation shading a stream has a significant cooling effect on the water.

Methods

Place the thermometer a few inches below the surface of the water.

Record temperature after obtaining a constant reading which takes a couple of minutes.

If you have a thermometer that reads in Fahrenheit, convert to Centigrade (°F - 32 + 1.8). To convert Centigrade to Fahrenheit (°C X 1.8 + 32).

Dissolved Oxygen

Description: Dissolved oxygen in a well aerated stream is usually not limiting unless the water contains large amounts of organic material. Less oxygen is found in pools where decomposition is commonly occurring at a faster rate than in riffles. Oxygen saturated water contains less than one percent by volume in contrast to the atmosphere with about 23 percent.

Winkler Method

Moisten the interior surface of a 250-300 ml ground glass bottle by rinsing which may help avoid getting air bubbles in the sample.

Tilt the bottle to a horizontal position allowing water to run in slowly. Let water flow over lip of bottle to further rid the sample of air bubbles.

Add 1 ml of manganous sulfate beneath the surface.

Add 3 ml of alkaline potassium iodide beneath surface. Do not be concerned if sample runs over.

Collecting water samples for nitrates, total solids, turbidity, fecal coliforms, biochemical oxygen demands, and pH to run inthe lab

Add 1 ml of manganous sulfate beneath the surface.

Add 3 ml of alkaline potassium iodide beneath surface. Do not be concerned if sample runs over.

Replace stopper and shake vigorously for about 15 seconds. Allow precipitate to settle. Observe this taking place in bottom half of bottle.

Holding tip of pipette against neck of bottle, add 2 ml of concentrated sulfuric acid or contents of sulfamic acid packet above the water level.

Pour 200 ml of treated sample into volumetric flask and transfer to Erlenmeyer flask.

Titrate sample with 0.025 N sodium thiosulfate or phenylarsene oxide (PAO).

Analysis in the field of dissolved oxygen, pH, alkalinity, and conductivity

After sample becomes pale yellow in color, add 1-2 ml of starch solution. Titrate until blue color disappears.

Dissolved oxygen in mg/l is equal to number of mg/l titrant.

Calculating Percent Saturation

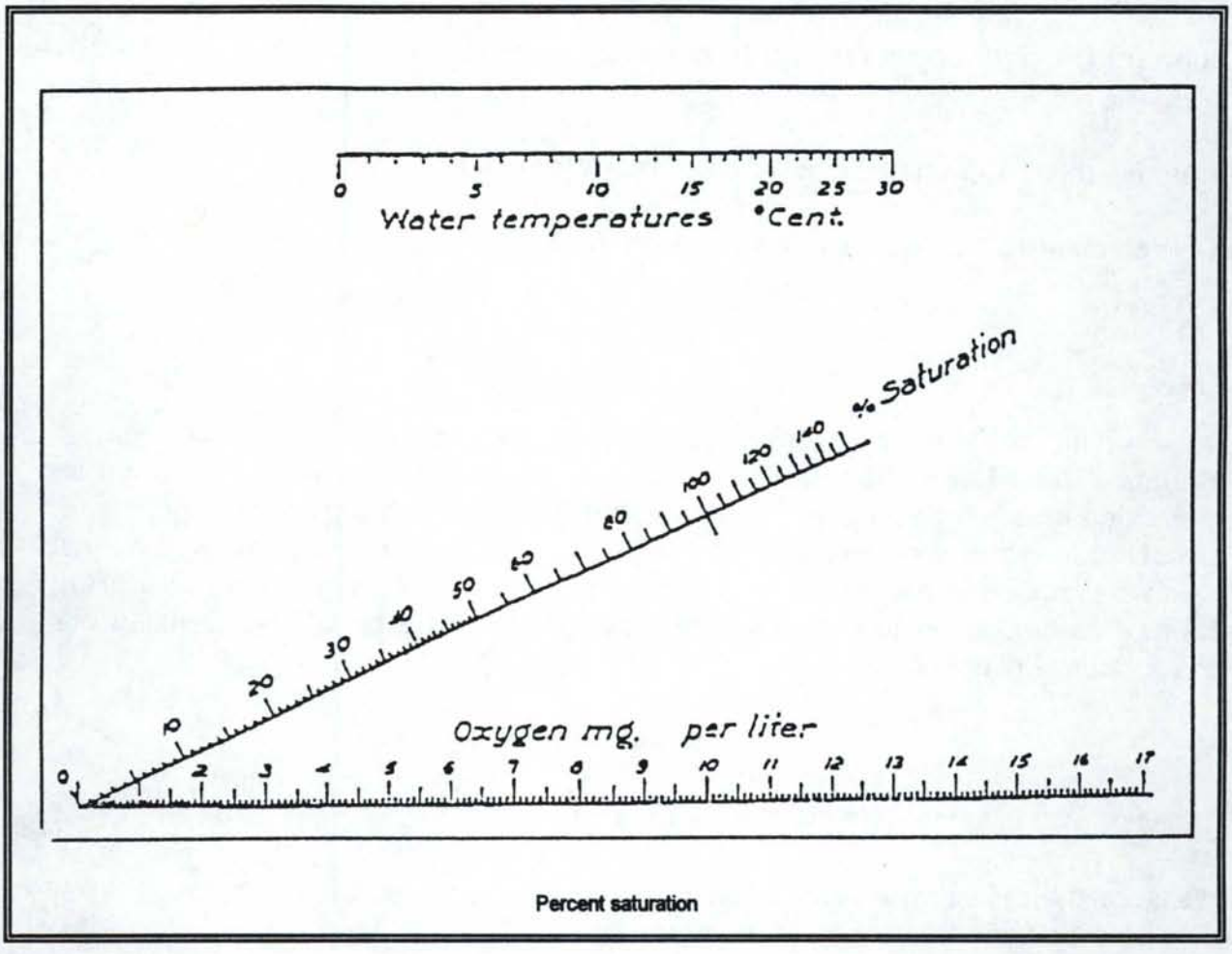
The percent saturation of dissolved oxygen at a certain temperature is determined by pairing dissolved oxygen value in mg/l with temperature of water in centigrade on a percent saturation chart. Use a straight edge connecting the two points and read saturation value.

Record results on Class Data Water Summary.

To calculate "Q" value of dissolved oxygen and locate percent saturation on horizontal axis. Follow that point up to where it intersects the line. The point of intersect is "Q" value.

Record value on WQI Summary Table.

Draw a line between water temperature °C and oxygen mg/l. At point of intersection is % of saturation.



Biochemical Oxygen Demand

Description: Biochemical Oxygen Demand (BOD) is high when the dissolved oxygen is low and low when dissolved oxygen is high. If considerable amounts of organic matter exist in a stream then the decomposition of this material by microorganisms requires ample oxygen for the process to take place.

Methods

Fill a light bottle and dark bottle with water being careful not to aerate the sample.

Measure the dissolved oxygen in the light bottle - refer to information regarding Winkler method.

Place the dark bottle in an incubator or a darkened room for five days at 20 degrees C.

