STREAM MONITORING
2005 OPERATIONS MANUAL

Loudoun Wildlife Conservancy,
Stream Quality Project
and
Audubon Naturalist Society

January 2005

TABLE OF CONTENTS

This document was prepared by Darrell Schwalm based upon information compiled from EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (EPA 841-B-99-002, July 1999). Cliff Fairweather, ANS, and Gem Bingol, LWC, provided editing. Photographs are of Loudoun streams taken by Darrell Schwalm. The Audubon Naturalist Society provided funding for printing. Information regarding stream monitoring in Loudoun County, Virginia, can be found at **www.loudounwildlife.org** , **www. Loudounwatershedwatch.org**, and **www.audubonnaturalist.org**.

PROGRAM ORGANIZATION

Audubon Naturalist Society

The Audubon Naturalist Society (ANS) is dedicated to natural history education and the application of strong conservation policies to protect the region's wildlife, open space, water, and air. ANS provides leadership for citizen stream monitoring in Fairfax and Loudoun Counties.

Loudoun Wildlife Conservancy

Loudoun Wildlife Conservancy (LWC) is dedicated to preserving wildlife habitat, and is the largest unaffiliated conservation group in Loudoun County. It monitors streams at 18 locations throughout the county utilizing over 50 citizen volunteers.

Program Mission – The mission of the Loudoun Wildlife Conservancy, Stream Quality Project is to maintain clean and healthy streams in Loudoun County, and educate citizens about the importance of our streams and stream corridors to people and wildlife.

Program Goals

- Identify trends in water quality and stream health in Loudoun watersheds over time;
- Develop baseline water quality and stream health data to supplement state and local data;
- Identify potential water quality and stream health problems;
- Assess the impacts of land use activities (urban, industrial, and agricultural) on water quality and stream health;
- Provide educational materials to the local community and stream users about pollution prevention and environmental stewardship; and
- Show public officials that citizens care about the health of streams and the wise management of water resources.

Program Objectives

- Collect stream monitoring data that includes physical, chemical, biological, and habitat parameters;
- Establish sampling stations that provide trend data;
- Record data in a database and make the data available to state and local officials;
- Compile and analyze data and provide results to the general public;
- Provide educational materials on water quality, stream health, and environmental stewardship;
- Establish and train stream monitoring leaders and teams; and
- Maintain and implement a Quality Assurance Program Plan (QAPP).

STREAM MONITORING CODE OF ETHICS[1]

We Carry Out Our Monitoring With Integrity

- We use proper scientific methodology.
- We fully document our technical observations.
- We accept the responsibility to report our data, our interpretations, and our conclusions so decision-makers and those who use or may be affected by the results can review them.
- We truthfully answer questions about sampling techniques, frequency and location.
- We make a good faith effort to include as many different interests and perspectives in our monitoring program as possible.

We Develop Good Relations with Private Landowners

- We request permission from the landowner if access to private property is necessary in our monitoring plan.
- In contacting the landowner, we offer explanations about who we are, the purpose of our group, what the project entails and the intended use of the data.
- After receiving permission, we contact the landowners in advance to let them know the exact date(s) of sampling events.
- We do no harm to private property.
- We take complete responsibility for our personal safety while on private property.
- We share sampling results with the public upon request and in periodic publications.

Liability Considerations

The responsibility of Loudoun Wildlife Conservancy for the conduct of its volunteers should be understood. The organization does not carry liability insurance, and volunteers need to sign a "liability waiver" indicating they will not seek compensation for injuries.

Waiver of Liability

I, ___________________________________, have volunteered to collect stream monitoring data for Loudoun Wildlife Conservancy. I understand that driving to and from the sampling sites, entering into streams, and other related activities can be hazardous. My participation in this activity is entirely voluntar and I understand that Loudoun Wildlife Conservancy assumes no additional liability as a result of my activity. As a precondition to my participation in the stream monitoring program, I therefore hereby waiv and release all claim of liability against Loudoun Wildlife Conservancy for any injuries, foreseen or unforeseen occurring or sustained as a result of my participation.

Signature: ____ Date: _________________

[1] When we gather field information on environmental conditions for the benefit of our watersheds and the community, we must remember that: (1) we may be working on private property; and (2) our results may affect people's livelihood and/or use of their property. Therefore, it is particularly important that we carry out our monitoring ethically and with integrity in our relationships with other members of the community. Consider that your behavior will be the basis for what some people think about volunteer monitoring.

SAFETY CONSIDERATIONS

The safety of stream monitors is a critical consideration especially when access to streams is severely limited by private ownership of stream corridors and riparian zones. Safety precautions should include the following common sense guides:

- Selection of the monitoring site should include safety considerations regarding traffic and parking, access to the stream, and distance to the monitoring site.
- Monitors should not cross private property without the permission of the landowner. Sampling at public access points such as bridge or road crossings or public parks is preferred for routine, trend monitoring.
- Monitoring teams should have at least two members, with three or four monitors preferred. Monitors should not work alone. Monitors should have materials identifying them as monitors.
- Monitoring should not be done if severe weather is predicted. Monitoring should be interrupted if a thunderstorm occurs while at the site.
- Do not monitor in swift or high water such as when the stream is near or at flood stage, or if high turbidity obscures the bottom in riffles and runs.
- Monitoring team members should advise the team leader of any special health consideration that might arise during monitoring.
- The monitoring team leader should know how to summons emergency help.

PROTOCOL FOR BENTHIC MACROINVERTEBRATE FIELD ASSESSMENT

Benthic Macroinvertebrate Assemblage

Benthic macroinvertebrates inhabit the sediment or live on the bottom substrates of streams. The macroinvertebrate communities respond differently to a wide variety of stressors. It is often possible to determine the type of stress that has affected a benthic macroinvertebrate community because the macroinvertebrate community structure is a function of past conditions. Individual metrics that respond to different stressors are compared against expectations under conditions of minimal human disturbance (reference conditions).[2]

Monitoring Schedule

Benthic macroinvertebrates should be collected two times a year at each monitoring site in order to sample all taxa and forms present. The sampling schedule is as follows:

- April -- May
- September -- October

Monitoring Site Selection - Riffle/Run Prevalent Streams

The LWC/ANS stream monitoring protocol is designed for landscapes of moderate to high gradient that typically contain "riffle/run prevalent" streams that are wadeable. Such streams contain primarily coarse substrates (i.e., coarse gravel or larger) or numerous areas dominated by coarse substrates. Landscapes of low to moderate gradient have streams characterized by glides and pools that are dominated by finer substrates (fine gravel or smaller) or occasional areas of coarser sediment along a stream reach. Low gradient streams and unwadeable streams require different protocols[3], and are not sampled by LWC.

In most instances monitoring will be done at an established trend station. If this is the case, make sure you know exactly where sampling should be done.

If monitoring is at a new site, select a representative reach for sampling. A representative reach should:

- be no more than 100 yards long;
- have at least one, and preferably two riffles, with a substrate of cobble and rubble (2"-10" stones), gravel and sand, and a depth of < 1 ft; and
- have a pool or low velocity, deep run with coarse particulate matter (sticks, roots, and leaves). Pools should be > 1 ft in depth.

---

[2] EPA. Field Operations Manual for Wadeable Streams Assessment. EPA841-B-04-004. July 2004.
[3] EPA. Field Operations Manual for Wadeable Streams Assessment. EPA841-B-04-004. July 2004.

Monitoring Equipment

1) **Monitoring Kit** – Team leaders may pick up monitoring equipment at the Rust Sanctuary. Each kit should contain the items listed on **Table 1**.

Table 1. Inventory of Items in Monitoring Equipment Kits.

No.	Item	No.	Item
2	Rinse cup and thermometer jar	3	Ice cube trays
3	Collecting basins/pans	1	D-net
2	Field microscopes and hand lenses	2	Data survey sheets
3	Plastic "scope" dishes	2	Macroinvertebrate ID keys
1	Thermometer	2	Pencils
1	pH kit	1	Clipboard
5	Plastic spoons	1	Monitoring Protocol Manual
5	Forceps	1	Specimen vial filled with alcohol
5	Eye droppers		

2) **Personal Items** – Other items to bring include: (1) folding or camp table, (2) folding chairs, (3) waders or shoes for water, (4) drinking water, and (5) camera.

Safety Considerations

1) Observe the safety considerations listed in the Operations Manual. The team leader should inquire whether any team members have a medical condition that may require assistance (e.g. allergic to bee stings).
2) **Sampling During or After Rain Events** – If a monitoring team decides a site is unduly influenced by a storm event, do not sample the site that day. Examples of undue influence are:
   a) The stream is running at bank full discharge or the water is much more turbid than normal;
   b) It is temporarily unsafe to wade in the majority of the stream reach; and
   c) It is immediately after or during a period of prolonged heavy rains.

Completing the Field Assessment Data Form

Site #: ______ Sample #:____________ Monitoring Date:_______________________
Data Collectors' Name(s): ___________________________________Team Leader ______________Phone________
____ Recorder ______________ QA Review ____________
Watershed:________________________ Stream: ________________Specific Location: ______________________

1) **Site No.** – Existing trend stations will have a designated station number. If this is a new station, the Program Coordinator will assign the number.
2) **Sample No.** -- Leave this blank. The Program Coordinator will enter the sample number.
3) **Monitoring Date –** Enter the date of the field monitoring.

4) **Data Collector's Names –** List the first and last names, telephone numbers and email addresses of each data collector. These data will be included in a database listing volunteer stream monitors.
   a) **Team Leader –** List the team leader and his/her phone number.
   b) **Recorder –** List the team member designated as the "Recorder."
5) **QA Review –** The team leader should initial this space at the end of monitoring after the field data form is reviewed for completeness.
6) **Watershed –** Identify the major stream into which the tributary flows. These major streams are the ones that flow into the Potomac River (e.g. Goose Creek or Piney Run).
7) **Stream –** Identify the specific tributary on which the sampling site is located.
8) **Specific Location –** Provide sufficient information (street address or road intersection/bridge) to locate the monitoring site on a county map.

