Manitou Stream Monitoring Project

Field Methods

Valerie Brady, Lucinda Johnson, and Jane Reed

Natural Resources Research Institute
University of Minnesota Duluth

NRRI/TR-2004/36

April 2004

This stream monitoring protocol primarily describes collection of data about basic geomorphological and physical habitat parameters of stream reaches. Suggested protocols for future monitoring of stream biota and nutrients have been included at the end.

Ideally, all evaluations should be made during baseflow. Sampling should not be attempted during floods or bankfull flows due to danger to field crews and lack of comparability of data to past and future sampling.

List of measurements

Table 1: Transect scale measurements (detailed measurements taken along each transect)

Parameter	Scale	Description
Channel type/ dominant flow regime	Intertransect	Upstream and downstream of each transect, record the dominant channel type/flow regime.
Slope	Intertransect	Measure slope between each pair of transects.
Bankfull width (m)	Transect	Width of channel at bankfull
Bankfull depth (m)	Transect	Depth of channel at bankfull
Baseflow width (m)	Transect	Width of channel at baseflow
Baseflow depth (m)	Transect	Water depth during baseflow
Stream bed features (%)	Transect	Percent of intertransect streambed for each type of feature (pool-riffle, planebed, step-pool, cascades, bedrock chutes and falls)
Substrate type (%)	Transect w. reach summary	Estimate the percent substrate type of cross section (bedrock, boulder, cobble, gravel, sand, silt/clay, muck, marl, detritus)
Embeddedness (%)	Transect	Percent embeddedness of gravel/cobble substrates
Depth of unconsolidated sediments (cm)	Transect	Measure soft sediment depth in riffles and pools using a metal rod
Riparian vegetation	Transect	Describe the percent by type (herbs, shrubs, trees), size (small, medium, large), and density of riparian vegetation (sparse, moderate, dense)
Canopy cover (%)	Transect	Estimate the amount of stream shading
Bank: slope, undercut, stability	Transect	For each bank, measure bank slope, depth of undercut, and estimate stability on a scale of 1 to 5

Table 2: Reach scale measurements (more general measurements taken at the scale of the entire stream reach)

Parameter	Description
Channel bed morphology (%)	Percent of bed morphology in each category (cascade, step-pool, plane bed, forced pool-riffle, pool-riffle)
Channel pattern (%)	Percent of channel in each category (meandering, sinuous, straight, braided)
Bed material (%)	Colluvium, alluvium, bedrock
Sedimentation	Relative scale (5 to 1) for presence of surface fines within stream bed
Substrate type (%)	Estimate the percent substrate type of the entire reach (bedrock, boulder, cobble, gravel, sand, silt/clay, muck, marl, detritus, artificial)
Gravel bars (rank by dominance) and bar vegetation	Form (point, medial, lateral, forced), % active channel area, presence and type of vegetation, circumference of largest woody vegetation.
Gravel bar sediment	Relative scale (5 to 1) for presence of surface fines on gravel bars
Control of active storage (%)	List and estimate % for: LWD, boulder, bedrock, channel morphology, vegetation
Large wood (LWD) count	Count of all large wood
Primary LWD functions (rank)	Record dominant LWD functions in each reach: Pool scour, bank stability, bar stability, sediment trap, step former.
Channel alteration	Length of channel affected by channelization, dredging, filling, impoundment, and associated scour. Rank (5 to 1) of severity
Riffle quality	Rate riffle substrate stability as either stable, unstable, or bedrock
Side channels	Functional (yes/no); height of inlet above thalweg
Bank material (%)	Bedrock, boulders, alluvium, colluvium, till
Bank protection (%) & exposure (%)	Bank protection (bedrock, boulders, riprap, LWD, vegetation, levees) and exposure (as % unprotected banks)
Instream cover types	Estimate percentage of each type (undercut banks, overhanging vegetation, slow shallows, LWD, deep pools, oxbows, boulders, macrophytes)
Instream habitat types	Estimate percentage of each type (riffles, runs, pools, islands, dams, log jams)
Aufwuchs development	Categorize the amount of aufwuchs on streambed surfaces: none, normal, high, filamentous algae clumps
Beaver activity	Type and count (dam, lodge, channel excavation) and % of reach affected
Riparian landuse	Type (silvaculture, logged, rowcrop, orchard, pasture, grassland, shrubland, forest, wetland, bare ground, residential, urban, road/RR, urban recreation) and percent area
Riparian buffer width (m)	Width of undisturbed land adjacent to the stream
Water parameters	Collected at upstream end of reach: water and air temperature, DO, pH, conductivity
Water clarity and color	Measure water clarity with a transparency tube or on a relative scale (1 to 5); note water color (none, white/milky, brown/tannic, tan/silty, green, orange/rusty)
Flow level	Flood, high flow, normal/baseflow, low flow, not flowing

