West Virginia Save Our Streams

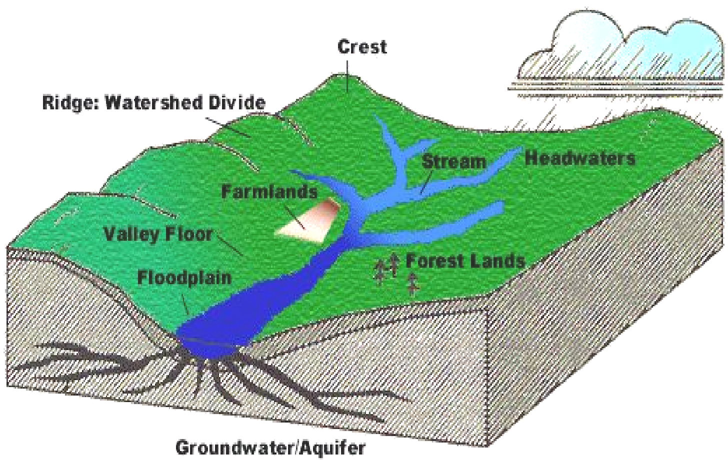
Intermediate Bioassessment Protocols

WEST VIRGINIA
Department of Environmental Protection

Introduction

To restore and maintain healthy watersheds, we need to understand what healthy watersheds are, how humans affect them, and how well our protection and restoration schemes are working. And that goes beyond ecological theories about how watershed forces interact. It goes beyond the models that attempt to predict what happens if we change this feature or that reach of river. It's getting out into the field and seeing what's really going on. It's getting your feet wet, as hydrologist Dave Rosgen says: "Wear out your waders!" You just can't understand what's going on in your watershed unless you get out into the field and look or take some measurements, that's monitoring. Then you try to figure out the story of you watershed's health, that's assessment. The introduction section briefly describes some of the general approaches to watershed monitoring and assessment, and defines some basic watershed terminology.

An Overview of Watersheds



A **watershed** is an area of land that drains water, and everything in the water, to some sort of outlet. From a plane, looking down on the landscape, I'm awed by the wide variety of drainage patterns. Water is a great maker of landforms, and the patterns that water carves in the landscape are striking. Most look like tree branches. And in fact, the "**stream ordering**" system uses that concept. The upper-most streams are first-order, two first-order streams form a second-order, two second order streams form a third order, etc.

Streams begin in **headwaters**; typically steep areas with V-shaped valleys. These high-energy streams erode material from the slopes and carry it downstream to the **transfer zone**. Here larger particles begin to drop out as the gradient flattens and the stream starts to meander. Finally, the stream enters the **depositional zone** where the gradient flattens even more and even smaller particles are deposited. Water volume, stream channel size, deposition, food, habitat, and life forms all change as you move downstream.

Let's look at watersheds sideways. First, there's the **stream channel** itself, which carries flowing water and sediment. Channels take myriad forms. They may have one thread, or multiple threads. Their curvature may vary. Their cross sections may be v-shaped, u-shaped, rectangular, parabolic, and many more. Flowing water forms the channel. Moving out from there is the **floodplain**, which carries water that spills over the banks of the channel. The recent sideways movement of the channel forms floodplains. **Upland terraces** form the banks of the flooding river. The historic sideways and vertical movement of the channel forms them. Uplands are areas that do not flood. The larger geologic processes form them over time. If we are going to monitor and assess the health of our watersheds, how do we define it?

What Is Watershed Health?

Aquatic ecosystems are not simple. Neither are definitions of ecosystem health. So, as we explore these definitions, we'll also look into a little of the science of aquatic ecology.

The Clean Water Act itself. Briefly, the act describes healthy waters as the conditions needed to support various uses (for example drinking water, recreation, and aquatic life). These conditions are described either in terms of maximum concentrations of pollutants, acceptable ranges of physical components, minimum concentrations of desirable components (such as dissolved oxygen) or the attributes of communities of living things, such as diversity, the presence or absence of indicator organisms, and distribution of classes of organisms.

To assess the health of our watersheds, we must assess the health of its living communities in a range of conditions that reflect human impacts, from minimal to severe. We compare the condition of biota in areas with human impacts to areas with minimal impacts (reference conditions) to assess degradation and disturbance.

A possible way to assess the **physical** aspects of the watershed is in terms of **stability**, or the way the water flows over the landscape "fluvial geomorphology". David Rosgen defines stability as the ability of a stream over time (in the present climate) to transport the water and sediment produced by its watershed while maintaining the elevation of its bed, neither raising it with the long term depositing of bottom material or lowering it with the long term erosion of bottom material.

Yet another concept of health is **dynamic equilibrium**. This is the ability of an ecosystem to adjust to disturbances and be self-sustaining. This requires the ecosystem to be able to maintain its original form and return to this form relatively quickly after a disturbance. It also requires a good description of the original form (or reference condition) as a benchmark against which to compare change.

Healthy Compared to What?

Each of these definitions of health describes a desired end state. Applying this to any particular watershed requires a good description of the reference condition (the original form or stable form). Actual reference sites are elusive in the real world, because virtually all of our watershed ecosystems have been altered in some way. So, the reference condition often used is the **least impaired**. These are places where human impacts, though present, are minimal and the ecosystem is thought to be fairly close to its natural condition. We measure and describe these places so we can compare other sites to them. Understanding reference conditions is the basis for assessing change caused by humans.

Now we run into another problem; we can't compare a site in the depositional zone to a site in the headwaters. They are naturally different. So, we must come up with a way to classify our waters so we're comparing apples with apples. This means we need a reference site for each type of water. Simple, in theory, but try finding a reference site for a big river in a depositional zone. That's where cities tend to be located.

One way to avoid this dilemma is to develop theoretical reference conditions. Water quality criteria in state water quality standards are meant to describe conditions, which, if met, will support specified uses. There are problems with this approach. The main problem is that they tend to be based mostly on concentrations of water column materials.

Where does that leave us? In an imperfect world, we do the best we can. We use water quality criteria if we have to, and actual reference conditions if we can find them. Regardless, once we've decided on the benchmarks we'll use to assess watershed health, in order to find out what's going on in our watersheds, we've got to get out of our offices and measure things.

How Do We Measure Watershed Health?

To truly monitor and assess the health of our watersheds, we would need to monitor all their physical, chemical, and biological features – everywhere and all the time! Obviously, we can't do that, so, we need to make choices about the **indicators** (measurable features) that we will track and how, where we'll track them, and how often. We might think about understanding the health of our watersheds as a process of trying to understand

- The reference conditions,
- The stresses placed on those natural conditions by humans,
- The response of the watershed to the stresses, and
- The response of the watershed ecosystem to our attempts to reduce the stresses.

What is the West Virginia Save Our Streams Program?

West Virginia Save Our Streams (WVSOS) is a volunteer stream monitoring and assessment program that provides training on how to complete a streamside bioassessment survey. This kind of survey involves collecting benthic macroinvertebrate samples, recording their numbers, and calculating a series of biotic indexes to rate the stream site. Additional data about the stream's physical characteristics are evaluated using habitat assessment approach similar to EPA's Rapid Bioassessment Protocols (RBP). This manual provides the basic instructions and forms needed to conduct this type of field survey. After participating in a stream monitoring workshop and passing a quality assurance (QA) examination, the volunteer monitors will receive free stream monitoring equipment and official recognition that they are certified in accordance with the WV Water Pollution Control Act.

After each monitoring event the volunteer group should send the completed survey forms to the coordinator. The coordinator reviews the information and a photocopy of the survey is returned to the volunteer group. The information from the surveys collected by volunteer monitors are maintained both in paper and are summarized in a computer database. These surveys are used as a tool to help compliment the assessment of watersheds throughout West Virginia.

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Stream Monitoring Safety Considerations

One of the most critical considerations for a volunteer monitoring program is the safety of its volunteers. All volunteers should be trained in safety procedures and should carry with them a set of safety instructions and the phone number of their program coordinator or team leader. Safety precautions can never be overemphasized. The list below provides some basic common sense safety rules.

1. **Always monitor with at least one partner**. Teams of three or four people are best. Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.

2. **Develop a safety plan**. Find out the location and telephone number of the nearest telephone and write it down. Locate the nearest medical center and write down directions on how to get between the center and your site(s) so that you can direct emergency personnel. Have each member of the sampling team complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, etc.

3. **Have a first aid kit handy**. Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings). It is best if at least one team member has first aid/CPR training.

4. **Listen to weather reports**. Never go sampling if severe weather is predicted or if a storm occurs while at the site.

5. **Never wade in swift or high water**. Do not monitor if the stream is at flood stage.

6. **If you drive, park in a safe location**. Be sure your car doesn't pose a hazard to other drivers and that you don't block traffic.

7. **Put your wallet and keys in a safe place**. Use a watertight bag you keep in a pouch strapped to your waist. Without proper precautions, wallet and keys might end up downstream.

8. **Never cross private property without the permission of the landowner**. Better yet, sample only at public access points such as bridge or road crossings or public parks. Take along a card identifying you as a volunteer monitor, or some other form of identification.

9. **Confirm that you are at the proper site location**. Check your maps, site descriptions, and directions.

10. **Watch for dangerous animals**. Watch for irate dogs, farm animals, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps. Know what to do if you get bitten or stung.

11. **Watch for poisonous or irritating plants**. Watch for poison ivy, poison oak, sumac, and other types of vegetation in your area that can cause rashes and irritation.

12. **Never drink the water in a stream**. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap.

13. **Do not monitor if the stream is posted as unsafe for body contact**. If the water appears to be severely polluted, and is not posted, contact your program coordinator.

14. **Do not walk on unstable stream banks**. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb streamside vegetation as little as possible.

15. **Be very careful when walking in the stream itself**. Rocky-bottom streams can be very slippery and can contain deep pools; muddy-bottom streams might also prove treacherous in areas where mud, silt, or sand has accumulated in sinkholes. If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck. Your partner(s) should wait on dry land ready to assist you if you fall. Do not attempt to cross-streams that are swift and

above the knee in depth. Wear waders and rubber gloves in streams suspected of having significant pollution problems.