At the end of this period, analyze for dissolved oxygen.

Subtract the dark bottle reading from the light bottle reading. This gives the BOD in mg/l.

Transfer this information to the Class Data Water Summary.

Next calculate a "Q" value and record on WQI Summary Table.

pH

Description: pH is a way to measure the acidic or basic nature of water in a stream. Water has a slight tendency to fall apart or dissociate into hydrogen and hydroxide ions. An acid is a substance that gives off hydrogen ions when dissolved in water whereas a base is any substance that accepts hydrogen ions when dissociated in water. The pH scale runs from 0-14. Acid rain has a pH of about 4 as compared to the Great Salt Lake which has a pH of 10. Distilled water has a neutral pH of 7.

Methods

Collect a water sample below the surface.

Measure the pH using a color comparison method such as the Hach Kit. pH paper may also be used but is not as satisfactory.

Take an additional sample. Put on ice and return to lab. Analyze sample using a pH meter and compare with color disc technique.

Record information on Class Data Sheet and WQI Table after determining Q value.

Fecal Coliform

Description: Fecal coliform is a type of bacteria associated with mammal and human waste. When animals defecate, some of these bacteria pass out of their bodies and into the stream. In all probability, pathogens may be present along with the coliform type. The chance of pathogens being in the water sample increases significantly when the coliform count is over 200 colonies/100 ml water. Drinking water should not exceed 1 coliform/100 ml and treated sewage effluent is expected to be less than 200/100 ml.

Methods

Collect the sample in a 300 ml bottle that has been sterilized. Avoid touching the inside of the cap.

Face the bottle into the current below the surface. Wear gloves if there is a chance of pathogens being present in the water.

Place the sample on ice and keep cool as possible. Analyze the water within 24 hours.

In order to obtain more accurate results and save on time, it is recommended that a state or commercial water testing lab analyze the water for fecal coliform.

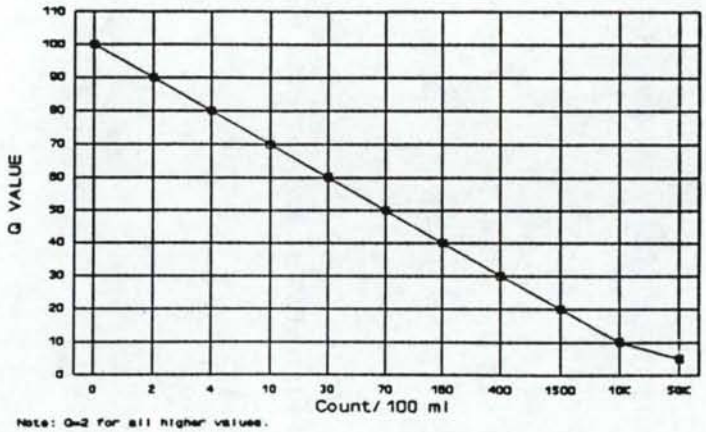
Record results on Class Data Water Summary,

To calculate "Q" value, refer to Fecal Coliform figure and locate fecal coliform count on horizontal axis. Follow that point up to where it intersects the line. The point of intersect indicates "Q" value.

Record value on WQI Summary Table.

Water quality Q value

FECAL COLIFORM



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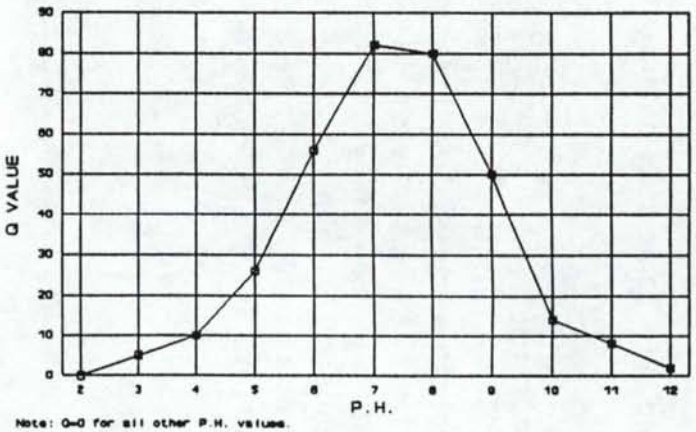
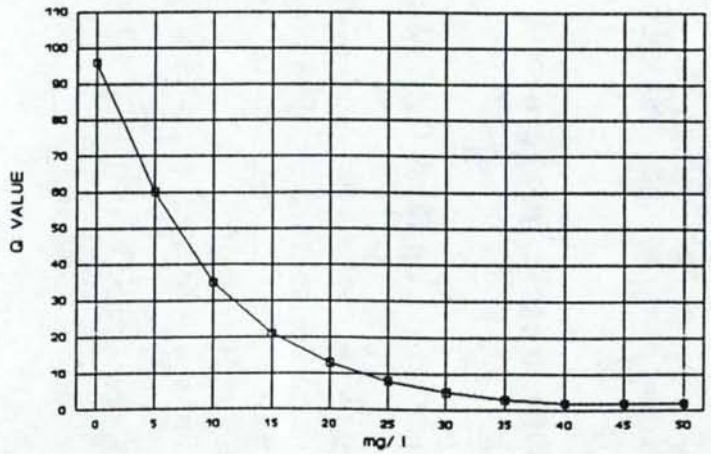
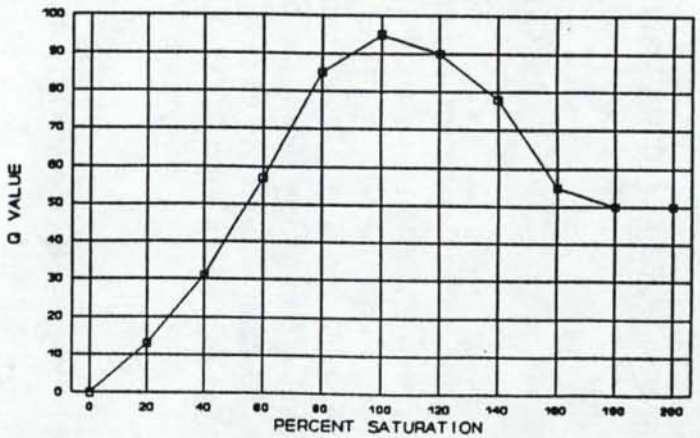


BIOCHEMICAL OXYGEN DEMAND



DISSOLVED OXYGEN



Phosphates

Description: Phosphates are nutrients necessary for the growth of plants. If too much phosphorus gets into a stream from sources such as manure, septic tanks, or lawn fertilizer undesirable changes in the water occur. The phosphates taken up by plants may cause undesirable mats of algae or unruly growth of aquatic weeds in the stream channel. These plants eventually die and during the process of decomposition decrease the dissolved oxygen and thus increase the biochemical oxygen demand.

Methods

Collect sample below the water surface in a 100 ml container.

Place sample on ice and return to lab.