Current variability	Types of current velocities present (torrential, fast, moderate, slow, no flow, eddies, interstitial flow)
Dom flow regime	Dominant flow regime for the reach (pool-riffle, planebed, step-pool, cascades, bedrock falls & chutes)

Table 3: Laboratory calculations (reach scale)

Parameter	**Description**
Entrenchment	Calculated as baseflow width:bankfull width
Channel pattern	Ratio of stream length to reach length based on straight line vs streambed intertransect measurements.
Floodplain landuse	Percent landuse (silvaculture, logged, rowcrop, orchard, pasture, grassland, shrubland, forest, wetland, bare ground, residential, urban, road/RR, urban recreation) by category in floodplain, calculated using GIS.
Watershed storage	Percent of upstream watershed water storage
Width to depth ratio	Average width/average thalweg pool and run depth
Total fish cover available	Sum percents of all cover types (undercut banks, overhanging vegetation, slow shallows, LWD, deep pools, oxbows, boulders, macrophytes) for the reach.
Valley shape and stream size	Use GIS to estimate valley shape, stream size, overall stream gradient
Watershed water storage	Use GIS to calculate the percent land area as lakes and wetlands for the watershed above the stream reach.

Detailed description of parameters and sampling methods

Establishing the survey reach and transects:
Survey reach: Begins 30 m downstream of bridge or stream access point; continues for 30 mean stream widths (MSW; minimum length 100 m; maximum length 500 m). Measure using a tape. Justification for downstream start: Collecting data downstream of roads will allow changes in the stream due to increased logging truck traffic and logging road construction or maintenance to be detected.

Finding MSW: MSW is measured as the wetted surface of the channel during baseflow (excluding islands, wetlands, etc). Average ten stream channel cross-sectional measurements between 30 and 50 m downstream of the bridge. Calculate intertransect distance as reach length divided by the number of transects (10).

If possible, create GPS waypoints for each end of the reach. Document the reach by taking photographs of the reach from each end and from the center of the reach looking both upstream and downstream. An overview photograph showing the valley segment is also useful, but may not be possible.

Transects: Ten transects (cross sections) should be placed in the reach, one transect about every three mean stream widths.

Sampling: Transect (cross section-specific) information is collected first. Most reach information is gathered while walking back the other direction after sampling the transects. Note that photographs, water quality, MSW and mapping need to be conducted at specified places within the reach.

Transect measurements:
Channel type/dominant flow regime: From the previous transect to the current transect (or from 10 m prior to the first transect), record the channel type: pool-riffle, planebed (run), step-pool (boulder or LWD formed steps), cascades (large boulders, white water, small pools associated with individual particles), bedrock falls and chutes (Montgomory and Buffington 1993).

Slope: Measure using either a laser level or a clinometer. Measure between transects where bends and obstructions are not in the way. Clinometer method: While working upstream, orange flagging is placed at eye height on adjacent vegetation while standing with heels at the water line. This flagging is then "shot at" with the clinometer while working back downstream. With either method, measure the distance between transects both along the stream channel and as a straight line; this information will also be used to calculate reach sinuosity. For more details, refer to Harrelson et al. (1994). Laser levels, while more precise, are much more difficult to carry in rough terrain and take more time to use. Clinometers are much easier to carry and use, but are less accurate and more subjective.