If at any time you feel uncomfortable about the condition of the stream or your surroundings, stop monitoring and leave the site at once. Your safety is more important than the data!

First Aid Kit

The minimum first aid kit should contain the following items:

- Telephone numbers of emergency personnel such as the police and an ambulance service.
- Several band-aids for minor cuts.
- Antibacterial or alcohol wipes.
- First aid crème or ointment.
- Several gauze pads 3 or 4 inches square for deep wounds with excessive bleeding.
- Acetaminophen for relieving pain and reducing fever.
- A needle for removing splinters.
- A first aid manual, which outlines diagnosis and treatment procedures.
- A single-edged razor blade for minor surgery, cutting tape to size, and shaving hairy spots before taping.
- A 2-inch roll of gauze bandage for large cuts.
- A triangular bandage for large wounds.
- A large compress bandage to hold dressings in place.
- A 3-inch wide elastic bandage for sprains and applying pressure to bleeding wounds.
- If a participant is sensitive to bee stings, include their doctor-prescribed antihistamine.
- Be sure you have emergency telephone numbers and medical information with you at the field site for everyone participating in fieldwork (including the leader) in case there is an emergency.

When using chemicals:

1. Know your equipment, sampling instructions, and procedures before going out into the field. Prepare labels and clean equipment before you get started.

2. Keep all equipment and chemicals away from small children. Many of the chemicals used in monitoring are poisonous. Tape the phone number of the local poison control center to your sampling kit.

3. Avoid contact between chemical reagents and skin, eye, nose, and mouth. Never use your fingers to stopper a sample bottle (e.g., when you are shaking a solution). Wear safety goggles when performing any chemical test or handling preservatives.

4. Know chemical cleanup and disposal procedures. Wipe up all spills when they occur. Return all unused chemicals to your program coordinator for safe disposal. Close all containers tightly after use. Do not switch caps.

5. Know how to use and store chemicals. Do not expose chemicals or equipment to temperature extremes or long-term direct sunshine.

Chemical and Physical Aspects of Water Quality

Dissolved Oxygen

Aquatic animals depend on dissolved oxygen (the oxygen present in water) to live. The amount of dissolved oxygen in streams is dependent on the water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration. Dissolved oxygen (DO) is measured in milligrams per liter (mg/L) or parts per million (ppm). The temperature of stream water influences the amount of dissolved oxygen present; less oxygen dissolves in warm water than cold water. For this reason, there is cause for concern for streams with warm water. Trout need DO levels in excess of 8 mg/L; Smallmouth bass prefer DO levels above 5 mg/L, and warm water bottom dwelling fish (Carp certain kinds of catfish) need DO in excess of 2 mg/L.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the amount present for aquatic life. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Incubating a sealed sample of water for five days and measuring the loss of oxygen from the beginning to the end of the test determine biochemical oxygen demand. Samples often must be diluted prior to incubation or the bacteria will deplete all of the oxygen in the bottle before the test is complete. The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The excess bacteria grown in the system are removed as sludge, and this “solid” waste is then disposed of on land.

Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.

If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal for most fish and macroinvertebrates. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the DO sag curve.

pH, Acidity and Alkalinity

The pH of water is a measure of the amount of free hydrogen ions in water. Specifically, pH is the negative logarithm of the molar concentration of hydrogen ions.

- pH = -log [H +]
- For example, at pH 2, [H +] = 10^{-2} or .01
- At a pH 10 [H +] = 10^{-10} or .0000000001
- At a pH 4 [H +] = 10^{-4} or .0001

Because pH is measured on a logarithmic scale, an increase of one unit indicates an increase of ten times the amount of hydrogen ions. A pH of 7.0 is considered to be neutral.

Acidity increases as pH values decrease, and alkalinity increases as pH values increase. Most natural waters are buffered by a carbon-dioxide-bicarbonate system, since the carbon dioxide in the atmosphere serves as a source of carbonic acid.

- $H_2CO_2 \rightarrow HCO_3 + H + pK \sim 7.5$

This reaction tends to keep pH of most waters around 7 to 7.5, unless large amounts of acid or base are added to the water. Most streams draining coniferous woodlands tend to be slightly acidic (6.5 – 6.8) due to organic acids produced by the decaying of organic matter. Natural waters also receive acidity from the soils. In waters with high algal concentrations, pH varies diurnally, reaching values as high as 10 during the day when algae are using carbon dioxide in photosynthesis. The pH drops during the night when the algae respire and produce carbon dioxide.

The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH.

Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is derived principally from the salts of weak acids. Hydroxide, carbonates, and bicarbonates are the dominant source of natural alkalinity. Reactions of carbon dioxide with calcium or magnesium carbonate in the soil create considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause gastrointestinal discomfort.

Nutrients

Nutrients such as phosphorous and nitrogen are essential for the growth of algae and other plants. Aquatic life is dependent upon these photosynthesizers, which usually occur in low levels in surface water. Excessive concentrations of nutrients, however, can over stimulate aquatic plant and algae growth. Bacterial respiration and organic decomposition can use up dissolved oxygen, depriving fish and macro-invertebrates of available oxygen in the water *(*eutrophication).

Fertilizers, failing septic systems, waste water treatment plant discharges, and wastes from pets and farm animals are typical sources of excess nutrients in surface waters. In aquatic ecosystems, because phosphorous is available in the lowest amount, it is usually the limiting nutrient for plant growth. This means that excessive amounts of phosphorous in a system can lead to an abundant supply of vegetation and cause low DO. The forms of nitrogen found in surface water are nitrate, nitrite, and ammonia. Ammonia is usually rapidly converted to nitrate in aerobic waters, as is true in soils (nitrate is a stable form of nitrogen, while ammonia is unstable). Ammonia is associated with municipal treatment discharges, and the stressing effects of ammonia on aquatic organisms, increase at low dissolved oxygen levels and at increased pH. Increased nitrogen levels adversely affect cold-water fish more than they do warm water fish. Nitrogen concentrations of 0.5 mg/L are toxic to certain kinds of trout. Nitrogen is also a concern in drinking water because an increased level of nitrate has been linked with blue-baby syndrome in infants. In 1986, the U.S. EPA established a 10-mg/L concentration of nitrate as a standard for drinking water.

Limnologists and stream ecologists have broadly categorized the productivity of lakes and streams into three classes: **Oligatrophic**, **Mesotrophic**, and **Eutrophic**. Oligatrophic water has very low inputs of nutrients and carbon, and so primary biological productivity (mainly plant growth) is low. This type of water tends to be very clear. Most mountain streams and lakes in pristine areas tend to be oligatrophic. Mesotrophic water has moderate amounts of nutrients and carbon. Aquatic life tends to be very diverse in mesotrophic waters. Eutrophic water is highly productive because of high amounts of nutrients and carbon. Eutrophic waters tend to be unstable in their chemistry and biology, and as a result, species richness and diversity tends to be low even though biomass can be quite high. Often times, eutrophication is a man-induced process where elevated nutrient levels over-stimulate biological production.

Conductance or Electrical Conductivity

Conductivity is the ability of a substance to conduct electricity. The conductivity of water is a more-or-less linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. Conductivity is measured in terms of conductivity per unit length, and meters typically use the microsiemens/cm unit.

All natural waters contain some dissolved solids due to the dissolution and weathering of rock and soil. Evaporating a known volume of water and weighing the residue determine dissolved solids. Some but not the entire dissolved solids act as conductors and contribute to conductance. Waters with high total dissolved solids (TDS) are unpalatable and potentially unhealthy. Examples of water with high conductivities are those that have been impacted by mining and have high concentrations of metals dissolved in the water. Water treatment plants use flocculants to aggregate suspended and dissolved solids into particles large enough to settle out of the water column in settling tanks. A flocculent is a chemical that uses double-layer kinetics to attract charged particles.

Sediment and Substrate

Sediment enters streams by upland soil erosion, bank erosion, and land sliding. Sediment is a natural component of streams, but excessive sediment can be carried into streams and rivers from erosion of unstable streambanks, construction sites, agricultural activities, and urban runoff. Sediment moves downstream in a river in two forms: suspended load and bed load. Suspended load includes the particles in suspension in the water column. Bed load refers to the sediment pushed along the bottom of the channel. Coarser substrate such as sand and gravel tends to move as bed load, not suspended load.

Sediment is usually measured as a concentration of total suspended solids (TSS), which is the dry weight after filtering a water sample, expressed in mg/L. To determine a suspended sediment load (mass/time), the TSS concentration must be multiplied by the flow rate (volume/time). Turbidity is another indicator of the amount of material suspended in water; it measures the amount of light that is scattered or absorbed. Suspended silt and clay, organic matter, and plankton can contribute to turbidity. Photoelectric turbidimeters measure turbidity in nephelometric turbidity units (NTUs). Turbidity units are supposed to correspond to TSS concentrations, but this correlation is only approximate. Turbidity in a stream will fluctuate before, during and after storm flow. Most state rules and regulations for water quality control, give general criteria for all waters, which include narrative standards for turbidity.

Fine sediment deposited on the streambed can fill gravel spaces, eliminating spawning habitat for some fish species and also eliminating habitat for many invertebrate species. Turbidity and or TSS can reduce light penetration, decreasing algal growth, and low algal productivity can reduce the productivity of macro-invertebrates. High turbidity levels affect fish feeding and growth; the ability of salmonids to find and capture food is impaired at turbidities from 25 to 70 NTUs. Gill function in some fish and macro-invertebrates may be impaired after 5 to 10 days of exposure to a turbidity level of greater than 25 NTUs.

Average turbidities of less than 10 describe clear waters. Waters with turbidity in excess of 50 are quite cloudy, and waters with turbidities exceeding 500 are extremely muddy. Large bed loads can also reduce or eliminate habitat essential to low-flow and summer survival of aquatic organisms. Essentially, channels with high bed loads tend to feature shallower water and a larger wetted perimeter. Channel bed topography as well as the size distribution of sediments on the bottom of the channel (referred to as substrate) are vital factors for the productivity of many aquatic organisms. Pools provide resting areas for fish, protection from terrestrial and avian predators, and sometimes provide cooler water, which lowers metabolic needs. Areas of cool water in streams and lakes are called thermal refugia.