WATER QUALITY ASSESSMENT DATA

Record the physical and chemical parameters for **every** monitoring event.

Rain Conditions Past 48 Hours: ☐ Little/None ☐ Light ☐ Moderate ☐ Heavy

Days since heavy rain: _______ Stream Flow Conditions: ___High ___Medium ___Low ___ Drought

Air Temperature ____ ^{0}F _____ ^{0}C Water Temperature _____ ^{0}F ____ ^{0}C pH _______

Turbidity: ______ NTU's **or** High Medium Low Clear

Dissolved Oxygen ______ mg/l Total Nitrogen _________ppm Total phosphates __________ ppm

Turbidity __________ Fecal Coliform __________cfu E. coli _________ cfu Other: ___________

9) **Water Quality Assessment Data –**
   a) **Rain Conditions in Past 48 Hours –** Characterize recent rainfalls as "little/none," "light," "moderate," or "heavy." Estimate the number of days since a heavy rain (if more than a week, indicate ">7 days").
   b) **Number of Days Since Heavy Rain** – Record the number of days or ">7" if more than a week.
   c) **Stream Flow Conditions** – Estimate the stream flow conditions by observing height of water in the streambed, velocity and volume of flow, turbidity of the water, and recent rain events. Record flow conditions as "high," "medium," "low," or "drought."
   d) **Air Temperature –** Check to insure that the mercury bar in the thermometer is whole.
      i) Hang or hold the thermometer in shaded area approximately 3 feet above the ground.
      ii) Wait at least 3 minutes before reading. When reading, hold the top part of thermometer – not the bottom bulb.
      iii) Record the air temperature on the data sheet – either Fahrenheit or Celsius.
   e) **Water Temperature –** Check to insure that the mercury bar in the thermometer is whole.
      i) Totally submerge the thermometer within the run/riffle sampling area for a minimum of three minutes. Place the thermometer inside a 1-pint clear container, and place the thermometer and container in the stream.

ii) Remove the container from the stream, keep the thermometer bulb in the water-filled container, and read the water temperature. Have a second person check your reading. Record the temperature in Celsius or Fahrenheit.

f) **pH Collection Method –** Use a pH indicator kit.
   i) Rinse the tube first with stream water.
   ii) Follow instructions accompanying the pH kit (i.e., fill tube to 5 ml line, add drops of indicator, place cap (not finger) on tube and mix, and compare color with chart).
   iii) Record reading on data form.
   iv) Dispose the solution on land, and rinse the tube and cap in the stream.

g) **Turbidity** – Estimate the amount of suspended materials in the water by observing the extent to which the bottom is obscured because the water is cloudy or muddy. Characterize turbidity as "high," "medium," "low," or "clear." ("NTU's are recorded if a turbidity column is used.)

h) **Chemical and Bacterial Parameters** – Leave the chemical and bacterial parameters blank unless special samples are taken of these parameters.

Benthic Macroinvertebrate Collection Method

1) **Nine Subsamples** – Nine subsamples are to be collected – three in one riffle/run, three in a pool/glide, and three in a second riffle/run. Each subsample will be collected in a 1ft^2 area in a 60 second period. Any area where there is not sufficient current to extend the net should be considered as a pool/glide. If only one riffle/run is available at the site, collect six subsamples in the riffle/run and three in the pool/glide. Begin sampling at the downstream riffle/run and work upstream so as not to disturb the substrate in the next upstream sampling site. The material from each subsample is to be combined into one composite sample for the site.
2) **Representative Sampling Sites** – The objective is to collect a composite sample that is representative of the reach of the stream being sampled and not the best habitat in the reach. Choose three spots in the downstream riffle/run – preferably one spot each in the right, center, and left portions of a stream cross-section transect. Do not sample stream channel edges that may be above the water line under normal flow conditions. Sampling in pools/glides should include: (a) edges where there are vegetation and root structures that may hold macroinvertebrates, (b) leaf packs and woody detritus, (c) submerged logs, and (d) the substrate.
3) **Sampling in a Riffle/Run** –
   a) With the net opening facing upstream, position the D-net flat on the stream bottom to eliminate gaps under the frame (avoid large rocks) so the water current will carry dislodged material into the net. One team member should hold the net and be the timer. A second team member should visually define a rectangular quadrat that is one net width wide and one net width long upstream of the net opening. The area within this quadrat is 1 ft^2.
   b) Carefully pick up and rub all benthic macroinvertebrates from the rocks that are golf ball size or larger and which are over halfway into the quadrat keeping the rocks submerged while rubbing. Large rocks that are less than halfway into the qadrat should be pushed aside. Rubbing should continue for 45 seconds. As each rock is

cleaned, it should be placed immediately outside the sampling area to facilitate flow of materials into the net.

c) After 45 second of rock cleaning, fingers should be used to carefully disturb the stream bottom sediment to the depth of 1 – 3" to dislodge any burrowing macroinvertebrates for 15 seconds. Use a stick if glass or sharp objects are present or if the water is too cold.

d) Check the net contents for any large organisms that are good swimmers such as crayfish and adult beetles, and remove these organisms to the sampling basin so they will not be lost while collecting the second and third subsamples. Check to see if the net mesh is clogged with organic material or sand (if it is, see below). Then collect the remaining subsamples in the first riffle before rinsing the collected material from the three subsamples into the sample basin and moving to the next pool/glide or riffle/run sampling area.

4) **Sampling in a Pool/Glide Area** –
   a) Visually define a rectangular quadrat that is one net width wide and one net width long at the sampling point for each of the three subsample spots in the pool/glide area.
   b) Pick up any loose rocks or other large substrate particles within the quadrat. Rub any clinging organisms off of rocks, pieces of wood, tree root masses, other large pieces of organic materials, and other pieces of larger substrate into the net for 30 seconds.
   c) Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom for 30 seconds. The net may also be dragged through the water column in a figure eight pattern to collect any macroinvertebrates that become suspended. Keep moving the net all the time so that the organisms trapped in the net will not escape.
   d) Check the net contents for any large organisms that are good swimmers such as crayfish and adult beetles, and remove these organisms to the sampling basin so they will not be lost while collecting the second and third subsamples. Check to see if the net mesh is clogged with organic material or sand (if it is, see below). Then collect the remaining subsamples in the pool before rinsing the collected material from the three subsamples into the sample basin and moving to the next riffle/run sampling area.
5) **Clogged Mesh** – If sand or small vegetation material is clogging the mesh of the net, the sample materials need to be rinsed from the net into the sample basin before another subsample is collected. Otherwise, move onto the second and third subsample sites in the downstream riffle and collect at each for 60 seconds.
6) **Removing Mud** – Pour stream water through the net until the water runs clear before rinsing the collected materials from the three subsamples into the basin. This will reduce the murkiness of the water in the basin. Be careful not to dislodge any macroinvertebrates clinging to the outside of net.
7) **Rinsing Net** – Empty the net contents from each set of three subsamples into a white basin by carefully turning the net inside out and rinsing the collected materials into the basin. Use water in the basin to aid in the rinsing in order to minimize the amount of water in the basin. After rinsing, pick off any macroinvertebrates clinging to the canvas cover or caught in the mesh and place these in the basin. Carefully inspect any large organic matter (leaves, sticks) and large pebbles in the basin and wash any organisms found off of the objects and into the basin. Return these materials to the stream. Remove as much detritus as possible without losing any organisms. (If the site traditional has low

numbers of macroinvertebrates, macroinvertebrates picked from the net and substrate material may be placed directly into ice cube trays to avoid double picking.)

8) **Picking and Sorting Sample** – The sample in the plastic basin may be divided into one or two additional basins if this will facilitate picking and sorting. Try to have less than an inch of water in the basin – carefully pour out some water if necessary. Each basin should be thoroughly picked to insure that the macroinvertebrates selected are representative of the total original sample. Use spoons, eyedroppers, paintbrushes, and tweezers to pick the organisms out of basins. Pick out any large pieces of debris and examine for macros and then discard. Let the water become still in the basin and watch for moving macroinvertebrates. Do not bias the sample by avoiding small organisms in favor of the larger ones. Picking and sorting should include all aquatic macroinvertebrates, crustaceans, round worms, leeches, bivalves and gastropods, but not flat worms. Also, do not include fish, salamanders, and other vertebrates in your sample report. Organisms should be sorted into two or more ice cube trays – trying to keep the same type organisms in the same cube or cubes. **Pick and sort 200 organisms**.
9) **Insufficient Organisms** – If the sample does not contain 200 organisms, pick all that are present and can be identified, and quit. Indicate on the collection sheet that there were not 200 macroinvertebrates in the sample. Streams with a low abundance of macroinvertebrates will be rated as "poor" in its ecological condition.
10) **Identification and Recording** – Use available keys and a microscope, as necessary, to identify the macroinvertebrates. Insects should be identified to the **family level** and the non-insects to the order level, and recorded on **Table 2**. Identification to the family level is important because of the metrics that are used to characterize the health of the stream. Record totals for each family/order on the assessment survey form. Return the identified and recorded macroinvertebrates to the stream.
11) **Unidentified Macroinvertebrates –** If an organism cannot be identified, make a note on the survey form, and place the organism(s) in the vial of alcohol included in the sampling kit. Note the date and sample site number on the vial's label, and return the vial with the survey form. If there are a large number of individuals of an unidentified type, preserve two or three representative specimens.
12) **Quality Assurance** –
    a) The recorder and team leader should review the data form together after all data have been recorded to make sure all items have been completed. The team leader should initial the QA section in the header section.
    b) Once each year a trained and experienced team leader or QA officer who is not a member of the monitoring team will conduct a QA review using the Field QA Assurance Data Form (see Table 4). The same person may conduct a habitat assessment.
13) **Preserved QA Sample (Optional)** – Once each year the team leader may be requested to preserve the macroinvertebrates in the ice cube trays that make up the final sample, and submit the preserved specimens with the final field data collection form for a QA check. A 1 qt Mason jar, 1/3 filled with alcohol will be provided in the monitoring kit for this purpose, if necessary. All the macroinvertebrates recorded on the field data form are to be extracted from the ice cube trays and placed into the Mason jar with the preservative. The label on the jar is to be completed with information regarding the site identification, date, and team leader. The purpose of the QA check is to review the number of macroinvertebrates of each species and the species identification.