Bankfull determination: If the active floodplain is not obvious, look for the highest evidence of deposition, a change in vegetation, slope or topographic breaks in the bank, a change in bank particle size, height of undercuts (should be just below bankfull), stain lines, or the lower extent of lichens on bank rocks (Harrelson et al. 1994).

Baseflow width: Measure using a range finder or tape measure at each transect. If the stream has more than one channel, all channels should be measured and their widths summed. Do not include islands in the baseflow width measurement.

Baseflow depth: Measure actual water depth in the stream thalweg (deepest part of channel). Note whether the measurement is taken in a pool, riffle, or run (planebed).

Bankfull width: Measure using a range finder or meter tape at each transect. If the stream has more than one channel, all channels should be measured and their widths summed. Do not include islands in the bankfull measurement.

Bankfull depth: Measure depth from stream bottom to the top of the bank using a stadia rod or meter stick at the stream thalweg (deepest part of channel).

Floodprone width: Width of the valley at twice the bankfull depth. Use stadia rod to determine twice the bankfull depth, then measure the width of the valley using 100 m tape or range finder. This will be difficult or impossible in wide valleys filled with trees (i.e. streams that have a very large floodplain), but it may be possible to estimate floodprone width using GIS and elevation data for these streams.

Stream bed features: Estimate percent of the stream between the previous transect and the current transect as pool, riffle, run, plane bed, chute, point bar, medial bar, or lateral bar.

Substrate: Estimate the percent of each substrate type (bedrock, boulder, cobble, gravel (aka pebbles), sand, silt/clay, muck, marl, detritus, artificial) across the transect (Figure 1). Muck: black, fine, flocculent, completely decomposed organic matter. Marl: calcium carbonate; usually greyish-white. Artificial: substrates such as rock baskets, gabions, bricks, trash, concrete, etc., placed in stream for reasons other than habitat mitigation.

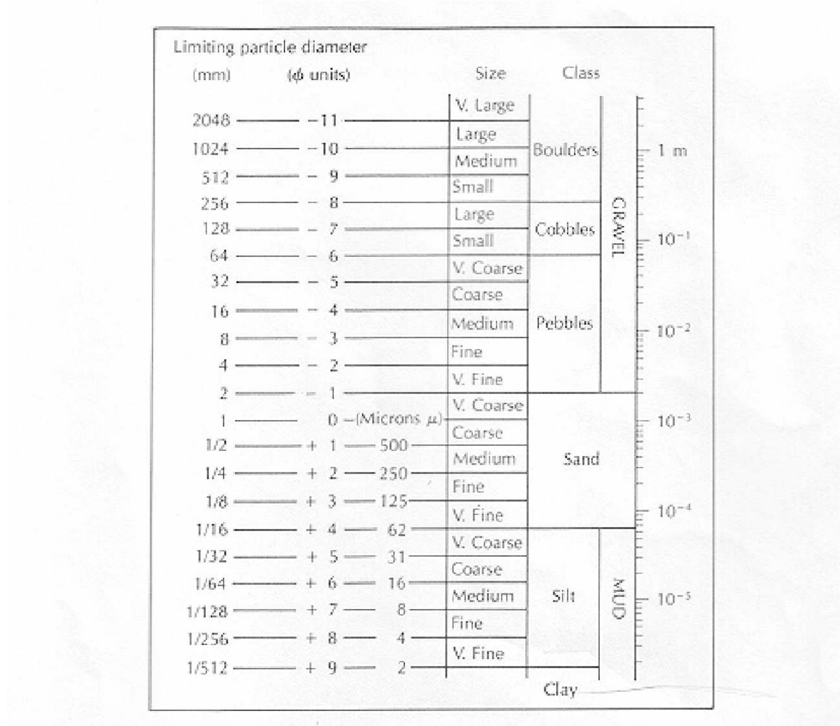

Figure 1. Standard sizes of sediments with limiting particle diameters. From: G.M. Friedman and J.E. Sanders. 1978. Principles of Sedimentology. John Wiley and Sons, New York.