In order to obtain more accurate results and save time, it is recommended that a state or commercial water testing lab analyze the sample for phosphates.

Record results on Class Data Water Summary. Calculate "Q" value and transfer information to WQI Summary Table.

Nitrates

Description: Nitrates like phosphates are necessary for plant growth. Elemental nitrogen in the atmosphere is fixed by bacteria and blue green algae to ammonia which is changed to nitrates by another team of microorganisms. Additional nitrates find their way into a stream through sources such as fertilizers, animal manure from cattle, and leaky septic tanks. Eutrophication or enrichment of the water occurs causing excessive plant growth in the stream.

Methods

Collect sample below the water surface in the same 100 ml container used to collect phosphates.

Place sample on ice and return to lab.

In order to obtain more accurate results and save time, it is recommended that a state or commercial water testing lab analyze the sample for nitrates.

Record results on Class Data Water Summary. Calculate "Q" value and transfer information to WQI Summary Table.

Turbidity

Description: Turbidity is caused by suspended solids in the water such as clay, silt, or organic wastes. These materials trap more heat resulting in less oxygen because of the warmer water. Biological agents, such as algae and plankton can also cause turbidity when enrichment takes place by excessive nitrates and phosphates.

Methods

Collect 100 ml water below the water surface. This can be part of the same sample collected for pH to be analyzed later.

Measure turbidity using a turbidimeter or send sample to state or commercial water testing lab for analysis.

Record results on Class Data Water Summary. Calculate "Q" value and transfer information to WQI Summary Table.

Total Solids

Description: Total Solids consist of both suspended and dissolved materials in the water column. Suspended solids retained by a fine mesh filter include clay and silt particles from erosion, sewage, pesticides and live organisms. Dissolved solids consist of inorganic materials such as nitrates, phosphates, calcium, and bicarbonate ions which pass through a fine filter. They provide nutrients for algae and higher plants at the base of the food chain and some are important buffering agents in the water.

Methods

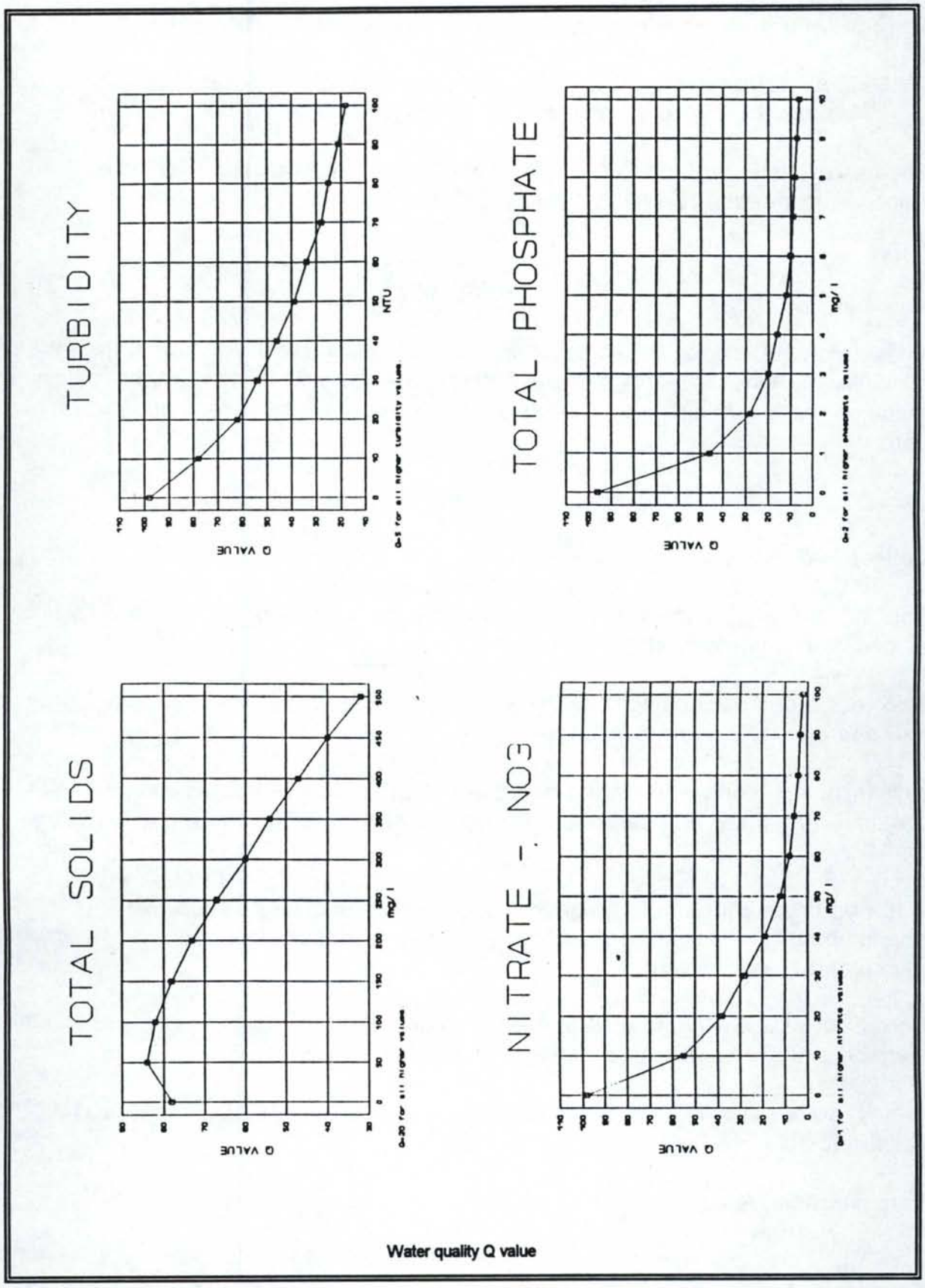
Collect at least a 100 ml sample from the stream.

Weigh a small, clean beaker on a sensitive balance to the nearest 0.0001 gram. Remove it with tongs so that you do not change weight of beaker by touching it.

Pour the 100 ml water sample into the beaker and place in a drying oven at 103 degrees C overnight to evaporate the water.

Allow the beaker to cool and reweigh it.

Calculate the weight of residue by subtracting weight of beaker before sample introduced from weight of beaker and residue.



Water quality Q value

The following formula is used to determine total solids:

$$\frac{\text{Increase in weight in grams}}{\text{Volume in milliliters (ml)}} \times \frac{1000\ \text{mg}}{1\ \text{gm}} \times \frac{1000\ \text{ml}}{1\ \text{liter}} = \text{mg/l}$$

Record results in mg/l on Class Data Water Summary. Calculate "Q" value and transfer information to WQI Summary Table.

Alkalinity

Description: Alkalinity is expressed as calcium carbonate in mg/l even though alkalinity represents hydroxides and bicarbonates as well as carbonates. Alkalinity readings are low in soft water regions such as mountainous areas and high where hard water exists.

Methods

Collect 100 ml water.