Temperature

Metabolic rate and the reproductive activities of aquatic life are controlled by water temperature. Metabolic activity increases with a rise in temperature, thus increasing a fish’s demand for oxygen; however; an increase in stream temperature also causes a decrease in DO, limiting the amount of oxygen available to these aquatic organisms. With a limited amount of DO available, the fish in this system will become stressed. A rise in temperature can also provide conditions for the growth of disease-causing organisms.

Water temperature varies with season, elevation, geographic location, and climatic conditions and is influenced by stream flow, streamside vegetation, groundwater inputs, and water effluent from industrial activities. Water temperatures rise when streamside vegetation is removed. When entire forest canopies were removed, temperatures in Pacific Northwest streams increased up to 8° C above the previous highest temperature. Water temperature also increases when warm water is discharged into streams from industries.

Woody Debris

Depending on the size and gradient of a channel, the amount and size of woody debris in the channel can have a dramatic effect on the habitat quality and productivity of a channel. Woody debris serves as a scour element, meaning that during high flows water is accelerated in a downward direction around the woody debris and scours out a hole around the bottom of the debris. This hole serves as a pool between storms. The wood itself provides cover, or hiding places, for the fish using the pool and also provides a support surface and food source for many kinds of macroinvertebrates. When a stream is surveyed by electro shocking methods, many kinds of the fish are found in the pools below and around woody debris. In sandy-and muddy bottomed (slow moving) streams; wood serves as one of the best food source and growth platform for macroinvertebrates. In coastal streams, more than 60% of the food source for resident fish comes from macroinvertebrates associated with woody debris. To protect the quality of habitat in a stream or river, it is necessary to maintain a forested riparian corridor from which large woody debris can fall into the channel.

Bacteria

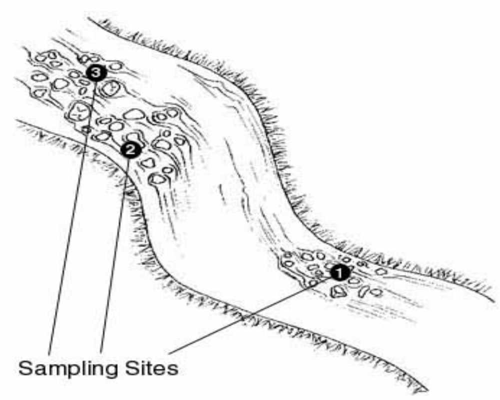
Bacteria and viruses from human and animal wastes carried to streams can cause disease. Fecal coliform, found in the intestines of warm-blooded animals, is the bacteria for which many states' surface water quality standards are written. Fecal coliform bacteria do not cause disease but are used as an indicator of disease causing pathogens in the aquatic environment. Most states have a standard is 200 colonies per 100 ml of sample water for drinking water and slightly higher for other waters, but the State of California Water Pollution Control Board recommends concentrations of less than 5 colonies per 100 ml of sample for shellfish culture. Typical sources of bacteria are sewage from septic system failure and stormwater overflows, poor pasture management and animal-keeping practices, pet waste, and urban runoff. High bacteria levels can limit the uses of water for swimming or contaminate drinking water in groundwater wells.

Collecting a Stream Sample for Chemical Analysis

In general, sample away from the streambank in the main current. Never sample stagnant water. The outside curve of the stream is often a good place to sample, since the main current tends to hug this bank. In shallow stretches, carefully wade into the center current to collect the sample. The steps for collecting a water quality sample are provided below:

1. **Label the bottle** with the site number, date, and time.
2. **Remove the cap from the bottle just before sampling**. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.
3. **When wading**, try to disturb as little bottom sediment as possible. In any case, **be careful not to collect water that has sediment from bottom disturbance**. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also tape your bottle to an extension pole to sample from deeper water of a lake or pond.
4. **Hold the bottle near its base and plunge it** (opening downward) **below the water surface**. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. **Collect the sample mid-way between the surface and the bottom.**
5. **Turn the bottle underwater into the current and away from you**. In slow moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.
6. **Leave a slight air space**, except for DO and BOD samples, **so that the sample can be shaken just before analysis**. Recap the bottle carefully, remembering not to touch the inside.
7. **Fill in the bottle number and site number on the appropriate field data sheet**. This is important because it tells the lab coordinator which bottle goes with which site.
8. **If the samples are to be analyzed in the lab**, place them in the cooler and add a preservative, if necessary. **Transport to the lab as soon as possible**.

Macroinvertebrate Sampling Protocols



Select a 100-meter stream reach - If possible, your reach should begin at least 50-meters upstream of any human modification to the channel such as bridges, dams, pipeline crossings etc. WVSOS recommends using a topographic map to select possible sites prior to your visit. The sites should be marked on the topo map, so that latitude and longitude can be determined. Once at your site, you will collect samples from several locations within the stream reach. The sample locations may be separate riffles (a riffle is a shallow area, consisting mainly of cobble-size stones), one large riffle with different current velocities or, if no riffles are present use the muddy-bottom sampling protocols discussed on page six.

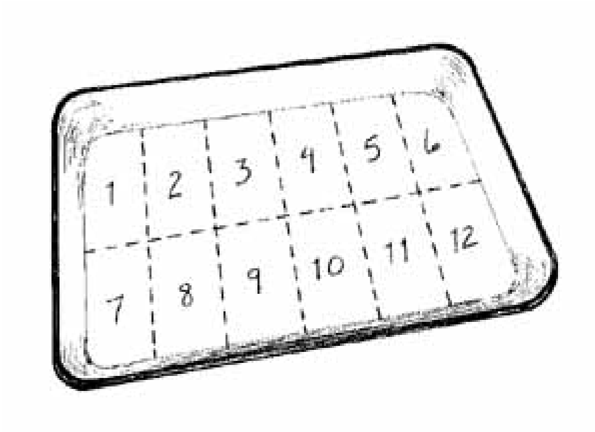
Set the kick-net - Place a kick-net perpendicular and downstream to the flow of water in the first riffle area you have selected to sample. Your sample size should be a 3x3 foot (meter^2) area directly in front of the net. The bottom of the net should fit snugly against the streambed. This is accomplished by using several large rocks from inside your sample area to help anchor the bottom of the net. If large rocks are not available (within your sample area), or are to embedded to move, use larger rocks from other nearby areas. Tilt the net slightly (approximately 45°angle), so that water flowing through, covers a larger portion of the nets surface area. However, be careful not to tilt the net to far and allow water to flow over the top.

Sample your target zone - Begin sampling your target area by lifting-up and rubbing all larger rocks to dislodge any clinging organisms. Also, rub the surfaces of rocks that are either to large or to embedded to lift. A small brush is a useful tool to use during rock rubbing. Kick the smaller cobble-size, gravel-size, and fine sediments of the riffle to dislodge any burrowing organisms. The kick consists of a back and forth twisting motion of your feet. The entire sample area should be kicked, starting from the back and moving forward towards the net. After you have rubbed all rocks and completed the kick, carefully rub the rocks that were used to anchor the net (if they came from inside your sample area). Remove the net from your sample area with an upstream scooping motion. This keeps most of the organisms collected in the middle portions of the net.

Remove the invertebrates from the kick-net - After removing the net, place it on a nearby stream bank. Choose an area that is close to the riffle you've just sampled, and is as flat as possible. It is a good practice to place a light-colored material, such as a white garbage bag, shower curtain etc., on the area, and then lay the net on top. This will help you see the organisms more clearly, and will also catch organisms that might escape through the net's mesh, if you are not using a 500 micron-mesh. Using tweezers and your fingers gently pick all organisms from the net and place them into collection containers. Make sure to check both sides of any debris caught in the net. Macroinvertebrates will cling to almost any available surface. Look closely for very small organisms, take your time and pick the net thoroughly. It is important to collect all organism captured by the net to obtain a sample that is representative of the riffle habitat. Many times, the net may begin to dry during picking causing the organism to stop moving, thus making them harder to see. Periodically wetting the net using a small spray bottle will cause the organisms remaining to move, and will wash away very fine sediments. After you have completely picked the entire top surface of the net, lift the net and closely examine its underlying areas. Many times organisms can be found

clinging to the backside of the net. Also (very important), collect any organism that have escaped the net and have been caught on the light-colored material that you placed underneath.

Separate the invertebrates collected into look-alike groups - Using the tally sheet, a couplet key, or a field ID card, identify all the organisms collected. Record the number of organisms from each look-alike group. Although counting all organisms can be tedious and time consuming, keep in mind that a complete count is a more accurate representation of the diversity of life within the stream reach.



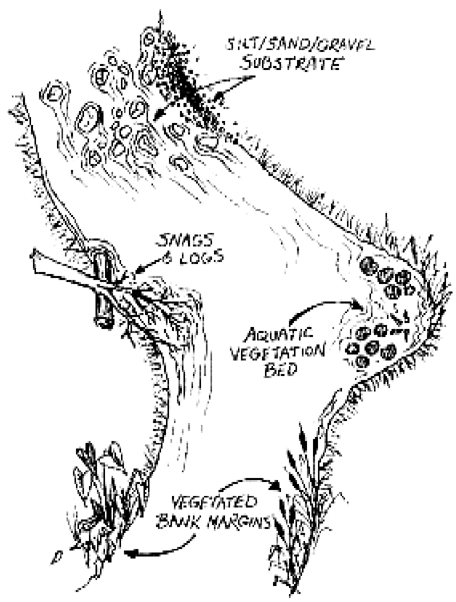
Complete the habitat assessment portion of your stream survey - After your sample collections are complete and are recorded, complete the habitat assessment survey form. This part of the survey is designed to provide you with a better understanding of the physical conditions within your stream reach and will help you interpret the benthic macroinvertebrate information.

A quality assurance review should be completed by either your team leader, if you have an approved QAPP (Quality Assurance Project Plan), or by a qualified professional. Calculate the stream index based on the numbers you've recorded and review all of the information that you have recorded. A copy of the survey and the result of the calculations should be sent to your regional coordinator or the appropriate state agency program.