Embeddedness of gravel/cobble: Estimate percent (to within 10%) embeddedness of riffles/runs. General guidelines: 0% = no fine sediments even at base of top layer of gravel/cobble; 25% = rocks are half surrounded by sediment; 50% = rocks are completely surrounded by sediment but their tops are clean; 75% = rocks are completely surrounded by sediment and half covered; 100% = rocks are completely covered by sediment (Simonson et al. 1994).

Unconsolidated sediment depth: Measure depth of unconsolidated sediments in riffles/runs and in pools separately by pushing a strong meter stick into the stream bed until it stops; depth (cm) from surface of the sediment to the point where the meter stick stops. Average three measurements across the transect. This is only applicable for streams with sand, silt, clay, muck, or marl substrates or with high embeddedness.

Riparian vegetation: For each bank, describe the type and percent, size, and density of riparian vegetation from bankfull height to 10 m upslope of bankfull at each end of the transect. Type: Estimate the percent of the riparian area covered by each vegetation type: herbs, shrubs, and trees (if bare ground were included, the number should sum to 100%). Note whether shrubs and trees are primarily deciduous, coniferous, or mixed. For trees, estimate tree size: small (<6 inches dbh); medium (between 6 and 20 inches); and large (>20 inches dbh) and measure the circumference of the largest tree on each bank. Rank woody vegetation density as either sparse (>1/3 of area between trees is open to sky), moderate (~ ½ of area between trees is open sky) or dense (<1/3 of area between trees is open).

Canopy cover: Estimate the amount of stream shading as a percent using a densiometer. This is best done during the summer at near mid-day standing near the center of the stream. Count the number of grid squares showing obstructions to sunlight for each of 4 directions (upstream, downstream, right, and left) while standing in the center of the transect. Average these numbers and divide by the total number of grid squares (96) on the mirror to get a percent of the stream that is shaded (Simonson et al. 1994).

Bank slope: At each end of the transect, measure bank slope using a clinometer or laser level. Clinometer method: While standing at the top of the bank (bankfull), hang flagging at eye level. Then, standing directly beneath the flagging at the water's edge with heels at the water line, look up to the flagging and measure the slope.

Bank undercutting: Measure depth of undercutting in meters using a meter stick at each end of the transect.

Bank stability: For each bank, estimate bank stability on a scale of 1 (very unstable, e.g. actively eroding banks) to 5 (very stable, e.g. bedrock or riprap).

Reach measurements:
Water physical parameters: At the upstream end of the reach, measure water and air temperature (to obtain temperature difference), dissolved oxygen, pH, and specific conductivity. Note meter type and when the meter was calibrated.

Water clarity: Measure water clarity using a turbidity tube (m) or rank it on a scale of 1 (very clear) to 5 (very turbid). Note water color as none, white/milky, brown/tannic, tan/silty, green, orange/rusty.

Channel bed morphology: Estimate the percent of the channel reach that is each type: colluvial (sediment deposited by gravity; such channels are only found in small headwater streams where there is little fluvial sediment transport), cascade (large boulders, white water, small pools assoc. with individual particles), step-pool (boulder or LWD formed steps), plane bed (runs; laminar flow, no pools), bedrock, forced pool-riffle (most pools and bars are forced by obstructions such as LWD), pool-riffle (Montgomory and Buffington 1993).

Channel pattern and development: Percent of the channel in each category [braided (numerous threads/channels with numerous large, unstable medial and lateral bars), meandering (sinuosity >1.5), sinuous (sinuosity between 1.2 and 1.5), and straight (very few bends, sinuosity <1.2)]. Sinuosity is the ratio of the length of the actual stream channel to the length of the valley. Measure the actual stream by running a tape along the stream thalweg or one of its banks, and measure the valley length by running a tape in a straight line from one end of the reach to the other (this will be done transect by transect and calculated later in the laboratory; see transect measures). If it is possible to create GPS waypoints for the ends of the reach and all channel bends, sinuosity could be calculated using GIS.

Bed material: Estimate the percent of the channel comprised of colluvium (sediment deposited in the stream by gravity; colluvial-dominated channels are typically small headwater streams), alluvium (sediment deposited in the stream channel by the stream), and bedrock.