Pour off into a graduated cylinder and transfer to a white porcelain casserole placed over a white card.

Add four drops of phenolphthalein indicator to water. If solution becomes colored, carbonate or hydroxide is present.

Add 0.02 N sulfuric acid from a pipette until color disappears. Phenolphthalein alkalinity (mg/l) calcium carbonate is equal to number of ml sulfuric acid multiplied by 10.

Add two drops of methyl orange indicator to sample after titration for phenolphthalein alkalinity or if solution remains colorless after adding phenolphthalein indicator.

Introduce 0.02 N sulfuric acid to yellow-colored solution until it turns a faint pink (salmon pink) or until solution no longer appears yellow.

Methyl orange alkalinity (mg/l) of calcium carbonate is equal to number of ml 0.02 N sulfuric acid used multiplied by 10.

Total alkalinity is equal to the addition of methyl orange and phenolphthalein alkalinity values.

Record this information on Class Data Water Summary and WQI Summary Table. It is not used in the Water Quality Index.

Conductivity

Description: Conductivity is a measure of the ability of water to conduct an electrical current. This ability is dependent upon the amount of dissolved charged particles (ions) present in the water and temperature. Ions such as sodium, calcium, and bicarbonate are dissolved into water from weathering of rock material in a drainage area. Conductivity values for freshwater are generally within the range of 10-1000 micromhos (reciprocal of resistance).

Methods

Use a conductivity meter and place probe in water.

Adjust temperature knob on the meter to the temperature of the water.

Turn the other knob until needle lines up with a red line on the scale.

Next turn this same knob to the appropriate scale and read needle in micromhos.

Turn meter off when finished.

This data should be included on Class Data Water Summary and WQI Summary Table but is not used in Water Quality Index.

Table 4. Class Water Quality Data Summary

Name _____

Date _____

Test	Stream:	Stream:	Stream:
Temperature (C)			
Dissolved Oxygen (mg/l)			
pH			
BOD (mg/l)			
Fecal Colliform (mg/l)			
Phosphates (mg/l)			
Nitrates (mg/l)			
Turbidity (NTU)			
Total Solids (mg/l)			
Alkalinity (mg/l)			
Conductivity (umhos)			

Comments:

Table 5. Water Quality Index

Stream _____

Station No. _____

TEST	UNITS DATA RECORDED IN	CLASS DATA-AVER. RESULTS	Q-VALUE -REFER TO TABLES	WEIGHTING FACTOR	TOTAL Q-VALUE X WT. FAC. = TOTAL
1. Dissolved Oxygen	% Sat. See Table For Q-Value	mg/l		0.17	
2. Fecal Coliform	Colonies /100 ml			0.16	
3. pH	Units			0.11	
4. B.O.D.	mg/l			0.11	
5. Temperature	Change in Degrees C.			0.11	
6. Total Phosphate	mg/l			0.10	
7. Nitrates	mg/l			0.10	
8. Turbidity	NTU/Secchi Feet			0.08	
9. Total Solid	mg/l			0.07	
				Add Column to Determine Water Quality Index	

modified from Mitchell and Stapp(1991) and Beckwith(1991)

WATER QUALITY INDEX

100-90	EXCELLENT
89-70	GOOD
69-50	MEDIUM
49-25	BAD
24-0	VERY BAD

Alkalinity mg/l_____

Conductivity micromhos_____

REMARKS:

Notes

Biomonitoring

BIOMONITORING

The objectives of this module are 1) learn about sampling aquatic macroinvertebrates and processing them, 2) identify the macroinvertebrates, and 3) analyze the data as it relates to the structure and function of the macroinvertebrate communities.

The biomonitoring methodology is modified from Rapid Bioassessment Protocols 2 and 3 (Plafkin 1989) and Wisseman (1994).

Aquatic macroinvertebrates are animals without backbones large enough to be seen by the unaided eye and live at least part of their life upon or within substrates in an aquatic medium. They are retained in a U.S. Standard No. 30 sieve screen comprised of 28 meshes per inch (0.6 mm openings).

They utilize many available substrate in the stream channel such as rocks, soft sediment, plants, logs, and detritus.

Macroinvertebrates consist primarily of insects. Other representatives include snails, clams, leeches, aquatic worms, flatworms, mites, freshwater shrimp and crayfish.

Some macroinvertebrates are grazers consuming algae and plant material. Others specialize in utilizing detritus or dead plant material conditioned by bacteria and fungi in the stream.

Macroinvertebrates provide an important index for detecting changes in water quality brought about by point and non-point sources of pollution. Some species are sensitive to perturbation or stress whereas others are more tolerant to changes in the stream environment.

Macroinvertebrates usually live as long as one to two years (although some live up to 9 years) and remain in one location for quite a while. As a result of their prolonged exposure to the changing stream conditions, their presence or absence provides an indication of the health of a stream.

A systematic non-random sampling design is used to include a number of *habitat types* in the stream. These habitat types are erosional water (riffles and runs), aquatic vegetation and coarse particular organic material (CPOM). Some of the above habitat types are obviously not collected because they are absent from the stream reach. It is important then to make note of the presence or absence of habitat types at each site sampled.

Stream habitats not collected include wetted substrates in slower water near shore (margin cobbles), fine sediment and undercut banks.

The reason for sampling habitat types qualitatively is to collect as many taxa as possible in a reasonable period of time. Qualitative sampling is less time consuming than quantitative sampling. The objective of this approach is to make between station comparisons to detect the presence or absence of macroinvertebrates that are sensitive or tolerant to stress and to obtain information about the richness of the community (Klemm et al. 1990).

If habitat types are destroyed or altered by physical or chemical impairment of the environment, then we expect to see a reduced biological integrity of the macroinvertebrate community.

Sampling

It is important to make an early reconnaissance of the streams to be studied. By selecting sampling sites and identifying the various habitat types present, you save time and avoid problem situations later on during the actual sampling.

Each station consists of a reach which is defined as a section of stream channel having similar physical characteristics. Length of a reach may vary. Some investigators recommend a 20:1 ratio for every meter width of a bank full stream. If a stream is 3 meters wide the reach would be 60 meters long.

If possible, all stations should be collected at the same time of day so physical, chemical, and biotic samples can be related. Always work upstream in order to keep streambed disturbance to a minimum.

Select a control or reference station that represents the best habitat and water quality conditions attainable for the

Collection of macroinvertebrate from riffle area using dip net

region or watershed. If time and resources are available, choose more than one station or stream to serve as a reference, or control. Additional information describing reference stations and controls are included in the habitat section.

The number of erosional habitats (riffles, runs) sampled depends upon the size of the stream and the time and resources available. A minimum of three sampling sites at each station or reach is recommended. Choose only those sites which appear to be favorable habitat for macroinvertebrates. The three samples collected are later combined into one composite sample.

A long-handle dip net is used to sample erosional habitats. Place the net securely in the substrate with the opening facing upstream. Stand to the side and kick the streambed vigorously to a depth of about four inches overturning the substrate about a foot above the net opening. Repeat this procedure for a couple of minutes. Each of the three samples you take should cover about 0.1 sq meter.