Recommended Equipment

- Kick seine net
- White shallow pan and/or white ice cube trays
- Macroinvertebrate identification card, sampling worksheets and surveys
- Thermometer
- Magnifying glass or Magni-cubes
- White plastic trash bag or other white plastic tarp to place under the net
- Tweezers
- pH kit or other chemical test kits (optional)
- Clipboard and pen or pencil
- Long plastic or rubber gloves
- White 5-gallon bucket (optional)
- Screen-bottomed bucket (optional)
- Spray bottle

Sampling Muddy Bottomed Streams



Select the habitat to sample - Observe the different aquatic habitats present to determine where you will sample. Generally there are four habitat types in low-gradient (slow moving) streams: (1) Vegetated stream banks, (2) Silty bottoms with organic debris, (3) Fallen logs and woody debris and (4) Sand, rock and gravel substrate. Determine if all four types are available and their location.

The number of scoops - Using a standard size dip-net a total of 20 scoops (20 square feet) is collected. The most productive habitats should be scooped more frequently to get the best possible sample. If all four habitat types are available, the number of scoops taken from each habitat are as follows:

- Ten from vegetated stream banks
- Four from fallen logs and woody debris
- Three from silty bottom with organic debris
- Three from sand, rock and gravel substrate

If one or more habitat types are missing, redistribute the number of scoops taken with the most productive habitat (the highest type on the list) getting the most scoops.

How to Sample the Habitats

1. **Vegetated stream banks** - Jab the net in a bottom to surface motion covering one square foot of submerged area.
2. **Silty bottoms and organic debris (leaf packs)** - Jab the net in an upstream direction for one square foot. Dislodge the top few inches of organic debris.
3. **Fallen logs, woody debris** - Hold the net under the log or woody area and rub the log with your hand covering an area of one square foot. Try to dislodge some of the bark and collect any loose sticks.
4. **Sand, rock and gravel substrates** - Jab the substrate in an upstream direction for one square foot. Dislodge the top few inches of substrate.

Sorting through the debris - After you have taken several scoops, you can clean out the dip-net by repeatedly dipping it into the stream (do not allow water to flow over the top). This will wash out much of the fine silt. Periodically dump the net into your collection bucket. The rocks, sticks, leaves, and other debris should be rubbed, rinsed and inspected before being discarded.

Identifying and counting the sample - After sorting through the debris pour the sample into your collection containers. If you used a five-gallon bucket to rinse the debris, pour small amounts of the water into the containers, let it settle then begin counting and sorting the organisms. Repeat this until all of your samples are removed from your bucket. Identify your sample according to the protocols discussed in the previous section.

Important Note: It is important that 20 square feet are measured. Some dip nets are not 12 inches wide (16 inches is another popular size). If your net is 16 inches wide then take 15 scoops of one foot long (a 16 X 12 inch scoop). If the muddy-bottom method is used then your habitat assessment should reflect this.

The Habitat Assessment Survey

A habitat assessment is a visual estimate of several physical characteristics of the stream in order to determine the quality of the habitat for benthic macroinvertebrates. Together with water quality, these characteristics determine the types and numbers of macroinvertebrates capable of living there. The results of the habitat assessment will help you better interpret the macroinvertebrate data and help you understand the possible impacts from human activities.

This type of stream assessment can be separated into two basic approaches: (1) **Designed for moderate to high gradient landscapes** (riffle/run prevalent streams). Natural high and moderate gradient streambeds contain primarily coarse sediment particles (i.e., gravel size or larger) along most of the stream length. (2) **Designed for low-gradient landscapes** (soft-bottom streams). Natural low-gradient streambeds have substrate consisting of finer sediments, with infrequent coarse deposits along the length of the stream. The habitat assessment survey descried in this manual is designed for high to moderate gradient streams.

General Information

Stream, Station and County - The official name of the river or stream, any station number you assign the monitoring site and the county in which you are monitoring.

Location Description - This is important. Describe the station location so someone unfamiliar with the area can locate your station on a county road or topographic map. WVSOS recommends that monitors send a photocopy of a map with the exact location of their stations marked. Unless the station locations change, this eliminates the need to fill in the location on every survey. Examples of good descriptions include, using route numbers, distances from landmarks (bridges, churches etc.). Another method for stating location is to use "**River Reach**", which is the mileage to your site from the mouth of the stream.

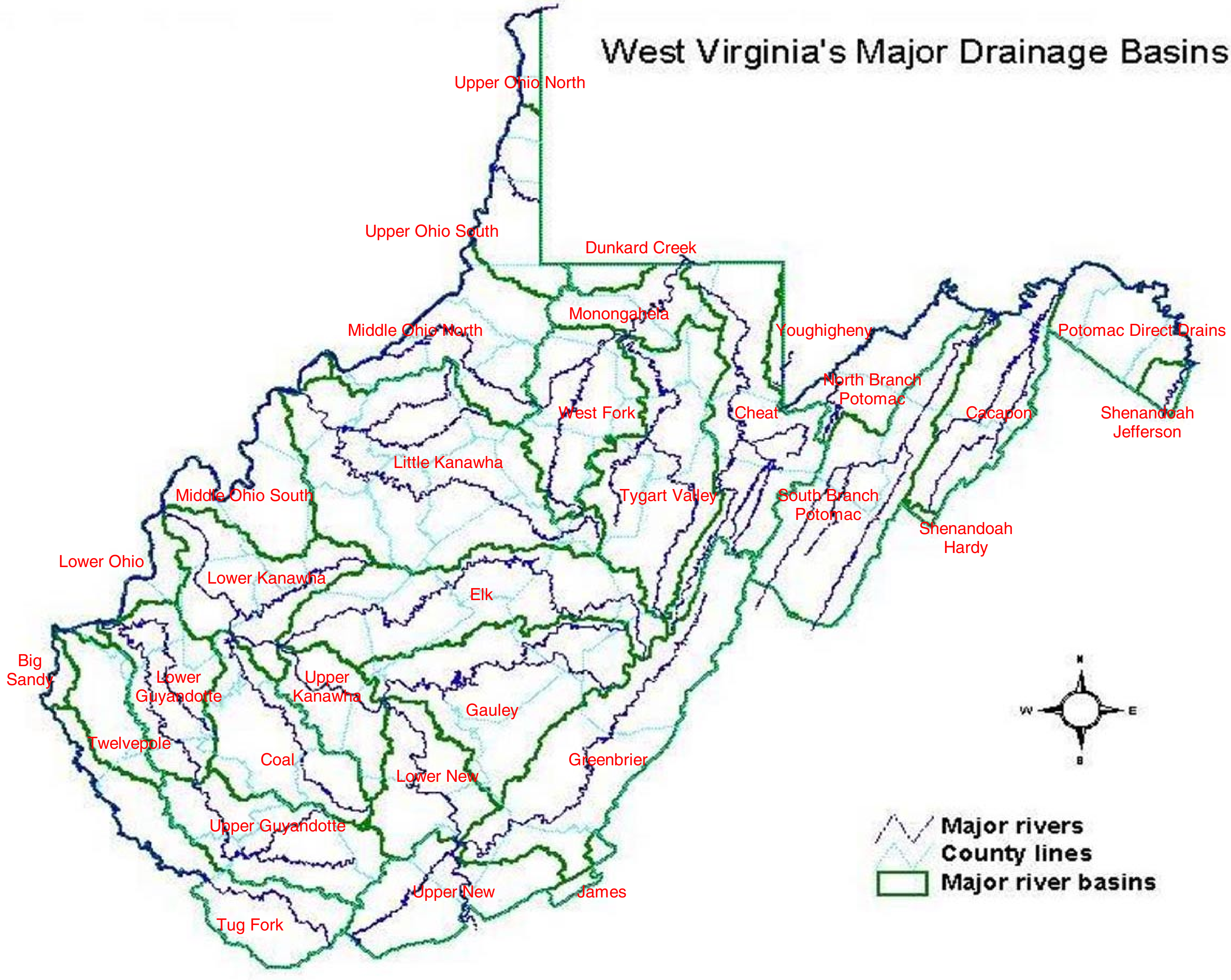
Monitor Group - Name of the group or individuals completing the survey and their affiliation, if any.

Velocity - The velocity (how fast the water is moving) is measured at several stream sections in relatively fast current (runs or glides). While standing in the stream, several transects (20-foot length, or more, from an upstream to downstream point) along the reach are determined. A minimum of two people works together. One person holds a float (a small rubber ball or some other neutrally buoyant object), just ahead of the observation area (transect). The person then releases the float and when the float passes the beginning of the transect, another person starts the timer. The person acting as the timer, measures the number of seconds the float takes to travel through the entire length of the observation area (usually 10-20 feet). This measurement is repeated several times in different sections of each transect. The velocity is an average from all measurements and is expressed in feet or meters/second. Stream discharge is determined by calculating the cross sectional area of the stream and the appropriate correction factor. See EPA's Volunteer Stream Monitoring Methods Manual for more information. Another method used to estimate flow is a velocity head rod (VHR). Contact the coordinator for more information about VHR's.

Stream order - Determine the stream order from your topographic map. For more information on stream order visit the web site: http://www.cotf.edu/ete/modules/waterq/wqphysmethods.html.

Watershed - This refers to the major hydrologic region in which your stream is located. For more information visit: http://www.epa.gov/surf/. West Virginia's major hydrologic regions are shown on the next page.

Tim Craddock, Citizens Monitoring Coordinator
West Virginia Save Our Streams



Macroinvertebrate Count - You will complete a tally sheet, designed for recording the number of kinds of macroinvertebrates collected from within your stream reach.

Water and Streambed Conditions

Water clarity (**turbidity**) - Refers to how clear the water is. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears. Turbidity can be measured using a variety of instruments, or it can be described. Common description include; **clear**, which is water that can be seen through to the bottom of the stream; **murky**, which is water that can be seen through, but is somewhat obscured; and **muddy**, which is water that is opaque or brown and completely obscured. Other describers such as milky, are also occasionally used. More precise measurements can be obtained by using a turbidity meter or transparency tube.

Color and odor - Refers to any color or odor noticed in the water. To determine the odor, a small amount of sediment and water should be scooped from the stream and smelled.