14) **Sampling Equipment** – Make sure all the sampling equipment is rinsed, cleaned, and gathered together before leaving the sampling site. Please return the equipment as soon as possible to insure that equipment is available to every monitoring team.

Managing Time During Stream Monitoring

The following provides a suggested order in which the stream assessment can be completed to best use the team's resources and minimize time in the field. Experienced teams should be able to complete monitoring in about 2 ½ hours.

1) **Equipment Check –** Check all equipment items before leaving the car park area.
2) **Set-Up –** Set up a table with the sample collection equipment as close to streamside and the sampling site as possible. A shaded site is preferred to help keep water in the sorting basins from heating up and killing the macroinvertebrates.
3) **Recorder –** One team member should be assigned "recorder" duties. The recorder begins by filling out the header portion of the field assessment survey form. The recorder should also have the sample collection protocol, and should observe that the team members collecting the sample are following the protocol.
4) **Physical/Chemical Parameters –** One team member should collect the air and water temperatures, and the pH. This member can be the recorder. Be careful not to disturb the substrate in the sampling sites.
5) **Habitat Assessment –** If the annual habitat assessment is to be done, the trained Habitat Assessment Officer can begin the assessment while the team members are doing the chemical testing and collecting the macroinvertebrate sample.
6) **Macro Collection –** Two or three team members should immediately begin collecting the macroinvertebrate sample. One person holds the D-net, one person rubs the rocks in the streambed, and one person times the sample collection. The holder of the net can also time if only two team members are collecting.
7) **D-Net Rinse –** The D-net should be emptied into a basin and picked over for macroinvertebrates on the canvas guard after each set of three subsamples are collected. Try to minimize the amount of rinse water that is used. If there is a lot of debris covering the mesh of the net after any single subsample is collected, the net should be rinsed into the basin.
8) **Picking and Sorting Macroinvertebrates –** Divide the sample into two or three basins to facilitate three or four team members picking at the same time. Sort into two ice cube trays, and try to keep similar species in the same cube. If there is an abundance of one or two species, place each species into two or more cubes to facilitate counting.
9) **Macroinvertebrate Identification –** The team leader or other certified team member should begin identifying species to the **family level** using a microscope as the picking and sorting are going on. Once a macroinvertebrate is identified, it should be placed in a third ice cube tray or different container in order to separate the identified from the unidentified macroinvertebrates. Keep a running tally of the hard to identify macroinvertebrates on the field assessment survey form. Preserved any macroinvertebrates that cannot be identified to the family level.

TABLE 2. BENTHIC MACROINVERTEBRATE ASSESSMENT DATA

Organism (Class/Order/Family)	Tol. Metric	# Individuals	# of Taxa	Organism (Order/Family)	Tol. Metric	# Individuals	# of Taxa
Non-Insects				**Trichoptera Caddisfly)**	**(4)**		
Oligochaeta: Worms	8			*Glossosomatidae (Saddlecase)*	0		
Hirudinea: Leeches	7			*Hydropsychidae (Netspinner)*	6		
Gastropoda: Snails	7			*Hydroptilidae (Micro)*	6		
Bivalvia: Clams & Mussels	8			*Lepidostomatidae (Lepido Casmk)*	1		
Isopoda: Sowbugs	8			*Limnephilidae (Northern Casemk)*	4		
Amphipoda: Scuds	6			*Philopotamidae (Fingernet)*	3		
Decapoda: Crayfish	5			*Psychomyiidae (Net Tube)*	2		
				Rhyacophilidae (Free-living)	0		
Macroinvertebrates				**Diptera (True Flies)**	**(6)**		
Plecoptera (Stonefly)	**(1)**			*Athericidae (Watersnipe)*	2		
Capniidae (Slender Winter)	1			*Chironomidae (Midge)*	6		
Chloroperlidae (Green)	1			*Simuliidae (Black)*	6		
Nemouridae (Nem. Broadback)	2			*Tabnidae (Horse/Deer)*	6		
Perlidae (Common)	1			*Tipuliidae (Crane)*	3		
Perlodidae (Perlodid)	2			**Megaloptera**	**(5)**		
Taeniopterygidae (Taen. Broadback)	2			*Corydalidae (Dobson/Fishflies)*	5		
Ephemoptera (Mayfly)	**(4)**			*Slalidae (Alderflies)*	4		
Ameletidae (Ameletid Minnow)	2			**Coleoptera (Water Beetles)**	**(5)**		
Baetidae (Small Minnow)	4			*Dytiscidae (Predaceous Diving)*	6		
Caenidae (Small Squaregills)	4			*Elmidae (Riffle Beetle)*	4		
Ephemerellidae (Spiny Crawler)	4			*Haliplidae (Crawling)*	7		
Ephemeridae (Common Burrower)	4			*Hydrophilidae (Water Scavenger)*	5		
Heptageniidae (Flathead/Clinging)	4			*Psephenidae (Water Penny)*	5		
Leptophlebiidae (Prong Gills)	2			*Ptilodactylidae*	5		
Oligoneuriidae,(Brushlegged)	2			**Odonata (Dragonflies & Damselflies**	**(5)**		
Potamanthidae (Hackle Gills)	4			*Aeshnidae (Damers)*	3		
Siphlonuridae (Primitive Minnow)	7			*Calopterygidae (BW-damselflies)*	5		
Tricorythidae (Little Stout Crawlers)	4			*Coenagrionidae (NW-damselflies)*	9		
Hemiptera (Waterbugs)	**(6)**			*Gomphidae (Clubtails)*	1		
Corixidae (Water Boatmen)	5			*Lestidae (Spreadwing Damselfly)*	9		
Veliidae (Water Strider)	6						
	Total				**Total**		

10) **Preliminary Count –** After picking and sorting has progressed for a while, the recorder should do a preliminary count of the macroinvertebrates to see if 200 macroinvertebrates have been sorted.
11) **Final Sort and Count –** If the count is short of 200 macroinvertebrates, resume picking until 200 are collected. If over 200 are sorted, record all sorted. If there are not 200 macroinvertebrates in the sample, count all that can be identified and quit.

Quality Assurance Procedures

The purposes of quality assurance procedures are to insure that the sampling protocol is being uniformly applied to all data collection, and that any errors in macroinvertebrate sorting, identification, and counting are within acceptable limits (<10% error). A QA protocol and documentation gives data users confidence that the stream monitoring data are an accurate reflection of the condition of the stream at the time of monitoring.

1) **QA Procedures for Stream Monitoring Team** – QA procedures are intended to insure that the team follows the sampling protocol so the data collected are a close measure of the actual conditions being monitored and are the same as would be collected by another team at the same site.
   a) **Team Leader** – The stream monitoring team leader should fully understand the sampling collection protocol and be skilled in identifying the macroinvertebrates collected in the sample to the family level.
      i) **Training** – Team leaders should attend three types of training courses sponsored by the Audubon Naturalist Society (ANS) and Loudoun Wildlife Conservancy (LWC). These courses are offered throughout the year and are advertised on the ANS and LWC websites. The courses are:
         (1) Benthic Macroinvertebrate Identification I – Introduction and Order Level
         (2) Benthic Macroinvertebrate Identification II – Family Level
         (3) Monitoring Protocol Practicum
      ii) **Macroinvertebrate Identification Quiz** – Team leaders should take and pass the Macroinvertebrate Identification Quiz offered by ANS/LWC in April to become certified. Taking the test yearly is required.
      iii) **Equipment** – Team leaders should be familiar with monitoring equipment and should examine the equipment before use to insure that it is clean and in proper working order.
   b) **Stream Monitoring Team –** Team members should understand the basics of stream monitoring and be familiar with the protocol and equipment being used by taking the basic training courses, which include "Benthic Macroinvertebrate Identification I" and "Monitoring Protocol Practicum."
   c) **Safety Procedures –** Safety procedures modeled after recommendations by EPA are included in monitoring protocol and the Monitoring Protocol Practicum training. The stream monitoring team should follow these.
   d) **Stream Monitoring Protocol** – The protocol used to sample physical and chemical parameters in stream water and benthic macroinvertebrates is modeled after EPA's recommended "Rapid Bioassessment Protocols," and after the protocol used by Virginia's Department of Environmental Quality. It is part of the LWC Stream Monitoring Operations Manual that is provided to each team leader. The protocol is reviewed annually by ANS and LWC, and modifications are made as appropriate.

e) **Unidentified Specimens –** The stream monitoring protocol includes provisions for preserving, labeling, and submitting any unidentified macroinvertebrates collected to ANS experts for identification and completion of the field data collection form.
f) **Meta Data** – The field data reporting form includes detailed information regarding where the sample is collected, who collected the sample, the current and recent weather conditions that may affect the sample, and the conditions in the stream where the sample is being collected.
g) **QA Documentation** – The "Recorder" is responsible for reviewing the monitoring protocol as the monitoring progresses to insure that each step in the protocol is being following. The Team Leader is responsible for initialing the monitoring reporting form that the sampling procedure has been followed and the data form completed.
h) **Preserved Sample (Optional)** – Each team leader may be requested to preserve one complete macroinvertebrate sample each year for a QA review by ANS and LWC stream monitoring program trainers and designated experts.
   i) The label on the preserved sample is review to insure accurate information that will enable the preserved sample to be associated with a completed field data form.
   ii) The specimens are sorted by type and identified to the family level for macroinvertebrates and the class/order level for non-insects. The results are recorded on the QA Assessment Form provided in **Table 3**.
   iii) The results on the QA Assessment Form are compared with the results on the field data form, and reported on the QA check form. Any substantial differences should be discussed with the team leader before the next sampling period.
   iv) QA check results are compiled, analyzed, and summarized yearly. A report should be made to the ANS/LWC stream monitoring program officials by February 1 with recommendations regarding training needs, protocol modifications, etc.