The material collected from the three sampling sites is transferred from the net to a single labeled ziplock bag. Place the bags in an ice chest and return to the lab where they are kept refrigerated. One advantage of keeping specimens alive is that their movement makes them easier to see in the sorting process. Also, some groups such as leeches are easier to identify alive. A disadvantage in working with live specimens is they need to be processed no later than 24 hours following collection.

Select an area along the stream reach with the densest shore vegetation. Make three individual sweeps upstream with a dip net as far as you can reach out not moving from your position. A sweep consists of dragging the net forward right below the surface so that you cover about a meter of water space. Practice this maneuver before actual sampling. Be careful and not drag net along the stream bottom.

If instream vegetation is observed then sample it where it is densest. Make three individual sweeps upstream while standing in the channel rather than from the bank.

Transfer contents of all vegetation samples to a properly labeled ziplock bag. Place in an ice chest and return to lab.

Collect coarse particulate organic matter (CPOM) when present in the stream. The CPOM, especially deciduous leaves, require a length of time in the stream before being conditioned and subsequently used as a source of foods by certain macroinvertebrates.

Small CPOM consists of leaves, needles and twigs. Collect this from leaf packets

in fast and slow water along pool bottoms and stream margins. If CPOM is present, fill a single ziplock bag with material.

Large CPOM is comprised of pieces of bark and branches which do not fit inside a ziplock bag. Choose several pieces of this woody material and place in a screen bucket. It is best to select CPOM that is partially decomposed and resembles wood pulp.

Next, wash down material by raising and lowering sieve bucket in the stream. Remove each piece of wood and break apart to search for invertebrates. Use forceps to place the collected organisms into the ziplock bag with the fine CPOM.

Collection of macroinvertebrates from aquatic vegetation using dip net

Optional collections can be made of filamentous algae and aquatic vascular plants if present in sufficient amounts. Place the algae in a jar of water and plants in a press.

Photographs taken of the stream system are invaluable when interpreting habitat. Be sure to include riparian vegetation in the photo. Extensive notes of sampled habitat types are important when it comes time to analyze the information collected.

Processing Macroinvertebrates

Remove ziplock bags containing live organisms from the refrigerator. Samples should not remain refrigerated for more than a day, otherwise the organisms may die and spoil. Transfer materials from ziplock bags to a U.S. Standard No. 30 sieve (0.6 mm diameter screen). Run tap water through the screen to reduce volume removing any mud or silt. Concentrate material at one edge by tilting screen and running tap water through it.

Next, transfer sample from screen to a flat tray or other container. If there appears to be more than 100 organisms in the sample, mix well and divide into four or more equal parts depending upon the number of organisms.

Throw a dice to select one of the parts to process. Place a tablespoon of material in a white enamel pan or flat glass baking dish filed partially with water. Examining a small amount of sample enables you to better see the organisms since the material is spread out rather than being layered. The use of an illuminated magnifier is helpful in locating specimens.

Using a forceps place similar appearing forms together in a partitioned ice tray or glassware containing preservative or water depending upon how active the organisms are.

If one of your objectives is to know which invertebrates inhabit what habitat types then use a separate partitioned container for each habitat type. This step is usually unnecessary unless time is not a factor.

Processing macroinvertebrates in the lab

Use flat more pliable forceps to transfer soft bodied organisms such as mollusks (snails and clams). Leeches, aquatic earthworms and flatworms are placed in water rather than preservative for ease in identification. Fast moving forms such as freshwater shrimp can be sucked up by the use of a small pipette or caught with a spoon.

If extremely large numbers of invertebrates are present, such as aquatic earthworms or black fly larvae, further subsample these groups. If you do subsample, pick out all of the less dominant taxa from the remaining quadrant or quadrants using forceps.

If you have not counted about 100 specimens by the time the first quadrant has been completely picked, begin the second quadrant. Once you begin processing a quadrant, always finish it even though you have picked out over 100 organisms. Once you have finished, have an instructor check to see if you did not overlook many specimens. This is a means of practicing Quality Control.

Record the number of quadrants processed from each sample to calculate the relative number of organisms.

Identification

Some basic instruction is provided in the use of keys, which will be used to identify immature aquatic insects, leeches, aquatic earthworms, and gastropods. Insect identification is to family. Refer to the total taxa richness section below for more information.

Remove a specimen from the partitioned ice tray or glassware and place in a shallow dish containing 70-80 % ethanol preservative. Use a dissecting microscope to observe the specimens and attempt to identify them using the keys provided. An instructor will be available to answer questions.

Teasing needles and forceps enable you to manipulate or turn the organism around in the dish as you work on it. After specimens are identified, check your work with the instructor to see if the identification is correct. This is a Quality Control measure. If identification is wrong, compare specimen (s) with reference collection and verify again with instructor.

Record the number of individuals belonging to that taxa on specifying the stream name, station number, date, and habitat type if you
have previously kept habitats separate by using different partitioned containers.

Once the specimens have been identified, enumerated and recorded on the above form, analyses of data can begin.

Table 6. Indentification list of macroinvertebrates

Stream _____

Site _____

Identifier _____

Date _____

	Erosional Hab					Macrophytes					CPOM					Function	Tolerance
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5		
Ephemeroptera																	
Siphlonuridae																Collector/Gatherer	7
Baetidae																Scrapers	4
Heptageniidae																Scrapers	4
Ephememrellidae																Collector/Gatherer	1
Tricorythidae																Collector/Gatherer	4
Caenidae																Collector/Gatherer	7
Leptophlebiidae																Collector/Gatherer	2
Plecoptera																	
Pteronarcidae																Shredders	
Peltoperlidae																Shredders	2
Taeniopterygidae																Shredders	2
Nemouridae																Shredders	2
Leuctridae																Shredders	
Capniidae																Shredders	1
Perlidae																Predators	1
Perlodidae																Predetors	2
Chloroperlidae																Predators	1
Trichoptera																	
Rhyacophilidae																Predators	
Glossosomatidae																Scrapers	1
Hydroptilidae																Collector/Filterers	4
Philopotamidae																Collector/Filterers	3
Hydropsychidae																Collector/Filterers	4
Limnephilidae																Shredders	4
Brachycentridae																Collector/Filterers	1
Lepidostomatidae																Shredders	1
Phryganeidae																Collector/Gatherers	4
Leptoceridae																Collector/Gatherers	4
Diptera																	
Tipulidae																Omnivores	3
Ceratopogonidae																Predators	6
Culicidae																Collector/Gatherers	8
Psychodidae																Collector/Gatherers	10
Ptychopteridae																Collector/Gatherers	7
Simuliidae																Collector/Filterers	6
Empididae																Predators	6
Pelecorhynchidae																Predators	3
Muscidae																Predators	6
Athericidae																Predators	4
Ephydridae																Collector/Gatheres	6
Statiomyiidae																Collector/Gatheres	8
Tabanidae																Predators	6
Sciomyzidae																Predators	10
Blepharoceridae																Scrapers	2
Chironomidae																Omnivores	6