Algae location, color and texture - Refers to the algae location within the stream reach, its color and how it exists in the stream (texture). Several choices are possible under this category (mark all that apply).

Foam - Refers to how much foam is on the stream's surface.

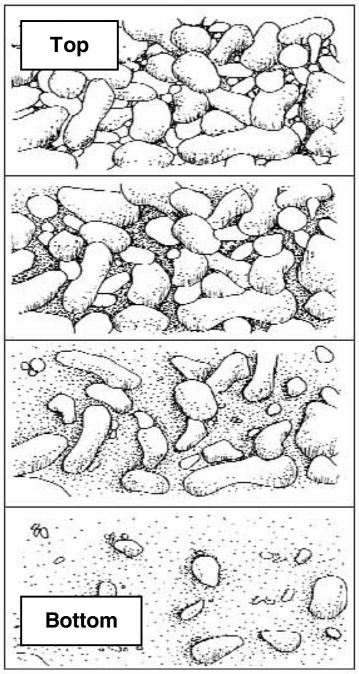
Streambed color - Refers to the color of the stream bottom (streambed) deposits. Frequently, stream deposits look similar to a coating of algae, but are easily disturbed by lifting and shaking the rocks.

Bed composition - Refers to the percentage of materials that make-up your riffles and pools; (1) fine materials silt/clay (smooth not gritty), (2) sand (gritty to ladybug size), (3) gravel (ladybug to tennisball size), (3) cobble (tennisball to basketball size), (4) boulder (basketball to car size) and (5) bedrock (smooth rock surface bigger than a car). A **pebble count** is the most accurate method for determining the composition of bed materials within your stream reach. Streambed composition plays an important role in determining stream behavior. Pebble counts provide a simple yet quantifiable way to characterize the streambed. The method requires two people, one in the stream and one on shore. The person in the stream reaches down without looking, picks up the first particle he or she touches, and measures it along its intermediate axis (i.e., neither the shortest axis nor the longest). The onshore partner records the measurement. The in-stream observer then takes a step and repeats the process, continuing until 100 pebbles have been measured. Particles too large or too embedded to pick up are measured in situ. Various kinds are measuring equipment, such as the gravelometer, are designed to simplify the procedure.

Land Uses - This section asks for an estimate of how much potential a land use may have to cause problems in the stream. Place a (**0**) indicating none, (**1**) indicating slight, (**2**) indicating moderate, or (**3**) indicating high potential for impact. If there are land uses not included on the list, add them to the extra spaces provided. Only take in account land uses upstream and adjacent to your stream reach. Also, you may want to use this section to note the location of a particular land use in relation to your stream site (streamside, within ¼ mile of the stream or within the stream's watershed).

Sketch your Stream Reach - Draw a "**birds eye**" map of your 100-meter stream reach. Note the locations of riffles, runs, pools, dams, wetlands, tributaries, riprap, pipes, roads, ditches, vegetation types, landscape features, and any other land or water feature that you feel is significant. Be sure and mark the areas where your macroinvertebrate samples were collected. Use an arrow to indicate the stream flow direction.

Scoring the Habitat Assessment - The parameters below are evaluated and scored based upon the volunteer's best judgment of the each condition within the 100-meter stream reach. The parameters of embeddedness and sedimentation are scored on a scale from one to twenty.



Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, fewer living spaces are available to macroinvertebrates and fish for shelter, spawning and egg incubation. To estimate the percent of embeddedness, observe the amount of silt or finer sediments overlying and surrounding the rocks. If kicking does not dislodge the rocks or cobbles, they are probably greatly embedded. The pictures-boxes show a representation of embeddedness in a riffle habitat. The first picture-box (**top**) shows an optimal (excellent) condition with very little evidence of fine sediments between the gravel, cobble and boulders. Each descending picture-box represents a deterioration of conditions, with the last box (**bottom**) representing poor embeddedness conditions.

Sediment deposition is a measure of the amount of sediment that has been deposited in the stream channel and the changes to the stream bottom that have occurred as a result of the deposition. High levels of sediment deposition create an unstable and continually changing environment that is unsuitable for many aquatic organisms. Sediments are naturally deposited in areas where the stream flow is reduced, such as pools and bends, or where flow is obstructed. These deposits can lead to the formation of islands, shoals, or point bars (sediments that build up in the stream, usually a t the beginning of a meander) or can result in the complete filling of pools. To determine whether these sediment deposits are new, look for vegetation growing on them: new sediments will not yet have been colonized by vegetation.

For the last three parameters, evaluate the condition of the right and left stream banks separately. Define the " left" and "right" banks by standing at the downstream end of your study stretch and looking upstream. Each bank is evaluated on a scale of 0 - 10.

Bank vegetative protection measures the amount of the stream bank that is covered by natural (i.e., growing wild and not obviously planted) vegetation. The root systems of plants growing on stream banks help hold soil in place, reducing erosion. Vegetation on banks provides shade for fish and macro-invertebrates and serves as a food source by dropping leaves and other organic matter into the stream. Ideally, a variety of vegetation should be present, including trees, shrubs, and grasses. Vegetative disruption can occur when the grasses and plants on the stream banks are mowed or grazed, or when the trees and shrubs are cut back or cleared.

Condition of banks measures erosion potential and whether the stream banks are eroded. Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks and are therefore considered to have high erosion potential. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil.

The **riparian vegetative zone width** is defined here as the width of natural vegetation from the edge of the stream bank. The riparian vegetative zone is a buffer zone to pollutants entering a stream from runoff. It also controls erosion and provides stream habitat and nutrient input into the stream. A wide, relatively undisturbed riparian vegetative zone reflects a healthy stream system; narrow, far less useful riparian zones occur when roads, parking lots, fields, lawns, and other artificially cultivated areas, bare soil, rocks, or buildings are near the stream bank. The presence of "old fields" (i.e., previously developed agricultural fields allowed to revert to natural conditions) should rate higher than fields in continuous or periodic use. The riparian vegetative zone can be measured by observing the width of the area dominated by riparian or water-loving plants, such as willows, marsh grasses, and cottonwood trees.

Comments - Indicate what you feel are the present and future threats to your stream, any unusual discoveries or other comments about the stream. Feel free to attach additional information or photographs that more completely describe the condition of the stream.

Calculating your Stream Score and Rating

It is important to understand that several different attributes of the macroinvertebrate population are important for determining your stream's condition. In order to obtain a clearer picture, WVSOS recommends using a multiple index approach, and then integrating the indexes into an overall stream score and rating.

- **% EPT Abundance** – This index is the percentage of the 3 most pollution sensitive groups, the mayflies "**E**", stoneflies "**P**", and caddisflies "**T**". Generally a high percentage of EPT's indicates healthy stream conditions. % EPT is calculated by dividing the total number of EPT's by the total number of organisms in your sample. Multiply by 100 to obtain the percentage.

- **Hillsenhoff Biotic Index** (**HBI**) – This index is based upon the tolerance of the organism to organic pollution. The families are rated on a scale from 0 to 10, with 0 being the most sensitive and 10 being the most tolerant to pollution. HBI is calculated by multiplying the number of families by their respective tolerance values. The results of all these multiplication are then summed and divided by the total number of organisms in the sample. Generally the HBI should be a low number (4.0 or less), which indicates that mostly sensitive types were collected. Higher HBI values indicate increasing numbers of tolerant organisms.

- **% Tolerance** – This index is the percentage of the samples tolerant organisms. The tolerant organisms are those families with a tolerance rating of 8 or more. % Tolerance is calculated by dividing the total number of tolerant organisms by the total number of organisms in the sample. Multiply by 100 to obtain the percentage. A high percentage of tolerant organisms are an indication of impaired conditions.

Integration of the Biotic Indices

<table>
<tr><th>Biotic Indices</th><th>Values</th><th>10</th><th>6</th><th>4</th><th>2</th></tr>
<tr><td>% EPT Abundance</td><td></td><td>> 80</td><td>80 - 60</td><td>59.9 - 40</td><td>< 40</td></tr>
<tr><td>Hillsenhoff Biotic Index</td><td></td><td>< 3.5</td><td>3.5 – 5.0</td><td>5.1 – 6.5</td><td>> 6.5</td></tr>
<tr><td>% Tolerance</td><td></td><td>< 5</td><td>5 – 25</td><td>25.1 – 50</td><td>> 50</td></tr>
<tr><td colspan="2">Column Totals</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Totals from each column are added together to determine your overall score and rating.</td><td>Score</td><td></td><td>Rating</td><td></td></tr>
</table>

Scores	Rating	Some Common Attributes of the Population
> 24	Good	Comparable to the best situation to be expected within the region. Excellent community structure with good species diversity. Dominated mostly by sensitive EPT taxa, but may have other more tolerant groups as well. A good balance of organisms.
24 - 10	Marginal	Communities structure less than expected. Richness (diversity) is usually lower due to the loss of a few pollution sensitive taxa, shown mainly by a decreased abundance of EPT's. More pollution tolerant forms are usually present. Stoneflies may be entirely missing from the community.
< 10	Poor	Very few species present (poor community structure). If there are high densities then the sample is dominated by just a few pollution tolerant groups.

Physical Indicators of Water Pollution

Water Colors

- **Brown** - Usually caused by sediment in the water. Some muddiness (brown color) is natural after storms, but if the condition persists, look for an activity upstream that has disturbed the soil such as construction sites, logging, storm water runoff from roads or urban areas, or agricultural activities such as cattle in the stream.

- **Multi-colored sheen** - Can occur naturally in stagnant waters, but a sheen that is moving or does not break up easily may be an indication of oil pollution. The source could be runoff from streets or parking areas or illegal dumping. In some areas the use of all-terrain (ATV's) vehicles may contribute to stream oil pollution.

- **Tea colored** - Usually associated with wetlands.

- **Black -** Usually caused by coalmine drainage, tar or sometimes, waste material from road construction.

- **Green** - Usually due to an algae bloom caused by excessive nutrients in the water. The source could be sewage, fertilizers from farms, homes or golf courses or waste from animal feedlots.