2) **QA Field Reviews** – ANS/LWC program QA officials should conduct a field review with each team each year. This can be most easily accomplished if trained Habitat Assessment Officers are also trained as QA reviewers. The QA field reviewers should complete a "Field QA Review Form" (see **Table 4**) that includes the following items:
   a) **Protocol** – review that the monitoring protocol and safety procedures are being followed.
   b) **Macroinvertebrate Sorting** – review that the macroinvertebrates are being properly sorted so that the sorted sample is an accurate representation of the full sample in the collection basin.
   c) **Macroinvertebrate Identification** – review that the macroinvertebrates are being properly identified to the appropriate level, and that any unidentified specimens are being preserved, labeled, and submitted with the field data collection form.
   d) **Recommendations** – suggestions discussed with the team leader regarding anything that could improve the monitoring data precision and accuracy.

% Difference = Total Form – Total Check / Total Check =

Table 3. PRESERVED BENTHIC SAMPLE QUALITY ASSURANCE DATA FORM

Site #:______ Sample #:_____ Monitoring Date:_________________

QA Reviewer Name:______________________________________ Team Leader:____

Organism (Class/Ocder/Family)	Field Data Form #	QA Check #	Difference	Organism (Class/Ocder/Family)	Field Data Form #	QA Check #	Difference
NON-INSECTS				**Trichoptera Caddisfly)**			
Nematoda: Planaria				*Glossosomatidae (Saddlecase)*			
Oligocheata: Worms				*Hydropsychidae (Netspinner)*			
Hirudinea: Leeches				*Hydroptilidae (Micro)*			
Gastropoda: Snails				*Lepidostomatidae (Lepido Casmk)*			
Bivalvia: Clams & Mussels				*Limnephilidae (Northern Casemk)*			
Isopoda: Sowbugs				*Philopotamidae (Fingernet)*			
Amphipoda: Scuds				*Psychomyiidae (Net Tube)*			
Decapoda: Crayfish				*Rhyacophilidae (Free-living)*			
MACROINVERTEBRATES				**Diptera (True Flies)**			
Plecoptera (Stonefly)				*Athericidae (Watersnipe)*			
Capniidae (Slender Winter)				*Chironomidae (Midge)*			
Chloroperlidae (Green)				*Simuliidae (Black)*			
Nemouridae (Nem. Broadback)				*Tabnidae (Horse/Deer)*			
Perlidae (Common)				*Tipuliidae (Crane)*			
Perlodidae (Perlodid)				**Megaloptera**			
Taeniopterygidae (Taen. Broadback)				*Corydalidae (Dobson/Fishflies)*			
Ephemoptera (Mayfly)				*Slalidae (Alderflies)*			
Ameletidae (Ameletid Minnow)				**Coleoptera (Water Beetles)**			
Baetidae (Small Minnow)				*Dytiscidae (Predaceous Diving)*			
Caenidae (Small Squaregills)				*Elmidae (Riffle Beetle)*			
Ephemerellidae (Spiny Crawler)				*Haliplidae (Crawling)*			
Ephemeridae (Common Burrower)				*Hydrophilidae (Water Scavenger)*			
Heptageniidae (Flathead/Clinging)				*Psephenidae (Water Penny)*			
Leptophlebiidae (Prong Gills)				*Ptilodactylidae*			
Oligoneuriidae,(Brushlegged)				**Odonata (Dragonflies & Damselflies**			
Potamanthidae (Hackle Gills)				*Aeshnidae (Damers)*			
Siphlonuridae (Primitive Minnow)				*Calopterygidae (BW-damselflies)*			
Tricorythidae (Little Stout Crawlers)				*Coenagrionidae (NW-damselflies)*			
Hemiptera (Waterbugs)				*Gomphidae (Clubtails)*			
Corixidae (Water Boatmen)				*Lestidae (Spreadwing Damselfly)*			
Veliidae (Water Strider)							

Name of Reviewer: ___________________
Date Recorded: ______________________

Table 4. FIELD QUALITY ASSURANCE DATA FORM

(Return completed forms to Rust Sanctuary)

Site #:______ Sample #:_____ **Monitoring Date**:_________________
Watershed:___________________________ Stream: ________________________
Specific Location: ____
Team Leader: __________________________________ Phone:__________________
Reviewers Name:____

ITEM	CHECK
Team Leader Training	
Safety Procedures	
Equipment	
Monitoring site location	
Sample collection	
Sample sorting	
Sample identification	
Physical/Chemical sampling	
Meta data recording	
Sampling data reporting	

RECOMMENDATIONS:

PROTOCOL FOR STREAM HABITAT ASSESSMENT[4]

Background

The potential for a healthy biological community is limited by the quality of the physical habitat. A stream habitat assessment is an evaluation of the structure of the physical habitat in the stream corridor that influences the quality of the stream and the condition of the resident aquatic community. The assessment includes an evaluation of the variety and quality of the substrate, channel morphology, bank structure, and riparian vegetation. The parameters included in this guide are for a riffle/run prevalent stream. Some different parameters apply to pool/glide prevalent streams.

Dynamic Equilibrium – Dynamically stable streams have a morphology that provides appropriate distribution and dissipation of flow energy during storm events. When a stream has any of its critical characteristics altered, some of the stream's capability to dissipate energy is lost, and channel erosion will result.

RBPs, EMAP, and MACS – Different types of approaches for evaluating habitat structure have been developed. The approach adopted by LWC/ANS is the Rapid Bioassessment Protocols (RBPs) of EPA, which provides a visual-based assessment approach that emphasizes the overall quality of the physical habitat. All parameters are evaluated and rated on a numerical scale of 0 to 20 (highest) for each sampling reach. The ratings are then totaled and compared to a reference condition to provide a final habitat ranking. Scores increase as habitat quality increases.

- **EMAP –** The Environmental Monitoring and Assessment Program (EMAP) of the EPA and USGS incorporate measurements of various features of instream, channel, and bank morphology that provide a comprehensive characterization of the physical structure of the stream.
- **MACS –** Mid-Atlantic Coastal Streams Workshop (MACS) is based upon the RBPs but with somewhat fewer and different parameters.

Parameters – Habitat evaluations are first made on instream habitat, followed by channel morphology, bank structural features, and riparian vegetation. Generally, a single, comprehensive assessment is made that incorporates features of the entire sampling reach as well as selected features beyond the reach. Additional habitat assessments may be made on neighboring reaches to provide a broader evaluation of habitat quality for a larger section of the stream ecosystem.

Reference Conditions – Reference conditions are used to scale the assessment to the "best attainable" situation. This approach recognizes that stream characteristics will vary dramatically across different regions. The station of interest is classified on the basis of its similarity to the reference condition.

[4] Taken from EPA's Rapid Bioassessment Protocols, 2nd Ed., July 1999

Quality Assurance

EPA's RBP habitat assessment is based on a visual evaluation that includes a degree of subjectivity. It is intended that an experienced stream biologist who has assessed a variety of stream corridors and who can distinguish between different levels of quality for an array of parameters will conduct the assessment. LWC/ANS will address these needs in the following manner.

- All stream habitat assessments will be conducted by a small cadre of trained monitors, and not by the monitor teams. Habitat assessments will be conducted during one of the scheduled monitoring events, preferably during the April/May monitoring window.
- The habitat assessors will attend a training titled, Stream Habitat Assessment, to be put on annually by LWC/ANS. As part of the training, the assessors will do two or three field assessments at different stream sites to standardize themselves against each other. The different sites will include a high quality, "reference site."
- The field data reporting form includes detailed information regarding where the assessment is conducted, who conducted the assessment, the current and recent weather conditions that may affect the assessment, and the conditions in the stream during the assessment.
- Digital pictures will be taken during the field assessment, and will be used periodically as checks of assessment results.
- LWC/ANS habitat assessors will conduct joint assessments with DEQ's regional biologist whenever possible, and compare results.
- The habitat protocol is reviewed annually by LWC and ANS. Updated reference materials and protocols provided by EPA and Virginia DEQ are considered. Modifications are made as necessary.

Habitat Assessment Schedule

The stream habitat assessment should be conducted once per year during one of the benthic macroinvertebrate monitoring events. An additional assessment should be done if there is a substantial change in the stream habitat between scheduled benthic macroinvertebrate monitoring events. The benthic macroinvertebrate monitoring schedule is as follows:

- April -- May
- September – October

Identifying the Habitat Assessment Reach

The stream habitat assessment consists of an assessment of watershed land use, human impacts, and the stream habitat both within the sampling reach and beyond. The areas of concern for these different assessments are as follows:

- **Watershed Land Use and Human Impact Assessment** – Identify land uses and human impact parameters within the sampling reach and beyond over an area that extends approximately 1/8 mile upstream and within sight adjacent to the stream.