Table 6 (cont). Indentification list of macroinvertebrates

Stream _____

Site _____

Identifier _____

Date _____

Taxa	Erosional					Macrophytes					CPOM					Function	Tolerance
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5		
Coleoptera																	
Amphizoidae																Predators	1
Dryopidae																Shredders	5
Dytiscidae																Predators	5
Hydrophilidae																Predators	5
Elmidae																Collector-Gatherers	4
Haliplidae																Omnivores	7
Psephenidae																Scrapers	4
Lepidoptera																	
Pyralidae																Scrapers	5
Hemiptera																	
Belostomatidae																Predators	11
Corixidae																Predators	8
Gerridae																Predators	11
Veliidae																Predators	11
Saldidae																Predators	11
Megaloptera																	
Slalidae																Predator	4
Odonata																	
Gomphidae																Predators	1
Aeshnidae																Predators	3
Libellulidae																Predators	9
Caenagrionidae																Predators	9
Calopterygidae																Predators	5
Corduliidae																Predators	5
Lestidae																Predators	9
Non-Insect Taxa																	
Oligochaeta																Collector-Gatherers	5
Lumbriculidae																Collector-Gatherers	10
Naididae																Collector-Gatherers	11
Tubificidae																Collector-Gatherers	10
Platyhelminthes																	
Turbellaria																Predators	4
Hirudinea																Predators	10
Glossiphoniidae																Predators	8
Piscicolidae																Predators	7
Hirudinidae																Predators	7
Erpobdellidae																Predators	8
Gastropoda																Scrapers	7
Hydrobiidae																Scrapers	11
Lymnaeidae																Scrapers	6
Physidae																Scrapers	8
Planorbidae																Scrapers	7
Lymanaeidae																	
Ancylidae																Scrapers	6
Pelecypoda																Collector-Filterers	8
Sphaeriidae																Collector-Filterers	8
Amphipoda																Collector-Gatherers	4
Hyallela axteca																Collector-Gatherers	8
Decapoda																Shredder	8
Pacifasticus sp.																Omnivore	6
Isopoda																Collector-Gatherers	9
Ostracoda																Collector-Gatherers	8
Nematoda																Predators	5
Nematomorpha																Predators	5
Acari																Predators	11

Data Evaluation

The Streamwalk III bioassessment approach is a modification of Rapid Bioassessment Protocols 2 and 3 (Plafkin et al. 1989). In Protocol 2 riffle/run and CPOM samples are collected and identified to family in the field. Eight different metrics are used in the scoring process based on a 100-organism subsample. Protocol 3 differs from Protocol 2 since subsampling and identification are performed in the laboratory and specimens identified to genus or species.

Streamwalk III bioassessment is unlike both of the above protocols in that samples may also be collected along the shore and in the channel where vegetation occurs and seven metrics are used in the scoring process. It is similar to Protocol 2, as identification is to the family level; it is similar to Protocol 3 because identification and analysis occurs in the lab. Scoring is also similar to Protocol 3.

Metric Analysis

The biological integrity of a macroinvertebrate community is described as the composition, structure, and function of a macroinvertebrate community. It is measured by scoring a number of metrics which in this methodology are relative abundance, total taxa richness, EPT taxa richness, EPT abundance, percent dominant taxa, Hilsenhoff Biotic Index and Shannon-Weiner Species Diversity.

Relative Abundance is a qualitative measure of the number of organisms within the sample. As a stream becomes impacted, the numbers of invertebrates are expected to decrease relative to the area sampled. Often, however large numbers of a few tolerant species may account for a high relative abundance.

Total Taxa Richness is the total number of different taxa (mix of species, genera and families) present in the sample. In most every case, identification will be to family. There may be more than one kind of species belonging to a family identified. In that case, specimens are listed as Species A, Species B, etc. under family or other taxonomic listing.

As a general rule, a high species richness is indicative of a healthy stream community. However, taxa richness of unimpacted streams may vary significantly in different geographical regions. Some streams contain more non-insect species than insects. Non-insect forms are often more tolerant to stress than insect species.

Expect to find a relatively high taxa richness where a number of habitat types exist (riffles/runs, aquatic plants, CPOM) when compared with a similar stream of the same water quality, but having only a small number of instream habitats.

EPT Taxa Richness is the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) found in the sample. Most taxa belonging to these three insect orders are sensitive to stressful conditions.

Stream reaches having a high EPT count are those waters usually associated with clean water and an unimpacted habitat.

EPT Abundance is the percentage of EPT species in the entire sample. Again, a high percentage indicates favorable water quality and habitat assessment.

Hilsenhoff Biotic Index (HBI) is a value given to an organism depending upon its tolerance to pollution. Low values indicate organisms sensitive (not tolerant) to pollution. High values indicate organisms more tolerant and less sensitive to stress.

$$HBI = \frac{\sum n_i a_i}{N}$$

Where:

n_i = number of individuals in each taxa
a_i = index value of that taxa
N = total number of individuals in sample

A family level biotic index (Hilsenhoff 1988) is available to record values in the formula above. Values from 0 to about 4 are considered to exhibit low tolerance and values over 6 have high tolerance to environmental conditions. Refer to the table describing family tolerance values following this section on metrics. Record value for each taxa identified on the list.

The presence of sensitive intolerant organisms provides evidence of satisfactory environmental quality; however, tolerant macroinvertebrates may be found in both polluted and clean water so their presence is of less significance.

Percent Dominant Taxa is the percent of the most dominant taxa in the sample. High dominance in a community usually relates to an impacted habitat or poor water quality. Dominance is often exemplified by such organisms as aquatic earthworms and fly larvae which can exist under environmental conditions unsuitable to most EPT forms.

Taxa richness is usually lower where high dominance exists.

Species Diversity is a unique biological characteristic of a community. It is based on the richness or number of species and evenness or relative abundance of a community. A community has a high diversity if many equally or nearly equally abundant species are present. If a community is comprised of only a few species or if only a few species are abundant (high dominance) then species diversity is low.

As an example, community A is comprised of five species with the following number of individuals corresponding to each species: 5, 1, 1, 1, 1. Community B likewise contains five species, but the distribution of individuals is more even: 2,2,2,2,1.

The **Shannon-Weiner** index is a measurement of species diversity based on information theory and the idea of "uncertainty." In community A, with 9 individuals, we would be more certain in randomly selecting the first species having 5 individuals. In community B, we would be more uncertain of which species is selected because of the evenness of distribution. High diversity is thus associated with high uncertainty and low diversity with low uncertainty.