Sedimentation (presence of surface fines): On a scale of 5 (high) to 1 (none), estimate the amount of sedimentation as presence of surface fines for the whole reach. A 1 indicates a lack of fines found even in natural depositional areas such as the lee of large obstructions and in pools. A 5 indicates large patches of fines throughout active channel and between particles even in high-energy parts of channel.

Gravel bars and bar vegetation: Count all bars by type [point (created on inside of meander bends), forced (associated with other hydraulic roughness elements such as wood or bedrock), medial (as islands within the wetted channel), or lateral (on stream edges other than inner bends)] and record number without vegetation, number with only herbaceous vegetation, and number with woody vegetation. If bars have woody vegetation, measure the circumference of the largest piece as an indication of bar age.

Gravel bar sediment: On a scale of 5 (high) to 1 (none), rank the amount of fine sediments on the surface of each bar.

Control of active storage in channel: Estimate the percent that each type (LWD, boulder, bedrock, channel morphology, and vegetation) controls active storage of sediment in the channel along the reach.

Large wood (LWD): LWD is defined as wood within the bankfull channel that is greater than 10 cm diameter and 1 meter long. Count LWD throughout reach for numbers less than 10; for amounts greater than 10 pieces, estimate the number as 11-15, 16-20, or more than 20. Also note the number of jams and estimate their size (LxWxH) in meters.

LWD functions: Rank the dominant functions of LWD within the reach. Functions: pool scour (pool former), bank stability, bar stability, sediment trap, step former.

Channel alteration: Note the length of channel affected by channelization, dredging, filling, impoundment (by humans), or other anthropogenic channel activity, including any associated scour. Rank the severity of the alteration from 5 (high) to 1 (low).

Riffle quality: Rate substrate stability as either stable, unstable, or bedrock. In unstable riffles, riffle material shifts around even under normal flow conditions. Stable riffles require bankfull or flood conditions to move riffle material.

Side channels: Measure the height of each side channel inlet above the thalweg and note whether or not it is functional (flowing).

Bank material: Percent of banks within reach by material (bedrock, boulders, alluvium, colluvium, till).

Bank protection: Percent of banks within reach protected by each category (bedrock, boulders, riprap, LWD, vegetation, levees).

Percent exposed bank: Estimate the percent of left and right banks that have exposed alluvium or bare mineral soil (not bedrock) **above** the bankfull flow. This provides an estimate of bank instability and erosion. Also note other sources of sediment and any bank alteration.

Instream cover types: Note all instream cover types (undercut banks, overhanging vegetation, slow shallows, LWD, deep pools, oxbows, boulders, macrophytes) and estimate the percentage of each along the reach. This is not meant to sum to 100%; instead, this represents the amount of the reach having each cover type; total cover values much above 35-40% are probably unlikely. Cover must be in or just above the water and should be large enough to serve as cover for fish at least 20 cm long (Simonson et al. 1994).

Instream habitat types: Note all instream habitat types (riffles, runs, pools, islands, dams, log jams) and estimate the percentage of each along the reach.

Aufwuchs development: Aufwuchs is the material that builds up on aquatic surfaces. Categorize the amount on streambed surfaces as none (rocks not slimy), normal (rocks slippery and difficult to walk on, but the slime layer is very thin), high (surfaces have visible fuzz on them), or filamentous algal clumps present.

Beaver activity: Percent and length of reach affected by activity of each type (dam, lodge building, channel excavation).

Riparian land use: For both the left and right banks, describe riparian land use and the percent of the riparian zone each occupies within 30 m of bankfull width. Land use types: silvaculture, logged, rowcrop, pasture, orchard, meadow/grassland, shrubland, natural forest, road/railroad, wetland, bare ground, residential, urban/developed, urban recreation (e.g. urban park, golf course).

Riparian buffer width: Estimate the average width of undisturbed land adjacent to the stream on each side of the reach.

Flow level: Note the flow condition during sampling (flood, high flow, normal (baseflow), low flow, not flowing).