- **Stream Habitat Assessment** – Identify the instream habitat features within the stream reach in which the benthic macroinvertebrate samples will be collected. The length of the reach should be approximately 100 yards. Ideally, the reach should be defined so it extends 25 yards downstream from the lowest station and 75 yards upstream from the upper station.

Habitat Assessment Equipment

Stream habitat assessment equipment is available at the Rust Sanctuary. The needed equipment is listed on **Table 5**.

Table 5. Inventory of Equipment for Stream Habitat Assessments.

No.	Item	No.	Item
2	Stream Habitat Field Data Sheet	1	Clipboard, pencil, eraser
1	Yard or meter stick, or tape measure	1	Digital camera

Personal Items – Other items to bring include: (1) waders or shoes for water, and (2) drinking water.

Safety Considerations

Observe the safety considerations listed in the Operations Manual. The assessment cannot be completed if the substrate, embeddedness, and sediment deposition cannot be observed due to high flows or high turbidity.

Completing Relevant Portions of the Field Assessment Data Form

1) Monitoring Station Information

LOUDOUN STREAM MONITORING PROGRAM Site #:______ Sample #:_____ Monitoring Date:_________

STREAM ASSESSMENT FIELD DATA FORM

Recording of italicized items is optional. Return completed forms to Gem Bingol at Rust Sanctuary.

Data Collectors' Names: ___________________________ Team Leader ___________________Phone #_______

____ Recorder _______________________QA Review ______

Watershed: ______________Stream: ___________________________ Specific Location: _________________________

a) Complete the station identification section of the Stream Assessment Field Data Form.
b) Sample # will be provided by the Project Coordinator.

2) Watershed Land Use and Human Impact Data

WATERSHED LAND USE AND HUMAN IMPACT

Annually estimate **land uses** and identify **human impacts** in watershed within ¼ mile upstream and adjacent to the site. For "Land Use Profile," record information as a percent. For "Human Impact Profile," **check each parameter** with "**1**" if not present or little impact, "**2**" if moderate impact, and "**3**" if any parameter has potential high impact on the stream and/or monitoring site. Update form when there are substantial changes in land use and human impacts.

Type of Assessment: ☐ Annual Comprehensive		☐ Update		☐ Other: ______________________________	
Land Use Profile:					
%	Forested Uplands	%	Pasture/crops/open lands	%	Wetlands
%	Commercial/Industrial	%	Low intensity residential	%	High intensity residential
Human Impact Profile:					
1 2 3 ☐ ☐ ☐	**Residential/Commercial** Single-family housing	**1 2 3** ☐ ☐ ☐	Multifamily housing	**1 2 3** ☐ ☐ ☐	Commercial/institutional
☐ ☐ ☐	**Roads --** Paved roads or bridges	☐ ☐ ☐	Unpaved roads	☐ ☐ ☐	Cleared right-of-ways
☐ ☐ ☐	**Construction underway on:** Housing development	☐ ☐ ☐	Commercial development	☐ ☐ ☐	Road or bridge construction/repair
☐ ☐ ☐	**Agricultural** – Active cropland	☐ ☐ ☐	Grazing land or animal holding areas	☐ ☐ ☐	Other:
☐ ☐ ☐	**Recreational** -- Golfing	☐ ☐ ☐	Camping	☐ ☐ ☐	Other:
☐ ☐ ☐	**Other** -- Trash dumping	☐ ☐ ☐	Landfills/wetland encroachment	☐ ☐ ☐	Storm drains/storm water runoff

a) Complete the Watershed Land Use and Human Impact section of the field data sheet. This should reflect uses and impacts within 1/8 mile upstream and adjacent to the assessment site.
b) Report land use as a percent, and human impacts as a rating between 1 (none or little) and 3 (high impact). Keep in mind that the ratings will be somewhat subjective and that an extensive effort to quantify the presence and intensity of each type of stressor is not required[5].
c) Base the reporting on what can be seen driving to the site and at the site.
d) Describe any entry under "Other" as necessary.

3) Water Quality Data

WATER QUALITY DATA

Record physical and chemical parameters for **every** monitoring event.

Rain Conditions Past 48 Hours: ☐ Little/None ☐ Light ☐ Moderate ☐ Heavy # Days since heavy rain: ______

Stream Flow Conditions: ☐ High ☐ Medium ☐ Low ☐ Drought Air Temperature ____ ^{0}F ______ ^{0}C

Water Temperature ____ ^{0}F ____ ^{0}C pH _____ Turbidity: _____ NTU's **or** ☐ High ☐ Medium ☐ Low ☐ Clear

Dissolved Oxygen ______ mg/l Nitrates _________ppm Orthophosphates __________ ppm Ammonia __________ ppm

Fecal Coliform __________cfu E. coli _________ cfu Other: _________________

a) Complete the rain conditions information to aid in interpreting the habitat assessment ratings
b) Complete the stream flow conditions information.
c) Complete any chemical data that is collected. Leave blank as appropriate.

---

[5] EPA. Field Operations Manual for Wadeable Streams Assessment. EPA841-B-04-004. July 2004.

4) Stream Habitat Assessment Data

Type of Habitat Assessment: ☐ Annual Comprehensive ☐ Update ☐ Other: ______________________ Estimated average stream width ______ ft. Estimated stream depth in riffle #1 ______ ft. & riffle #2 ______ft. Estimated stream depth in pool or run _____ ft.

a) The stream habitat assessment is an evaluation of the structure of the surrounding physical environment that influences the quality of the water resources and the condition of the aquatic life in the stream. Stable stream channels have a morphology (structure) that can effectively dissipate flow energy created by storm events. The assessment looks at the degree to which these structures are altered.

b) The habitat assessment is performed on the same 100-yard reach from which the biological sampling is conducted. The first five parameters are instream habitat features and are rated specifically for the sampling reach. The second five parameters are related to larger-scale effects and may require a visual assessment beyond the sampling reach.

c) Complete the measurement portion of the habitat assessment section of the field data sheet. Measure stream width and depth with a yardstick or measuring tape, and reflect the average conditions found in the sampling reach.

d) Complete the “Habitat Parameter/Score” portion of the assessment form that is shown in **Table 1**.
   i) Ratings should be based upon an average that reflects representative conditions over the length of the reach, including parameters that involve both left and right banks.
   ii) Wading in the stream may be necessary to assess “Embeddedness” and “Sediment Deposition.” If this is done before biological sampling, care must be taken to avoid disturbing stream sections that will be sampled.
   iii) The habitat assessment protocol is provided in **Attachment A**.

5) Stream Reach Diagram and Pictures

a) Provide a sketch of the 100-yard stream reach and riparian buffer adjacent to the stream. Include physical features of the stream (riffle, pool, etc.) and any feature that impact upon the health of the stream (houses, roads, livestock pastures, etc.). Use the reverse side of the field data sheet if necessary.

b) Mark the location of the biological sampling sites on the sketch.

c) Take a picture of the stream reach being assessed, and separate pictures of any major impacts upon stream health. Provide a brief and dated narrative along with the pictures as an attachment to the field report sheet.

SKETCH OF STREAM SITE **Annual** sketch should include riffles, runs, pools, tributaries or drainage into stream, wetlands, riprap, and riparian zone along 100-yard monitoring section: and landscape features, roads, houses, etc. in 100-yard distance adjacent to stream. Mark location of three sampling spots with Site 1 being furthest downstream.			

Table 6. Stream Habitat Assessment Data Form.

A comprehensive habitat assessment is to be done **annually** in a 100-yard stream reach that includes two riffles and a pool; three riffles; one large riffle; three run areas with gravel or cobble substrate, or a combination. Any substantial changes are to be recorded at the time of monitoring. Include photos if possible.

Type of Habitat Assessment: ☐ **Annual Comprehensive** ☐ **Update** **Other**: ____

Estimated **average** stream width ______ ft. Estimated stream depth in riffle #1 ______ ft. & riffle #2 ______ft. Estimated stream depth in pool or run _____ ft.

Habitat Parameter/Score	**Optimal 20 – 19 – 18 – 1 7- 16**	**Good 15 – 14 – 13 – 12 - 11**	**Marginal 10 – 9 – 8 – 7 - 6**	**Poor 5 – 4 – 3 – 2 – 1 - 0**
Epifaunal Substrate/ Available Cover Score ☐	>70% of substrate favorable for insect communities; mix of snags, submerged logs, undercut banks, cobble or other stable habitat to allow full colonization potential.	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat to maintain populations; additional substrate in form of newfall.	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	<20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
Embeddedness Score ☐	Fine sediment surrounds and fills 0-25% of living spaces around gravel, cobble, & boulders. Plume of sediment almost nonexistent. Rocks look as if placed on streambed.	Find sediment fills in 25-50% of living spaces around gravel, cobble, & boulders. Sides of rocks have partial "cemented in" look. Plume is small to moderate.	Find sediment surrounds and fills in 50-75% of living spaces around and between gravel, cobble, & boulders. Sides of rocks have a "cemented in" look. Plume is moderate to extensive.	Find sediment surrounds and fills in >75% of living spaces around and between gravel, cobble, & boulders. Sides of rocks have a "cemented in" look. Sediment plume is extensive.
Velocity/Depth Regime Score ☐	All four velocity/depth regimes present – slow-deep, slow-shallow, fast-deep, fast-shallow – and slow is <0.3 m/s and deep is >o.5 m/s	Only 3 of 4 regimes present (if fast-shallow is missing, score lower than if mission other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
Sediment Deposition Score ☐	Less than 5% of bottom affected by scouring and/or deposition; islands and point bars not enlarging	5-30% of bottom affected; scour at constrictions and where grades steepen; slight deposition in pools and/or bars	30-50% of bottom affected; deposits and/or scour at obstructions, constrictions, and bends; moderate deposition of pools and new bars prevalent	>50% of bottom affected; pools almost absent due to deposition; heavy deposition of fine material; new bars developing
Channel Flow Score ☐	Water reaches base of both lower banks; and minimal amount of channel substrate is exposed.	Water fills >75% of available channel; or <25% of channel substrate exposed.	Water fills 25-75% of available channel; and/or riffle substrates mostly exposed.	Very little water in channel, and mostly present as standing pools.
Channel Alteration Score ☐	Minimal impact from stream straightening, artificial embankments, dams, bridge abutments.	Some stream straightening, artificial embankments, dams usually in areas of bridges. No evidence of recent channel alteration.	Artificial embankments extensive and present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Bank shored with gabion or cement; over 80% of the stream site straightened and disrupted. Habitat greatly altered or removed.