According to Brower and Zarr (1984), if data is from a large community or subcommunity and randomly collected, we can use the Shannon-Weiner index.

$$\bar{H} = \sum pi \log Pi$$

Where pi = ni/N (an expression of relative abundance)

ni = each species

N = total number of individuals

Any logarithmic base may be used. Here base 2 is used. The following example will be used to illustrate the calculation of $\bar{H}$:

Species (i)	Abundance (ni)	Relative Abundance (Pi)
1	40	40/100
2	20	20/100
3	40	10/100
s = 3	N = 100	

By using algebraic manipulation some shortcuts can be taken:

$$\bar{H} = (N \log N - ni \log ni)/N$$

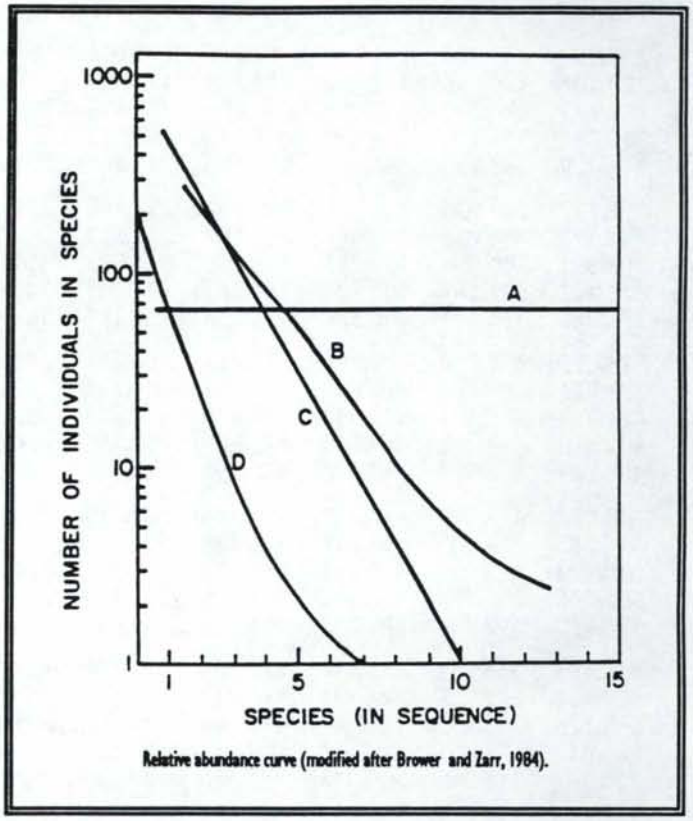
Utilize the accompanying table from Brower and Zarr to determine N log N and ni log ni values.

$$\bar{H} = [100 \log 100 - 40 \log 40 + 20 \log 20 + 40 \log]/100$$
$$= [200.00 - (64.082 + 26.021 + 64.082)]/100$$
$$= 45.815/100$$
$$= 0.45$$

To convert from log base 2 to log base 10 which is more commonly used multiply 0.45 by 3.3219.

$\bar{H}$ is used only in a relative manner or to compare diversities between communities or subcommunities.

The relative abundance curve or species importance curve is a graphic way of illustrating species diversity. On the horizontal axis, the species are ranked in sequence from 1 to s where s is the total number in the community or subcommunity. The species with the highest importance value (numbers, biomass, productivity) is ranked number one. The second most important is assigned rank 2, etc. The least important is ranked s. On the vertical axis, the important values are plotted on a logarithmic scale.



Relative abundance curve (modified after Brower and Zarr, 1984).

Scoring

A score is given to each resultant metric which is based on percent comparability to a reference or control station (refer to Tables 7-11 which follow). As an example, an impacted stream has a taxa richness value of 5, while a reference stream may have a value of 14. So, the taxa richness of the impacted stream is 64% that of the reference stream. When the percentage value is compared with a scoring criteria table, the score equals 4. Scores are totaled for the seven metrics of the macroinvertebrate community from impacted, reference, and control streams when present and a percent comparability to the reference is calculated.

These percent comparability scores for each station sampled are then categorized according to a biological condition, described as non-impaired, slightly impaired, moderately impaired and severely impaired. Habitat assessment and water chemistry values provide another means of evaluating the stream.

*Values of log $n_i!$ (or log N!) for use in equation 16.**

n_i	0	1	2	3	4	5	6	7	8	9	n_i
0	0.000	0.000	0.301	0.778	1.380	2.079	2.857	3.702	4.606	5.560	0
10	6.560	7.601	8.680	9.794	10.940	12.116	13.321	14.551	15.806	17.085	10
20	18.386	19.708	21.051	22.412	23.793	25.191	26.606	28.037	29.484	30.947	20
30	32.424	33.915	35.420	36.939	38.470	40.014	41.571	43.139	44.719	46.310	30
40	47.912	49.524	51.148	52.781	54.425	56.078	57.741	59.413	61.094	62.784	40
50	64.483	66.191	67.907	69.631	71.363	73.104	74.852	76.608	78.371	80.142	50
60	81.920	83.706	85.498	87.297	89.103	90.916	92.736	94.562	96.394	98.233	60
70	100.078	101.930	103.787	105.650	107.520	109.395	111.275	113.162	115.054	116.952	70
80	118.855	120.763	122.677	124.596	126.520	128.450	130.384	132.324	134.268	136.218	80
90	138.172	140.131	142.095	144.063	146.036	148.014	149.996	151.983	153.974	155.970	90
100	157.970	159.974	161.983	163.996	166.013	168.034	170.059	172.089	174.122	176.160	100
110	178.201	180.246	182.295	184.349	186.405	188.466	190.531	192.599	194.671	196.746	110
120	198.825	200.908	202.995	205.084	207.178	209.275	211.375	213.479	215.586	217.697	120
130	219.811	221.928	224.049	226.172	228.299	230.430	232.563	234.700	236.840	238.983	130
140	241.129	243.278	245.431	247.586	249.744	251.906	254.070	256.237	258.408	260.581	140
150	262.757	264.936	267.118	269.302	271.490	273.680	275.873	278.069	280.268	282.469	150
160	284.673	286.880	289.090	291.302	293.517	295.734	297.954	300.177	302.402	304.630	160
170	306.861	309.094	311.329	313.567	315.808	318.051	320.296	322.544	324.795	327.048	170
180	329.303	331.561	333.821	336.083	338.348	340.615	342.885	345.157	347.431	349.707	180
190	351.986	354.267	356.550	358.836	361.124	363.414	365.706	368.000	370.297	372.596	190
200	374.897	377.200	379.505	381.813	384.123	386.434	388.748	391.064	393.382	395.702	200
210	398.025	400.349	402.675	405.004	407.334	409.666	412.001	414.337	416.676	419.016	210
220	421.359	423.703	426.049	428.398	430.748	433.100	435.454	437.810	440.168	442.528	220
230	444.890	447.253	449.619	451.986	454.355	456.727	459.099	461.474	463.851	466.229	230
240	468.609	470.991	473.375	475.761	478.148	480.537	482.928	485.321	487.715	490.112	240
250	492.510	494.909	497.311	499.714	502.119	504.525	506.933	509.343	511.755	514.168	250
260	516.583	519.000	521.418	523.838	526.260	528.683	531.108	533.534	535.962	538.392	260
270	540.824	543.257	545.691	548.127	550.565	553.004	555.445	557.888	560.332	562.777	270
280	565.225	567.673	570.124	572.575	575.029	577.483	579.940	582.398	584.857	587.318	280
290	589.780	592.244	594.710	597.177	599.645	602.115	604.586	607.059	609.533	612.009	290
300	614.486	616.964	619.444	621.926	624.409	626.893	629.379	631.866	634.354	636.844	300
310	639.336	641.828	644.323	646.818	649.315	651.813	654.313	656.814	659.317	661.820	310
320	664.326	666.832	669.340	671.849	674.360	676.872	679.385	681.899	684.415	686.932	320
330	689.451	691.971	694.492	697.014	699.538	702.063	704.589	707.117	709.646	712.176	330
340	714.708	717.240	719.774	722.310	724.846	727.384	729.923	732.464	735.005	737.548	340
350	740.092	742.637	745.184	747.732	750.281	752.831	755.382	757.935	760.489	763.044	350
360	765.600	768.158	770.716	773.276	775.837	778.400	780.963	783.528	786.094	788.661	360
370	791.229	793.798	796.369	798.941	801.513	804.087	806.663	809.239	811.817	814.395	370
380	816.975	819.556	822.138	824.721	827.305	829.891	832.478	835.065	837.654	840.244	380
390	842.835	845.427	848.021	850.615	853.210	855.807	858.405	861.003	863.603	866.204	390
400	868.806	871.410	874.014	876.619	879.225	881.833	884.441	887.051	889.662	892.273	400
410	894.886	897.500	900.115	902.731	905.348	907.966	910.585	913.205	915.826	918.449	410
420	921.072	923.696	926.321	928.948	931.575	934.204	936.833	939.463	942.095	944.727	420
430	947.361	949.995	952.631	955.267	957.905	960.543	963.183	965.823	968.465	971.107	430
440	973.751	976.395	979.040	981.687	984.334	986.983	989.632	992.282	994.933	997.586	440
450	1000.239	1002.893	1005.548	1008.204	1010.861	1013.519	1016.178	1018.838	1021.499	1024.161	450
460	1026.824	1029.487	1032.152	1034.818	1037.484	1040.152	1042.820	1045.489	1048.160	1050.831	460
470	1053.503	1056.176	1058.850	1061.525	1064.200	1066.877	1069.555	1072.233	1074.913	1077.593	470
480	1080.274	1082.956	1085.639	1088.323	1091.008	1093.694	1096.381	1099.068	1101.757	1104.446	480
490	1107.136	1109.827	1112.519	1115.212	1117.906	1120.600	1123.296	1125.992	1128.689	1131.387	490