Current variability: Note all current velocities present within the reach: torrential (extremely turbulent with fast flow), fast (rapid but mostly non-turbulent flow), moderate (detectable and visible non-turbulent flow), slow (water flow is perceptible, but very sluggish), not flowing, eddies (small areas of circular current behind rocks and in pools), interstitial flow (flow between the bed substrate material).

Laboratory measurements and calculations:

Entrenchment: Calculate average floodprone width and average bankfull width for the reach. Entrenchment ratio is average floodprone width:average bankfull width.

Width to depth ratio: Calculated by dividing average width by average thalweg depth in runs and pools. This provides an indication of whether the stream is relatively deep and narrow or shallow and wide. It is used in fish habitat evaluations (Simonson et al. 1994)

Sinuosity: This is the reach length following the stream channel divided by the straight-line distance between the upstream and downstream reach ends. Calculate by adding up streambed and straightline intertransect distances, then dividing stream bed by straightline reach distance.

Total available fish cover: Sum percents for all cover types present in stream reach.

Floodplain land use: Calculated via GIS from land cover classes

Watershed storage: Ratio of area of the watershed in lakes, streams, and wetlands to total watershed area above the stream reach; calculated using GIS.

Valley shape and stream size: Use GIS to estimate valley shape, stream size, overall stream gradient.

Future monitoring

These sampling descriptions are not complete protocols, but rather illustrate recommended sampling methods while allowing the sampling crew flexibility to tailor the methods to the types of streams being monitored.

Fish community sampling:
Equipment needed: Backpack electroshocker for very small streams and streams with many obstacles: ~$6500 with accessories from Smith-Root. SR-6 tote barge 2.5 GPP electroshocker for larger streams with fewer obstacles: ~$10,000 with accessories from Smith-Root.

Method: Fish should be sampled using a single upstream pass along the reach, with sampling beginning and ending at natural fish barriers (riffles, debris dams). This may make the sampled section slightly longer than the reach. Sampling should only be done during baseflow or low flow conditions. Depending on stream size and number of obstructions, either a tote barge electrofisher (three person crew) or backpack electrofisher (2-3 person crew) should be used. Current amperage should be between 2 and 2.5 amps to maximize capture efficiency while minimizing impacts on fish. All habitats within the reach should be thoroughly sampled. Fish larger than 25 mm should be identified, counted, measured (first 25 individuals of each species), and released unless voucher specimens are needed or identification needs to be verified. Fish less than 25 mm in length are not effectively captured by electrofishing and should not be counted.

Electrofishing references: Lyons 1992a,b; Lyons et al. 1996; Simonson and Lyons 1995; Meador et al. 1993; McCormick and Hughes 1998.

Macroinvertebrate community sampling:
Equipment needed: D-frame net $50-$100; Surber sampler ~$350. Recommended mesh size: 350 – 500 um. Larger mesh sizes speed processing time and create cost savings, but at the loss of the smaller invertebrates. Mesh sizes larger than 1 mm or smaller than 250 um are not recommended.

Sample processing costs: See attached spreadsheet

Method: Macroinvertebrates should be sampled in an upstream direction through the reach. The Surber sampler is used to collect quantitative samples from riffles while the D-frame net is used to collect qualitative samples from other important habitats such as overhanging vegetation and undercut banks, underwater root wads and wood dams. Pool habitats typically are not sampled for invertebrate community monitoring because these habitats typically have fewer taxa and provide less information. However, pools or runs may be sampled instead of riffles if no riffles are present in the stream reach.

Sampling effort should be the same for all streams, no matter the size of the reach. One Surber sample should be collected from each of four riffles spread throughout the reach. Four D-frame net samples should be collected from other important habitats throughout the reach (banks, overhanging vegetation, wood dams, root wads). D net sample effort is standardized by time, so each sample should be collected for a period of 60 seconds. For example, the net should be jabbed under banks and through overhanging vegetation for 60 seconds.

All samples should be kept separate and processed independently for optimal statistical use of the data. Samples containing many invertebrates may be subsampled to save time and processing costs. Other time saving techniques for sample processing include the use of dyes, floatation, or size fractionation. Processing costs will also depend on the level of invertebrate identification, but lower resolution identifications (e.g. family level) provide lesser ability to detect change.