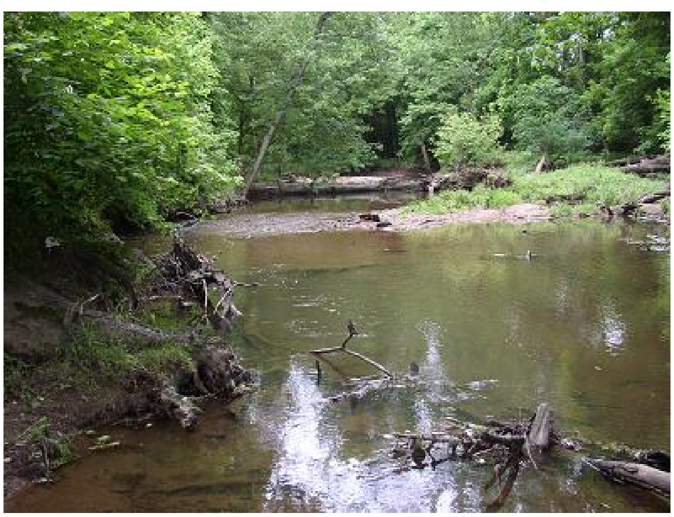
	20 – 19 – 18 – 1 7- 16	15 – 14 – 13 – 12 - 11	10 – 9 – 8 – 7 - 6	5 – 4 – 3 – 2 – 1 - 0
Frequency of Riffles (or bends) Score	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of stream <7:1 (generally 5-7); variety of habitat is good.	Occurrence of riffles infrequent; distance between riffles divided by stream width is 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by stream width is between 15-25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by stream width is a ratio of >25.
Parameter/Score L Bank R Bank	**Optimal 10 – 9**	**Good 8 – 7 – 6**	**Marginal 5 – 4 – 3**	**Poor 2 – 1 – 0**
Bank Stability	Banks stable; minimal evidence of erosion or bank failure; little potential for future problems; <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over; 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; bank sloughing; >60% with bank scars.
Bank Vegetation Protection	>90% of bank surfaces and immediate riparian zone covered by naturally growing trees, shrubs, and perennial plants; vegetation not disturbed	70-90% of bank surfaces covered by natural vegetation; some disruption evident; >1/2 of natural plant height remaining	50-70% of bank covered by vegetation; disruption obvious; patches of bare soil or low cut vegetation; <1/2 of natural plant height remaining.	<50% of bank surfaces covered by vegetation; high level of disruption evident; bare soil or low cut vegetation extensive
Riparian Zone	Width of riparian zone > 54 feet; human activity has not impacted zone	Width of zone between 36-54'; minimal human impact on zone	Width of zone between 18-36'; considerable human impact on zone	Width of zone <18'; little or no riparian zone due to human activity/alterations
Total Score	**Habitat Assessment Score: (Sum of Individual Scores) ______ /2 = ______ %** (>90% = Excellent; 75-89% = Good; 60-74% = Marginal; <60% = Poor)			

ATTACHMENT A.
HABITAT ASSESSMENT PARAMETERS

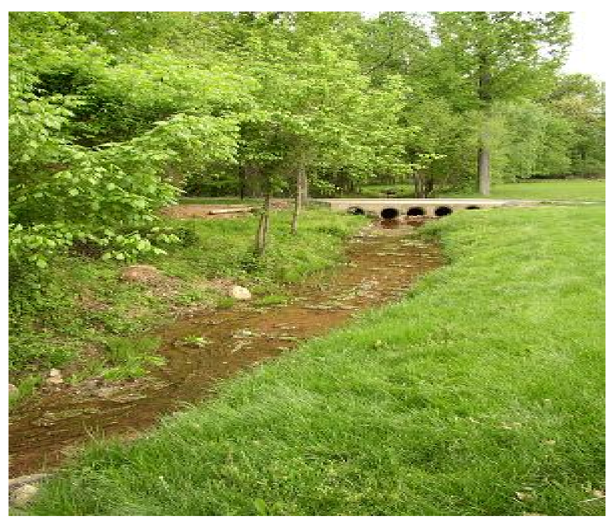
EPIFAUNAL SUBSTRATE/AVAILABLE COVER

Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refuge, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provide macroinvertebrates and fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbances decreases. Riffles and runs are critical for maintaining a variety and abundance of insects in high-gradient streams because they offer a diversity of habitat through variety of particle size.

Habitat Parameter	Condition Category			
	Optimal	**Good**	**Marginal**	**Poor**
Epifaunal Substrate/ Available Cover	>70% of substrate (>50% for low gradient streams) favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat, and at stage to allow full colonization potential (i.e., not new and not transient).	40-70% (30-50% in low gradient streams) mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
Score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0



Optimal Range



Poor Range

EMBEDDEDNESS

Embeddedness is the extent to which rocks (including gravel, cobble, and boulders) are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish is decreased. Embeddedness is a result of sediment movement and deposition, and is a parameter measured in the riffles and runs of high gradient streams. Embeddedness is different from sediment deposition, another parameter. Observations of embeddedness should be taken in the upstream and central portions of riffles and cobble substrate areas.

Habitat Parameter	Condition Category			
	Optimal	**Good**	**Marginal**	**Poor**
Embeddedness	Fine sediment surrounds and fills in 0-25% of living spaces around and between gravel, cobble, & boulders. Plume of sediment almost nonexistent. Rocks look as if placed on streambed.	Find sediment surrounds and fills in 25-50% of living spaces around and between gravel, cobble, & boulders. Sides of rocks have "cemented in" look. Plume is small to moderate.	Find sediment surrounds and fills in 50-75% of living spaces around and between gravel, cobble, & boulders. Sides of rocks have a "cemented in" look. Plume is moderate to extensive.	Find sediment surrounds and fills in >75% of living spaces around and between gravel, cobble, & boulders. Sides of rocks have a "cemented in" look. Sediment plume is extensive.
Score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

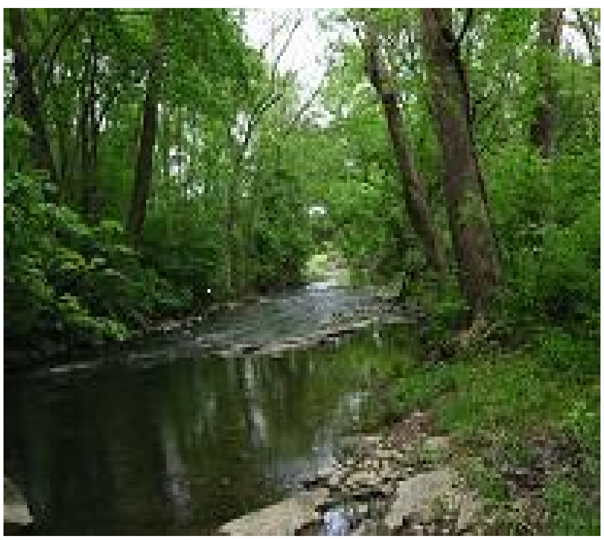

Optimal Range


Poor Range

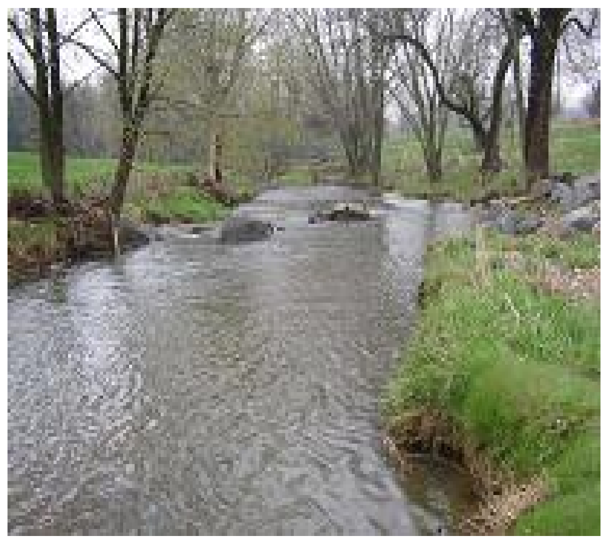
VELOCITY/DEPTH COMBINATIONS

Patterns of velocity and depth are an important feature of habitat diversity. The best streams in most piedmont regions will have all four patterns present: (1) slow-deep; (2) slow-shallow, (3) fast-deep, and (4) fast-shallow. The general guidelines are 0.5 m depth to separate shallow from deep, and 0.3 m/sec to separate fast from slow. The occurrence of these four patterns relates to the stream's ability to provide and maintain a stable aquatic environment.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Velocity/ Depth Regimes	All 4 velocity/ depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). Slow is <0.3m/s, deep is >0.5m.	Only 3 of the 4 regimes present. If fast-shallow is missing, score lower than if missing other regimes.	Only 2 of the 4 habitat regimes present. If fast-shallow or slow-shallow are missing, score low.	Dominated by 1 velocity/ depth regime (usually slow-deep).
Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Good Range