- **White or gray** - Can be caused by runoff from landfills, dumps or sewage.

- **Orange or red** - Usually associated with mine drainage (high iron content in the stream).

- **Foam** - Some foam occurs naturally due to the decomposition of leaves (this foam is generally less than three inches high and cream colored). Excessive foam is possibly due to detergent pollution.

Water Odors

- **Rotten egg** - This is an indicator of sewage pollution.

- **Musky** - This is a possible indicator of nutrient pollution such as livestock waste. May also indicate sewage contamination.

- **Oily** - This could indicate oil or gas pollution. It is sometimes caused by a natural bacterium on the water surface.

- **Chemical** - This could be an indication of a discharge of solvents or other chemical pollutants.

Stream Bed Deposits

- **White or gray** - A white cottony mass is a sewage fungus common to organic polluted waters. An even coating of white or gray flocculates may be metals (aluminum) precipitated out of solution from contamination due to mine drainage.

- **Orange, yellow or red** - A coating of flocculates on the sediments is usually due to polluted coalmine drainage.

- **Black** - This deposit can occur naturally in heavy organic soils but can also be due to fine coal particles, tars, ashes, sludge etc.

- **Brown** - An indication of silt deposits from sediment sources. Most stream bottoms are normally brown in color.

- **Green** - Possible indication of excessive algae growth from organic (nutrient) enrichment sources.

WV SAVE OUR STREAMS SURVEY FORM

General Information

Stream						Date	
County			Watershed				
Latitude		Longitude		River reach			
pH		Conductivity		Temperature		D.O.	
Other attributes							
Monitor(s)							
Affiliation							
Mailing address							
Phone/e-mail							
Directions to site							
Discharge		Or estimate	High	Normal	Low	None	

Physical Descriptions

Water and Streambed Conditions - Use the boxes to check the conditions that closely resemble those of your stream. Use the extra space to write in any additional comments.

Water Clarity

Clear		Murky		Muddy		Other	

Water Color

No color		Green		Brown	
Black		White/gray		Red/orange	

Water Odor

No odor		Musky		Rotten egg	
Sewage		Chemical		Other	

Algae Location

No algae		In spots		Everywhere	

Algae Color

Light green		Dark green		Brown		Other	

Algae Texture

Even coating		Hairy		Matted		Free-floating	

Surface Foam

No foam		Slight		Moderate		Heavy	

Streambed Color

Brown		Green		Yellow	
Black		White/gray		Red/orange	

Streambed "Riffle" Composition: Determine the composition of the streambed materials within your reach. Collect samples using a pebble count method from representative riffles. Use the table to record your results. Even if you do not complete a pebble count, you should **estimate** the composition of the streambed materials from the riffles of your stream reach.

Sediment Size Classes[1]

Silt/clay	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bedrock
< .062	.062 – 2	2 – 24	24 – 64	64 – 256	256 – 1096	> 1096
Smooth/slick texture	Grainy texture	Pea to marble size	Marble to tennisball size	Tennisball to basketball size	Basketball size or larger	Large solid surface

Pebble Count Data Sheet

Silt	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bedrock
Totals	**Totals**	**Totals**	**Totals**	**Totals**	**Totals**	**Totals**

% Silt/clay	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock

Average Reach Width		**Average Reach Depth**	

[1] Bed material size is shown in millimeters (mm)

Habitat Assessment - Score each parameter using the scales provided and add each parameter's score to determine your overall habitat score and rating. Feel free to describe additional stream and riparian features that you feel are important.

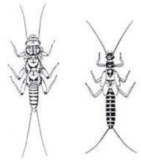
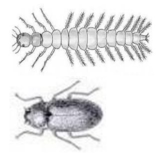
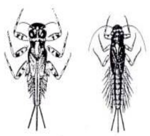
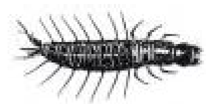
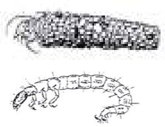
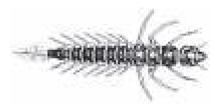
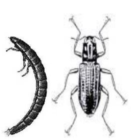
Parameters		Optimal	Sub optimal	Marginal	Poor
Embeddedness		Fine sediments surrounds and fills 0-25% of the spaces between the gravel, cobble and boulders.	Fine sediment surrounds and fills 25-50% of the spaces between the gravel, cobble and boulders.	Fine sediment surrounds and fills 50-75% of the spaces between the gravel, cobble and boulders.	Fine sediment surrounds and fills more than 75% of the spaces between the gravel, cobble and boulders.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Sediment Deposition		Little or no enlargement of islands or point bars; less than 5% of the streambed affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the streambed affected by sediment deposition.	Moderate amounts of sand/gravel deposits on new and old point bars; 30-50% of the streambed affected by sediment deposition.	Heavy deposits of fine materials and an increase in point bar formations; more than 50% of the streambed affected; pools are absent or very shallow due to substantial sediment deposition.
Score		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Bank Vegetative Protection		More than 90% of the banks are covered by natural vegetation; all levels "trees, shrubs and herbaceous vegetation" represented; disruption from grazing, mowing etc. minimal or absent; all plants allowed to grow naturally.	70-90% of the banks covered by natural vegetation; one level of plants may be missing or not well represented; some disruption of vegetation evident; more than 50% of the potential plant height remains.	50-70% of the banks covered by natural vegetation; patches of bare soil may be present and closely cropped vegetation is common; less than 50% of the potential plant heights remains.	Less than 50% of the banks covered by natural vegetation; disruption is high; vegetation has been removed or the potential plant heights are greatly reduced.
Left Bank		10 9	8 7 6	5 4 3	2 1 0
Right Bank		10 9	8 7 6	5 4 3	2 1 0
Bank Stability		Banks are stable; no evidence of erosion or bank failure; little or no potential for future problems.	Banks are moderately stable; infrequent areas of erosion occur, mostly shown by banks healed over.	Banks are moderately unstable; 60% of the reach has some areas of erosion; high potential for erosion during flooding events.	Banks are unstable; many have eroded areas (bare soils) along straight sections or bends; obvious bank collapse or failure; more then 60% of the reach has erosion scars.
Left Bank		10 9	8 7 6	5 4 3	2 1 0
Right Bank		10 9	8 7 6	5 4 3	2 1 0
Riparian Zone Width		Mainly undisturbed vegetation > 60 ft; no evidence of human impacts such as parking lots, roadbeds, clear-cuts, mowed areas, crops etc.	Zone of undisturbed vegetation 40-60 ft; some areas of disturbance evident.	Zone of undisturbed vegetation 20-40 ft; disturbed areas common throughout the reach.	Zone of undisturbed vegetation less than 20 ft; disturbed areas common throughout the entire reach.
Left Bank		10 9	8 7 6	5 4 3	2 1 0
Right Bank		10 9	8 7 6	5 4 3	2 1 0

Total Habitat Score	**Optimal**	**Sub optimal**	**Marginal**	**Poor**
	> 85	**85 - 60**	**59 - 40**	**< 40**

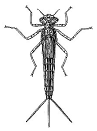
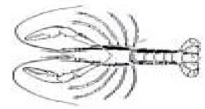
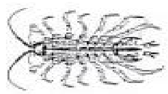
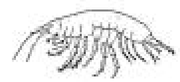
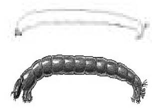
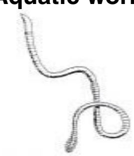
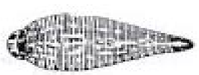
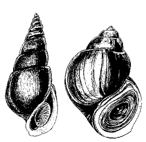
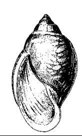
Comments ____

____

Macroinvertebrate Tally Sheet: Use the tally sheet to on the next page record the numbers of macroinvertebrates collected from your samples. Record the numbers for each major group, as well as, the number of different kinds found within each major group. The coordinator will review the information and calculate the stream index.

Stoneflies 	Total #	**Other beetle larva** 	Total #
Mayfly 	Total #	**Fishflies** & **Hellgrammites** 	Total #
Most Caddisflies[2] 	Total #	**Alderflies** 	Total #
Common Netspinner 	Total #	**Craneflies** 	Total #
Water penny 	Total #	**Watersnipe** 	Total #
Riffle beetle 	Total #	**Dragonflies** 	Total #

[2] All caddisflies, except for the common netspinner, are to be placed in the most caddisflies category.

Damselflies 	Total #	**Crayfish** 	Total #
Sowbug 	Total #	**Scud** 	Total #
Blackfly larva 	Total #	**Midge larva** 	Total #
Other fly larva 	Total #	**Mussels** 	Total #
Clams 	Total #	**Aquatic worms** 	Total #
Leech 	Total #	**Flatworm** 	Total #
Gilled snails 	Total #	**Pouch snails** 	Total #
Other organisms observed/collected (such as fish, amphibians etc.) or other comments about the invertebrate communities:			

Macroinvertebrate Score Sheet

Macroinvertebrate Groups	Total #	Tolerance	HBI Score
Stoneflies		2.0	
Mayflies		3.0	
Most Caddisflies		3.0	
Water penny		4.0	
Riffle beetle		4.0	
Watersnipe		4.0	
Hellgrammites & Fishflies		5.0	
Craneflies		5.0	
Other beetle larva		5.0	
Dragonflies		5.0	
Mussels		5.0	
Gilled snails		5.0	
Scuds “sideswimmer”		5.0	
Common netspinning caddisfly		6.0	
Alderflies		6.0	
Clams		6.0	
Crayfish		6.0	
Damselflies		7.0	
Aquatic sowbug		7.0	
Tolerant Groups			
Pouch/ snails		8.0	
Blackfly larva		8.0	
Midge larva		8.0	
Other fly larva		8.0	
Flatworms		8.0	
Water bugs		10.0	
Aquatic worms		10.0	
Leeches		10.0	
Totals		**Total HBI**	

Integration of the Biotic Indices

Biotic Indices	Values	10	6	4	2
% EPT		> 85	85 - 60	59.9 - 40	< 40
Hillsenhoff Index		< 3.5	3.5 – 5.0	5.1 – 6.5	> 6.5
% Tolerant		< 5	5 - 25	25.1 – 50	> 50
Column Totals					
Stream Index					

Biological Integrity Rating			
Excellent	Good	Marginal	Poor
> 24	24 - 16	15 - 8	> 8

Land Uses in the Watershed: Record all known land uses upstream and surrounding your monitoring site. Indicate whether they have a High (**3**), Moderate (**2**), Slight (**1**) potential to impact (**I**) the quality of the stream. Also, indicate the approximate location (**L**) of the land use Does it occurs beside the stream site (**S**), within ¼ mile of the stream site (**M**), or within the stream’s watershed (**W**).