Macroinvertebrate sampling references: Barbour et al. 1999; Cuffney et al. 1993; Lenat 1988.

Nutrient sampling:
Sample processing costs: See attached spreadsheet.

Stream hydrology:
Stream hydrology measurements were not included in the recommended monitoring because they are not informative for monitoring that occurs during baseflow on an annual or less frequent basis.

Schedule of sampling activities:
Ideally, the stream should be visited on two separate days for monitoring. On the first day, stream geomorphological information, water quality, and macroinvertebrates are sampled. Fish are sampled on the second day. Macroinvertebrates should be sampled working in an upstream direction in areas that have not been disturbed. Disturbance upstream of the sampling should be kept to a minimum. Geomorphological information should be collected following or downstream of invertebrate sampling.

These sampling activities will scare fish out of the reach, so it is recommended that fish sampling be performed at a later date. Alternatively, fish could be sampled by creating an adjoining reach immediately upstream of the main reach, provided this upstream area is geomorphologically similar to the main reach. A third alternative would be to divide the reach in half and sample fish in the downstream half of the reach prior to any other sampling activity, then sample invertebrates in the upstream half of the reach. This is the least preferable alternative because only half the recommended length of stream will be sampled for fish. In addition, it may not be possible to complete all sampling activities in one day, particularly if the stream presents electofishing challenges or contains a large number of fish.

Water quality should be taken at the upstream end of the reach upstream of any disturbances related to sampling activities. If approaching from upstream, samples should not be taken until a few hours have passed to allow conditions to normalize as much as possible. Grab samples should be kept chilled and should be collected as late in the sampling period as possible if ice is not easily available.

References

Barbour, M. T., Gerritsen, J., Snyder, B. D., and Stribling, J. B. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002, 1-D-10. Washington, D.C., U.S. Environmental Protection Agency, Office of Water.

Cuffney, T. F., Gurtz, M. E., and Meador, M. R. 1993. Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program. 93-406, 1-66. US Geological Survey.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An illustrated guide to field technique. USDA Forest Service Technical Report RM-245. 61 pp.

Lenat, D.R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. J. N. Am. Benthological Soc. 7(3):222-233.

Lyons, J. 1992a. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. N. Am. J. Fish. Manage. 12:198-203.

Lyons, J. 1992b. Using the index of biotic integrity (IBI) to measure environmental quality in warmwater streams of Wisconsin. USDA, Forest Service. Tech. Rep. NC-149.

Lyons, J., Wang, L., and T.D. Simonson. 1996. Development and validation of an index of biotic integrity for coldwater streams in Wisconsin. North American Journal of Fisheries Management 16:241-256.

McCormick, F.H., and R.M. Hughes. 1998. Aquatic vertebrate indicator. Pages 159-180 in J.M. Lazorchak, D.L. Klemm, and D.V. Peck, (eds.) Environmental Monitoring and Assessment Program Surface Waters: Field operations and methods for measuring the ecological condition of wadeable streams. EPA/620/R-94/004F. U.S. Environmental Protection Agency, Washington, D.C.

Meador, M.R., T.F Cuffney, and M.E. Gurtz. 1993. Methods for sampling fish communities as part of the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Rep. 93-104.

Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. GSA Bulletin, 109(5): 596-611.

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report TFW-SH10-93-002 for Washington State Timber/Fish/Wildlife Agreement.

Simonson, T.D., J. Lyons, and P.D. Kanehl. 1994. Guidelines for Evaluating Fish Habitat in Wisconsin Streams. USDA Forest Service Technical Report NC-164. 36 pp.

Simonson, T.D., and J. Lyons. 1995. Comparison of catch per unit effort and removal procedures for sampling stream fish assemblages. North American Journal of Fisheries Management 15:419-427.