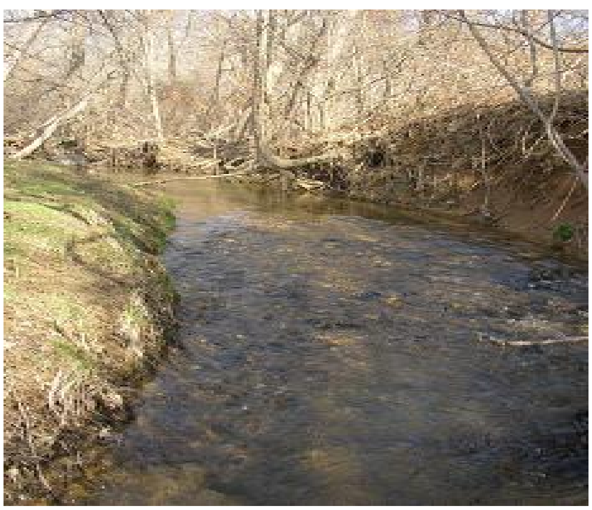


Poor Range

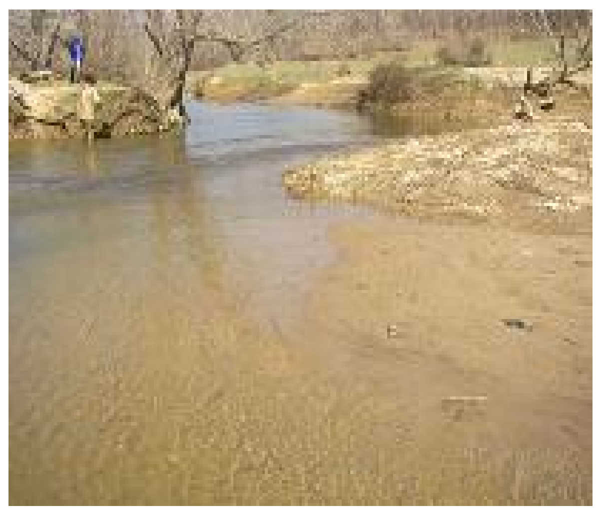
SEDIMENT DEPOSITION

Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of runs and pools. Usually deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% for the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% for the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition in pools evident.	Heavy deposits or fine material, increased bare development; more than 50% of bottom changing frequently; pools almost absent due to substantial sediment deposition.
Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range

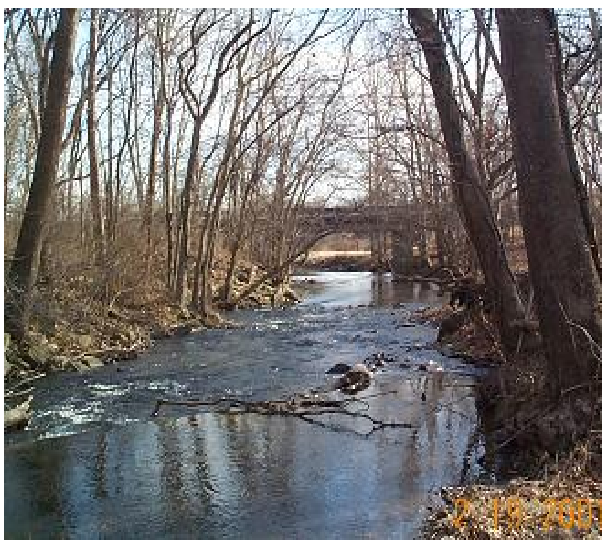


Poor Range

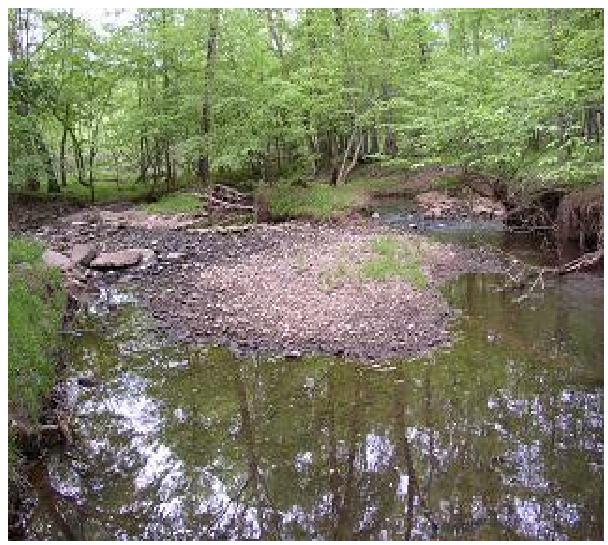
CHANNEL FLOW STATUS

Channel flow is the degree to which the channel is filled with water. The flow status will change as the channel enlarges or as flow decreases as a result of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions. This parameter becomes important when more than one biological index period is used for surveys or the timing of sampling is inconsistent among sites or annual periodicity.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Channel Flow Status	Water reaches base of both banks; and minimal amount of channel substrate exposed.	Water fills more than 75% of available channel.	Water fills 25-75% of available channel; and/or riffle substrates mostly exposed.	Very little water in channel, and mostly present as standing pools.
Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range

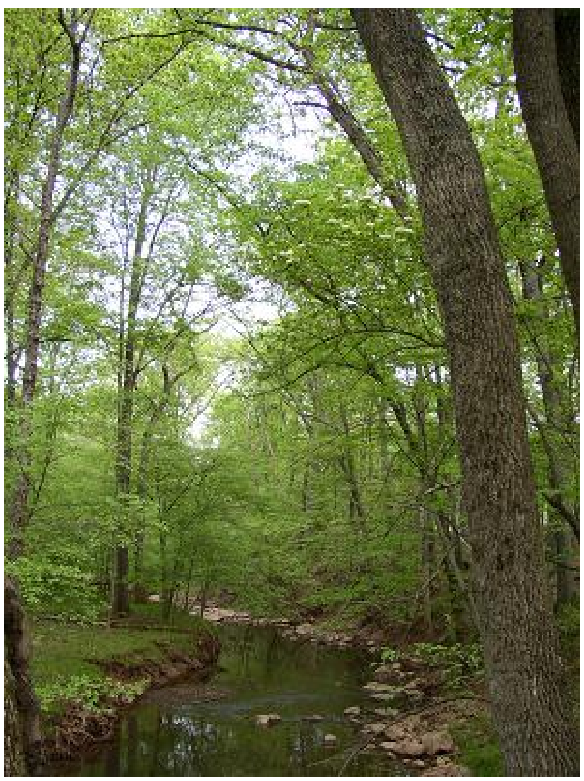


Poor Range

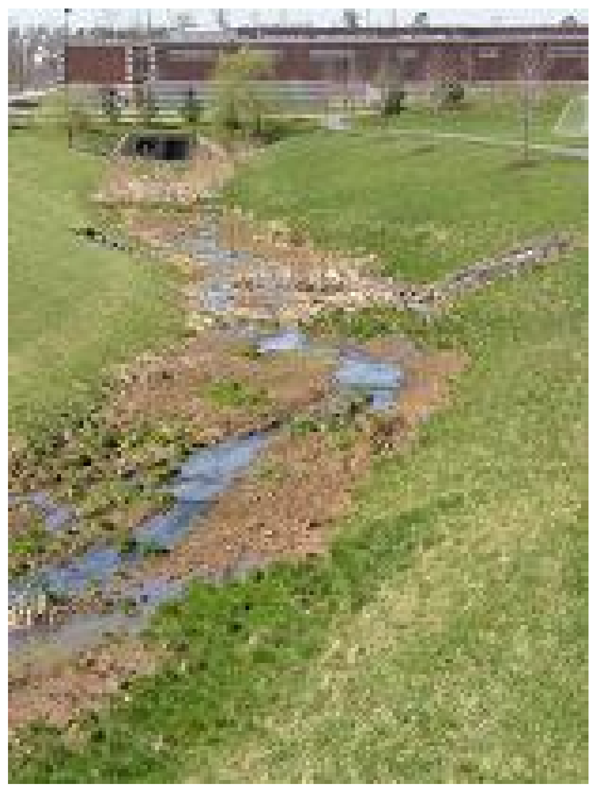
CHANNEL ALTERATION

Channel alteration is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control or irrigation purposes. Such streams have far fewer natural habitats for fish, macroinvertebrates, and plants than do naturally meandering streams. Channel alterations present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Channel Alteration	Minimal impact from stream straightening, artificial embankments, dams, bridge abutments.	Some stream straightening, artificial embankments, dams usually in areas of bridges. No evidence of recent channel alteration.	Artificial embankments present to some extent on both banks; and 40 to 80% of stream site straightened or otherwise altered.	Bank shored with gabion or cement; over 80% of the stream site straightened and disrupted.
Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range