* If values for n_i (or N) larger than 499 are needed, consult Lloyd, Zar, and Karr (1968), Pearson and Hartley (1966: Table 51), or Zar (1974: Table D.6). Or, one may use Appendix D, table D.1 to compute log $n_i!$ (or log $N!$) by "Stirling's approximation":

$\log n_i! = (n_i + 0.5) \log n_i - 0.4343\, n_i + 0.3991.$

Table 7. Bioassessment values of macroinvertebrate communities

Metric	Impaired Stations				Reference	Control
	1	2	3	4		
Relative Abundance						
Total Taxa Richness						
EPT Taxa Richness						
EPT Abundance						
Hilsenhoff Biotic Index						
Percent Dominant Taxa						
Species Diversity						

Table 8. Percentage of reference or control station values to impaired stations

Metric	Impaired Stations				Reference	Control
	1	2	3	4		
Relative Abundance						
Total Taxa Richness						
EPT Taxa Richness						
EPT Abundance						
Hilsenhoff Biotic Index						
Percent Dominant Taxa						
Species Diversity						

Table 9. Metric scoring criteria

Score					Explanation
	6	4	2	0	
Relative Abundance	> 80%	60-79	40-59	<40	1
Total Taxa Richness	> 80%	60-79	40-59	<40	1
EPT Taxa Richness	> 90%	80-89	70-79	<70	1
EPT Abundance	> 80%	60-79	40-59	<40	1
Hilsenhoff Biotic Index	> 85%	70-84	50-70	<50	2
Percent Dominant Taxa	< 20%	20-29	30-39	>40	3
Species Diversity	> 90%	60-79	40-59	<40	1

1 = Score based on ratio of impacted site to reference or control site x 100
2 = Score based on ratio of reference site to impacted site x 100
3 = Score based on actual site value and not % comparability to reference or control station

Table 10. Percentage of stations based on above criteria

Metric	Impaired Stations				Reference	Control
	1	2	3	4		
Relative Abundance						
Total Taxa Richness						
EPT Taxa Richness						
EPT Abundance						
Hilsenhoff Biotic Index						
Percent Dominant Taxa						
Species Diversity						
TOTAL						

Table 11. Biological condition categories based on total percentage scores

> 80% of total reference or control sites	NONIMPAIRED
60 - 79%	SLIGHTLY IMPAIRED
40 - 59 %	MODERATELY IMPAIRED
< 40%	SEVERELY IMPAIRED

Additional Metrics

Functional types reflect different feeding niches associated with macroinvertebrates in a stream. If many different types are present then this condition reflects a healthy community as compared to a stream with only a few functional types.

The following is a list of functional types:

Scraper	scrape algae and diatoms off substrate
Shredder	utilize coarse particulate organic matter
Collector/Gatherers	utilize fine particulate organic matter, mostly bottom detritus
Collector/Filterers	utilize fine particulate organic matter filtered from water column
Predator	pierce or engulf prey species

Once you identify organisms in the sample, refer to the lists of taxa functions following the discussion of metrics. Next, record the function that corresponds with the taxa identified on the macroinvertebrate identification list.

Index of Similarity indicates the similarity of taxa between two communities. When one community is highly stressed by poor water quality or inferior habitat and is compared to a reference stream, then low similarity (S) (or a high index of dissimilarity) is expected between the two communities.

$$S = \frac{2c}{A+B}$$

Where:

A	=	number of species in sample
B	=	number of species in sample
C	=	number of species common to both samples
1-S	=	Index of Dissimilarity

Data Reporting

Report results of the study in tabular form or pictorially with pie diagrams, histograms, or bar and line graphs. Creating charts can be accomplished on the computer using software such as Microsoft, WordPerfect, Excel, Lotus or Harvard Graphics

Equipment

Sampling

field book
net sampler
kick screen
dip net
screen bucket
ziplock bags
ice chest
garden fork
rubber boots or waders
pencils
marking pen
meter stick
forceps
pack to carry gear
stakes
camera and film

Processing

0.6 mm screen (US Standard No. 30)
flat tray
enamel pan
dice
tablespoon
illuminated magnifier
ice trays
squirt bottles
clicker
jars
plastic wrap
forceps
teasing needles
small pipette

Identification

keys to macroinvertebrates
dissecting microscope and light source
teasing needles, forceps
glass dish
partitioned trays
squirt bottle -80% alcohol
soda water
forms

Notes

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