Land Uses	Impact	Location	Land Uses	Impact	Location
Suburban			Oil and Gas wells		
Urban			Landfill		
Construction			Trash dump		
Recreation			Strip mining		
Logging			Cropland		
Roadways			Pastureland		
Other			Animal Feedlots		
Land Use Comments					

Overall comments – Indicate what you feel are the present and future threats to your stream or make any additional comments. Feel free to attach any additional information such as topographic maps, photographs or any other information that you feel is important. Add any other comments that you feel are necessary.

Submit the survey to the address below:

Citizens Monitoring Coordinator
Division of Water and Waste Management
414 Summers Street
Charleston, WV 25301

Questions? Send e-mail to tcraddock@wvdep.org or call (304) 558-3614.

WV SAVE OUR STREAMS SURVEY FORM

Use the space below to sketch a "**birds eye view**" of your stream reach. Include, as many features of the stream that you feel are important. Use an arrow to show the direction of flow and be sure to indicate the places within your reach where macroinvertebrate samples were collected.

Choose a section of your stream reach that you feel will represent the average velocity and use the boxes below to help you calculate the stream discharge. The stream depth and width measurements should be taken within the area that you choose for your float trials (float transects).

Stream Discharge – Float Method

Measure the cross section at both the top and bottom of the float transects.

Observation(s)	Float Distance (ft)	**Velocity** = Distance/Time (ft/sec)	**Cross Section** (ft^2)			
1			Depth (ft)		Width (ft)	
2			1	2	1	2
3						
4						
5						
6						
7						
8			**Average Depth**		**Average Width**	
Average Velocity (ft/sec)						

Average Cross Section[3] = Average Depth (ft) x Average Width (ft)

Average Cross Section = ______________ (ft^2)

Discharge = Average Cross Section x Correction Factor x Average Velocity

Average Cross Section	Correction Factor	Average Velocity
	0.80	

Total Discharge = ____________ (ft^3/sec) or cfs

[3] The **cross sectional area** should be measured at both the top and bottom of your float transect for better accuracy. Use the average cross sectional area for the calculation of the total discharge.

Stream Monitoring and Watershed Assessment Resources

1. American Rivers: http://www.amrivers.org
2. Appalachian Rivers: http://www.fetc.doe.gov/publications/proceedings/99/99apprvr/99apprvr.html
3. Biological Indicators: http://www.epa.gov/ceisweb1/ceishome/atlas/bioindicators/biologicalindicators.html
4. Biotic Index – a simple explanation: http://www.rst2.edu/masters1999/ECOSYS/bioticindex.html
5. Constructed Wetlands for AMD: http://dgrwww.epfl.ch/GS/genie_san/res_wa/h2.1-2e-1-1-1.html
6. Corps of Engineers – Stream Management: http://www.wier-assoc.com/stream_management.htm
7. Delaware's Adopt-A-Stream Resources: http://www.state.ma.us/dfwele/river/rivAAS_pubs.htm
8. EPA, Bioassessment and Bio-criteria: http://www.epa.gov/ost/biocriteria/
9. EPA, Monitoring Water Quality: http://www.epa.gov/owow/monitoring/
10. EPA, Rapid Bioassessment Protocols for Streams: http://www.epa.gov/owow/monitoring/rbp/index.html
11. EPA, The TMDL Process – Decision Guidance: http://www.epa.gov/owow/tmdl/decisions/
12. EPA, Volunteer Stream Monitoring Manual: http://www.epa.gov/owow/monitoring/volunteer/stream/
13. EPA, Watershed Protection Techniques: http://www.epa.gov/owow/nps/wpt/vol1no2.html
14. EPA, Wetland Bioassessment Fact Sheet: http://www.epa.gov/owow/wetlands/wqual/bio_fact/
15. Exploring the Environment – Methods for Monitoring: http://www.stormwater-resources.com/library.htm
16. Getting Started in Water Quality Monitoring: http://140.211.62.101/streamwatch/swm1.html
17. Izaak Walton League of America: http://www.iwla.org
18. Key to Orders of Benthic Macroinvertebrates: http://osf1.gmu.edu/~avia/orderkey.htm
19. Know Your Watershed: http://www.ctic.purdue.edu/KYW/glossary/whatisaws.html
20. Library of Storm water Management Resources: http://www.stormwater-resources.com/library.htm
21. Macroinvertebrate Biotic indexes: http://www.washjeff.edu/Chartiers/Chartier/mbi.HTM
22. Macroinvertebrate Key: http://www.woodrow.org/watershed/images/macro_key.gif
23. Monitoring of Macroinvertebrates: http://www.chebucto.ns.ca/Science/SWCS/ZOOBENTH/biotic.html
24. NC Water Quality Guidebook: http://www.bae.ncsu.edu/programs/extension/wqg/volunteer/mantoc.htm
25. Ohio State – Nonpoint Source Pollution: http://www.ag.ohio-state.edu/~ohioline/aex-fact/0465.html
26. Ohio's Stream Monitoring Project: http://www.dnr.state.oh.us/odnr/dnap/monitor/sqm.html
27. PA's Volunteer Monitoring: http://www.dep.state.pa.us/dep/deputate/watermgt/WC/subjects/cvmp.htm
28. Practice Samples: http://www.people.virginia.edu/~sos-iwla/Stream-Study/Samples/SampleIntro.HTML
29. Protecting Water Quality in Urban Areas: http://www.pca.state.mn.us/water/pubs/sw-bmpmanual.html
30. Protocols for Measuring Biodiversity: http://www.cciw.ca/eman-temp/research/protocols/freshwater/benthic/
31. Recommended Steps for Monitoring: http://www.for.gov.bc.ca/ric/pubs/aquatic/design/Design-02.htm
32. Stream Corridor Restoration: http://www.usda.gov/stream_restoration/newtofc.htm
33. Stream Doctor – Biological Monitoring: http://www.iwla.org/SOS/sd_monit.html
34. Stream Monitoring Teaching Activity: http://www.maf.govt.nz/MAFnet/schools/activities/stream/stract.htm
35. Stream Quality Indicators of Illinois: http://dnr.state.il.us/orep/inrin/ctap/bugs/
36. TMDL Fact Sheet: http://ctic.purdue.edu/kyw/tmdl/tmdlhome.html
37. Topographic maps on-line: http://www.maptech.com
38. Topographic Map List from USGS: http://mac.usgs.gov/mac/maplists/index.html
39. Topographic Map Resources: http://www.geography.about.com/science/geography/cs/topographicmaps/
40. USDA, Water Quality Information Center: http://www.nal.usda.gov/wqic/
41. Vermont Stream Macroinvertebrate Monitoring: http://www.uvm.edu/~snrdept/vmc/invt.html
42. Virginia's SOP for Completing a Stream Survey: http://www.sosva.com/sossop.htm
43. Water Quality Monitoring – How to guide: http://www.crcwater.org/wqmanual.html
44. Water Quality Monitoring Field Manual: http://www.for.gov.bc.ca/ric/PUBS/Aquatic/waterqual/
45. West Virginia Department of Environmental Protection: http://www.wvdep.org

Macroinvertebrate Identification: There are many ways volunteer monitors can identify their macroinvertebrate samples. Various types of macroinvertebrate picture ID-cards, couplet keys and a variety of excellent references describing simple identification techniques are available through organizations such as the Izaak Walton League of America and the Rivers Network. Also, many state volunteer monitoring programs have excellent resources for volunteers, available at no charge, or for a small fee.

The Save Our Streams Bug Card

On the next several pages following the reference section there are illustrations representing common stream macroinvertebrates that you may find during your collections. The stress tolerance rating for each major group, and in some cases for organisms within a major group, is printed beside the group. The statements below describe each of the tolerance ratings used for this example. A new macroinvertebrate identification card is now available from the Izaak Walton League. Visit them on the web at http://www.iwla.org/sos/ for more information.

Sensitive – Invertebrates that occur in pristine environments with little or no disturbances. They usually do not occur in high numbers, nor does one kind dominate the entire population.

Less Sensitive – Invertebrates that occur in a range of environments from little or no disturbance to moderately disturbed conditions. They may occur in high numbers under certain disturbed conditions.

Somewhat Tolerant – Invertebrates that occur in a range of environments from moderately to highly disturbed conditions, can also occur in less disturbed conditions. Their high numbers are often good indications of disturbance.

Tolerant – Invertebrates that occur most often in highly to very disturbed conditions. In very disturbed environments only one or two kinds may dominate the entire population. They are also found in good conditions, but usually not in high numbers.

References

1. Dates, G. et al. 1995. **Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess your River's Health**. Publication of the River Network.