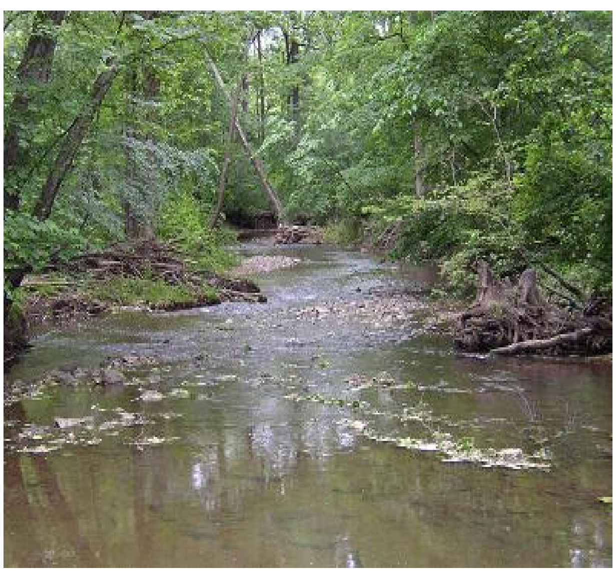


Poor Range

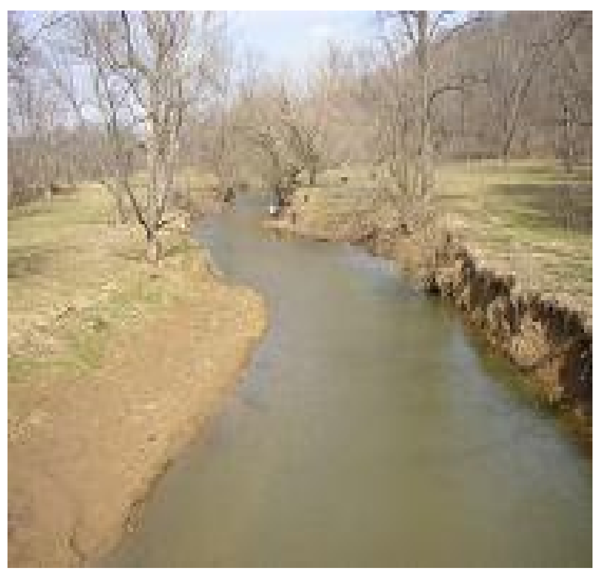
FREQUENCY OF RIFFLES

Frequency is a way to measure the sequence of riffles and thus the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna. An increased frequency of occurrence greatly enhances the diversity of the stream community. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding, and provides refuge for benthic invertebrates during storm events. To gain an appreciation of this parameter in some streams, a longer segment or reach then that designated for sampling should be incorporated into the evaluation. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Frequency of Riffles	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is 7 to 15.	Artificial Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio >25.
Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range

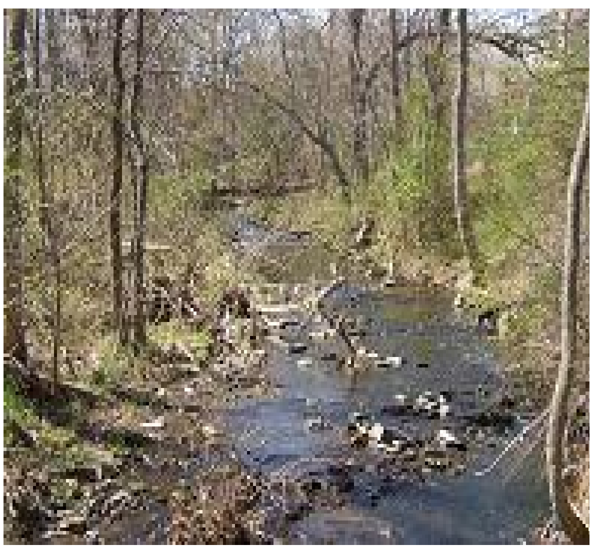


Poor Range

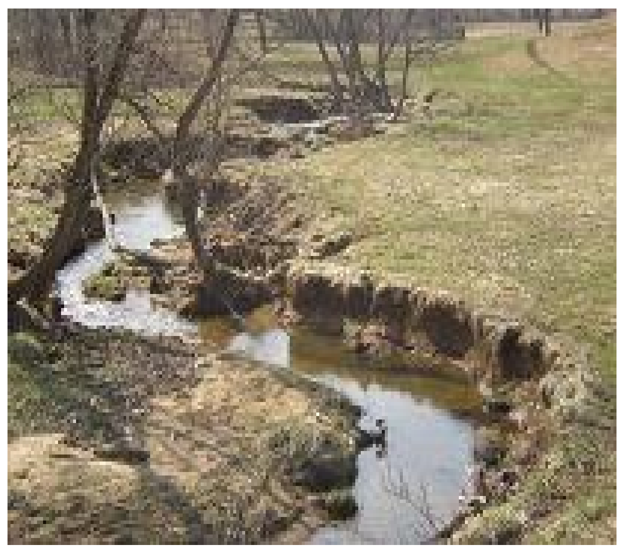
BANK STABILITY

Measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soils. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and organic input to streams. Each bank is evaluated separately and the cumulative score (right and left looking upstream) is used for this parameter.

Habitat Parameter	Condition Category			
	Optimal	**Good**	**Marginal**	**Poor**
Bank Stability	Banks stable; no evidence of erosion or bank failure; side slopes; little potential for future problems.	Moderately stable; infrequent, small areas of erosion mostly healed over; slight potential in extreme floods.	Moderately unstable; moderate frequency and size of erosion areas; high erosion potential extreme high flow.	Unstable; many eroded areas; “raw” areas frequent along straight sections and bends.
Left Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0
Right Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range



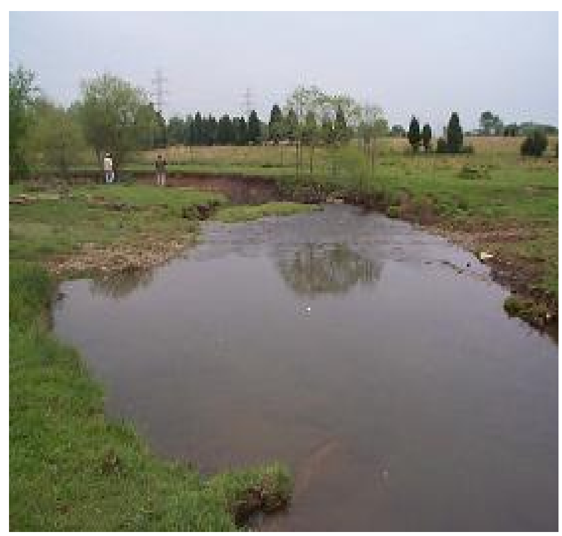
Poor Range

BANK VEGETATION PROTECTION

Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information of the ability of the bank to resist erosion as well as some additional information of the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded and can extend to the bank vegetative protection zone. Each bank is evaluated separately and the cumulative score (right and left looking upstream) is used for this parameter.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Vegetative Protection	>90% of bank surfaces and immediate riparian zone covered by naturally growing trees, shrubs, and perennial plants; vegetation not disturbed. Almost all plants are growing naturally.	70-90% of bank surfaces covered by natural vegetation but one class of plants is not well represented; some disruption evident but not affecting full plant growth; >1/2 of natural plant height remaining	50-70% of bank surfaces covered by vegetation; disruption evident; patches of bare soil or low cut vegetation common; <1/2 of natural plant height remaining.	<50% of bank surfaces covered by vegetation; disruption of streambank vegetation is very high; bare soil or low cut vegetation extensive
Left Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0
Right Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0

Optimal Range

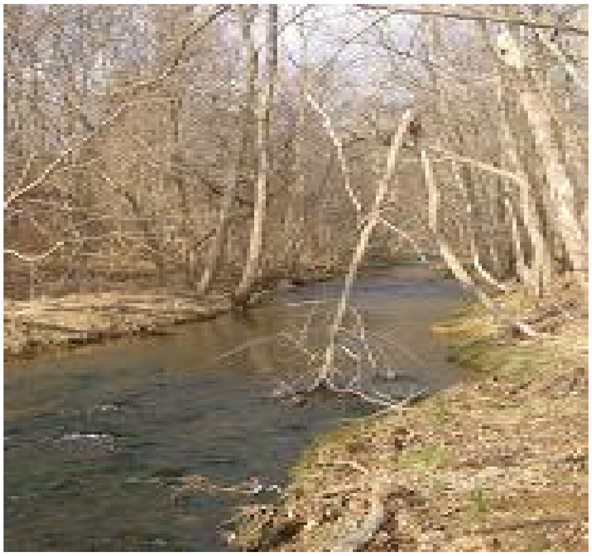


Poor Range

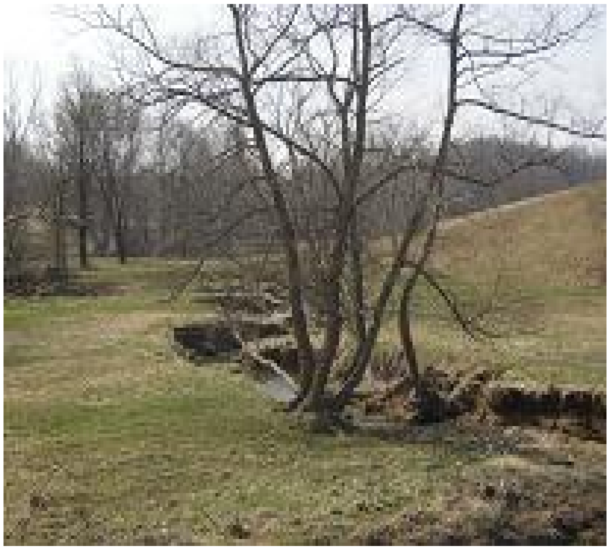
RIPARIAN VEGETATIVE ZONE WIDTH

Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input to the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. Residential developments, urban centers, golf courses, and grazing land are common causes of degradation of the riparian zone. Conversely, the presence of overgrown fields, paths, and walkways in otherwise undisturbed riparian zone may be judged to be inconsequential to altering the riparian zone and may be given relatively high scores. Each bank is evaluated separately and the cumulative score (right and left looking upstream) is used for this parameter.

Habitat Parameter	**Condition Category**			
	Optimal	**Good**	**Marginal**	**Poor**
Riparian Vegetative Zone	Width of riparian zone > 54 feet; human activity has not impacted zone	Width of zone between 36-54'; human activities impacted zone only minimally	Width of zone between 18-36'; human activities impacted zone a great deal	Width of zone <18'; little or no riparian zone due to human activity/ alterations
Left Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0
Right Bank Score	20 –19 –18 –1 7--16	15 –14 –13 –12 --11	10 – 9 – 8 – 7 --6	5 –4 –3 –2 –1 –0



Optimal Range



Poor Range