Equipment List

Geomorphology Equipment
30 m meter tape
30-100 m meter tape
Meter stick
Stadia rod
Laser level or clinometer
Flagging
GPS
Rangefinder
Camera
Densiometer
Calculator
Turbidity tube
Water quality meter(s)
Meter calibration solutions
GMU type sheets

General accessories
Data sheets
Clipboard
Pencils
Site maps
Gazetteer
Boots/waders
Extra rainproof paper

Glossary

Active channel area: The bankfull area of the stream channel.

Alluvium: A deposit of sediment left by a stream on the stream's channel or floodplain.

Aufwuchs: The algae, diatoms, and other plants and animals adhering to rocks and other open surfaces.

Bankfull width and depth: Width and depth of water when the water completely fills the channel just before it spills out onto the floodplain.

Baseflow width and depth: Width and depth of water during dry season conditions. Baseflow is the water in a stream that results from groundwater discharge to the stream.

Bedrock chute: A narrow bedrock passage where the water rushes rapidly.

Braided channel: A channel that divides into or follows an interlacing or tangled network of several small branching and reuniting shallow channels separated from each other by branch islands or channel bars.

Cascade: A stream segment with a stepped series of drops characterized by exposed rocks and boulders, high gradient, swift current and much turbulence.

Channel alteration: Any human activity within the stream banks that changes stream flow from the natural condition.

Channel pattern: The overall shape of the stream channel (straight, meandering, sinuous, braided).

Channelization: Modification of a stream, typically by straightening the channel, to provide more uniform flow; often done for flood control or for improved agricultural drainage or irrigation.

Colluvium: A loose deposit of rock debris accumulated through the action of gravity at the base of a cliff or slope.

Forced bar: Gravel bars associated with other hydraulic roughness elements such as wood or bedrock; these elements caused the creation of the bar.

Forced pool-riffle: Pools and riffles are created by obstructions such as large wood, rather than forming from gravel/cobble deposition and movement within the stream channel.

Interstitial flow: Flow in the spaces between stream bed material; so water flow within the stream bed itself.

Intertransect distance: The distance, either along the stream channel, or in a straight line, from one cross-channel transect to the next.

Large woody debris (LWD): Wood within the bankfull channel that is greater than 10 cm diameter and 1 meter long.

Lateral bar: Gravel bar formed along the sides of the stream channel in areas of lower flow other than on the insides of bends.

Levee: Elevated stream banks, produced either naturally or artificially, by deposition of material on top of the stream bank.

Meander: A bend or curve in the stream channel.

Medial bar: Gravel bars that form as islands within the stream channel.

Oxbow: An abandoned meander in a river or stream.

Planebed: A run; laminar flow with no pools.

Point bar: The point bar consists of channel material deposited on the inside of meander bends.

Pool-riffle: The standard stream sequence of pools and riffles occurring in sequence in close proximity one to another.

Reach: The section of the stream that is sampled. For this study, the reach begins 30 m downstream of the bridge or stream access point and continues for 30 mean stream widths (minimum length 100 m; maximum length 500 m).

Riprap: A facing layer (protective cover) of stones or other material placed to prevent erosion or the sloughing off of a structure or embankment.

Sinuosity: The degree to which the stream bends or curves. Calculated by dividing instream channel length by the straight-line distance.

Step: A vertical drop formed by wood, boulders, cobbles, bedrock, or other material.

Step former: Material within the stream channel which form vertical drops.

Step-pool: Stream bed form consisting of a series of pools separated by “steps” over which the water flows. These stream types typically form on steeper slopes than do typical pool-riffle sequences. The steps are often formed from cobbles or boulders.

Stream buffer: Natural vegetation or land cover along streams above the stream banks.

Thalweg: The line of maximum depth in a stream.

Till: Unstratified soil deposited by a glacier; consists of sand and clay and gravel and boulders mixed together.

Transect: Line along which data or samples are collected. For this study, transects are stream cross-sections; the ten transects are spaced every 3 mean stream widths along the reach.

Undercut bank: A bank that has had its base cut away by water action along man-made and natural overhangs in the stream.

Unprotected bank: Stream bank that lacks vegetation, rocks, or other material that might be protective against erosion caused by streamflow. Valid only for that portion of stream bank above bankfull flow.