2. Izaak Walton League of America, **Save Our Streams Program**. 707 Conservation Lane, Gaithersburg, MD 20878.

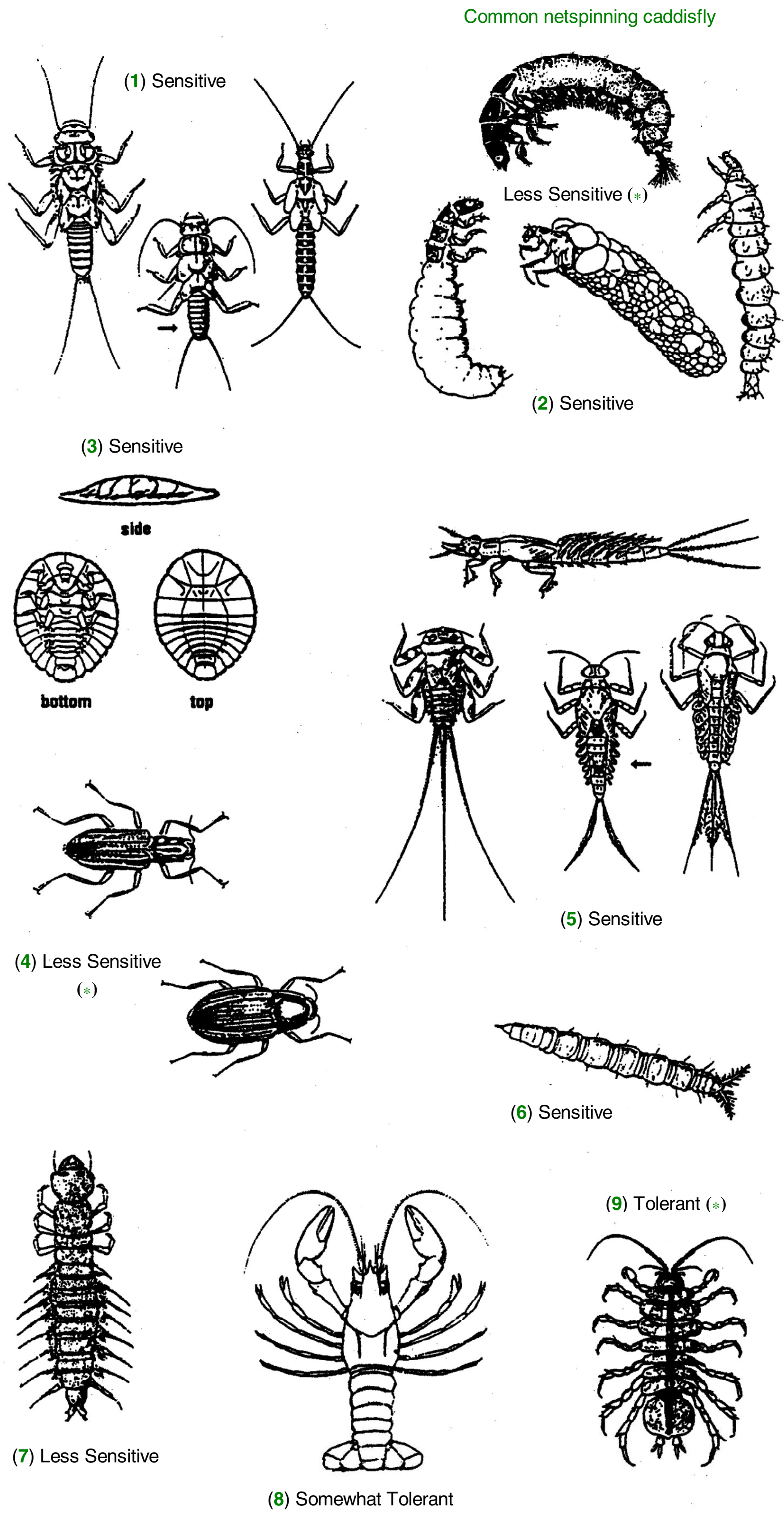
3. McCafferty, W.P. 1981. **Aquatic Entomology: The Fisherman's and Ecologist's Guide to Insects and their Relatives**. Jones and Bartlett Publishers.

4. Rosgen, Dave et al. 1996. **A Field Guide to Stream Classification**. Wildland Hydrology Publishers.

5. U.S. EPA, Office of Water. 1999. **Rapid Bioassessment Protocols for use in Wadeable Streams and Rivers**, Second Edition. EPA 841-B-99-002.

6. U.S. EPA, Office of Water. 1997. **Volunteer Stream Monitoring: A Methods Manual**. EPA 841-B-97-003.

7. Voshell, J.R. 2000. **A Guide to Common Freshwater Invertebrates of North America**. McDonald & Woodward Publishing Company.



Common Stream Macroinvertebrates

Sensitive Groups

1 *Stonefly: Order Plecoptera.* 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 *Caddisfly: Order Trichoptera.* Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on lower half.

3 *Water Penny: Order Coleoptera.* 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs on the other side. Immature beetle. Three views.

4 *Riffle Beetle: Order Coleoptera.* 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 *Mayfly: Order Ephemeroptera.* 1/4" - 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 *Watersnipe Fly Larva: Family Athericidae (Atherix).* 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

Less Sensitive and Somewhat Tolerant Groups

7 *Dobsonfly (Hellgrammite): Family Corydalidae.* 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along under-side, short antennae, 2 tails and two small hooks hooks at back end.

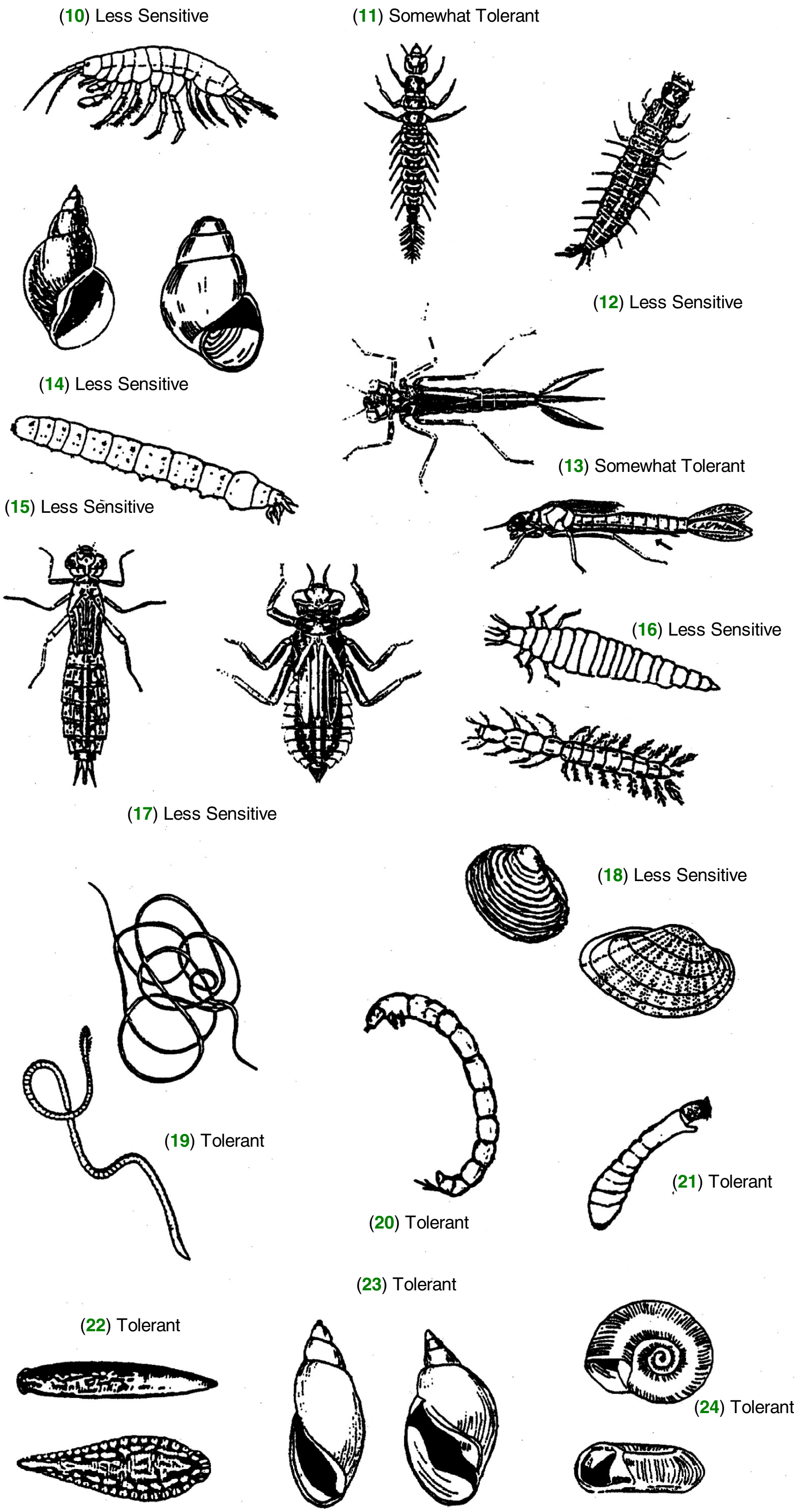
8 *Crayfish: Order Decapoda.* Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 *Sowbug: Order Isopoda.* 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Important – Note the exceptions to the group categories (*).

	Sensitive		Less Sensitive			Somewhat Tolerant		Tolerant	
1	2	3	4	5	6	7	8	9	10

This identification guide is based upon the original bug-card created and distributed by IWLA's Save Our Streams program.



Less Sensitive and Somewhat Tolerant Groups Continued

10 *Scud: Order Amphipoda.* 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 *Alderfly larva: Family Sialidae.* 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end. No gill tufts underneath.

12 *Fishfly larva: Family Corydalidae.* Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 *Damselfly: Suborder Zygoptera.* 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

14 *Gilled Snail: Class Gastropoda.* Shell opening covered by thin plate called operculum. Shell usually opens on right.

15 *Crane Fly: Suborder Nematocera.* 1/3" -2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 *Beetle Larva: Order Coleoptera.* 1/4" 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 *Dragon Fly: Suborder Anisoptera.* 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 *Clam: Class Bivalvia.*

Tolerant Groups

19 *Aquatic Worm: Class Oligochaeta.* 1/4" - 2", can be very tiny; thin worm- like body.

20 *Midge Fly Larva: Suborder Nematocera.* Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 *Blackfly Larva: Family Simulidae.* Up to 1/4", one end of body wider. Black head, suction pad on end.

22 *Leech: Order Hirudinea.* 1/4" - 2", brown, slimy body, ends with suction pads.

23 *Pouch Snail and Pond Snails: Class Gastropoda.* No operculum. Breathe air. Shell usually opens on left.

24 *Other snails: Class Gastropoda.* No operculum. Breath air. Snail shell coils in one plane.

DEP Department of Environmental Protection

	Sensitive		Less Sensitive			Somewhat Tolerant		Tolerant	
1	2	3	4	5	6	7	8	9	10