

Waterbugs

Important River Indicators



A Curriculum Unit of the Program
Monitoring the White River (MWR)

Developed by
The White River Partnership
Verdana Ventures LLC

Illustrations by
Susan Sawyer

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Waterbugs

Unit Summary

Rivers support hidden communities of small organisms that play a big role in river ecology and reveal information about water quality. Informally called “waterbugs,” these organisms are *macroinvertebrates* (animals without a backbone that can be seen with the unaided eye) such as insects, worms, snails, crustaceans, and bivalves (clams and mussels).

In a river, *benthic* (bottom-dwelling) waterbugs are used as biological indicators of river health. Since river health is correlated with water quality, these *bioindicators* can also help us to gauge water quality. During benthic waterbug assessments, a special scientific *protocol* is used that involves a series of precise steps. Waterbugs are collected, sorted, identified, and counted. Data results go into a special formula that produces a Water Quality Score that provides an overall measure of the river’s condition.

The Waterbug Assessment protocol and its associated Water Quality Score are best learned from a knowledgeable resource person. Please contact Emily Miller, Monitoring Coordinator at the White River Partnership, to receive training on conducting this assessment, and/or to request general support for your waterbugs project. (emily@whiteriverpartnership.org or 802-763-7733.)

Waterbug assessments can be implemented in the fall and/or spring, when water levels and temperatures allow students to work safely along and within their rivers. A ***Waterbugs Teaching Kit*** can be borrowed from the White River Partnership, which contains needed equipment for waterbug assessments.

Please note:

In this unit, words in italics are defined in the Glossary and/or within the text of the unit.

A. SETTING THE STAGE

Monitoring the White River: A School-Based Program

Monitoring the White River (MWR) is a school-based program sponsored by the White River Partnership, a nonprofit organization, and Verdana Ventures, an educational consulting firm. MWR uses a teacher-directed approach to involve students in grades 3 through 12 in investigating natural components of the White River watershed to produce information that fosters the health of our shared landscape. Fieldwork methods adapted from professional scientists help to address real-world issues identified by watershed stewardship projects. As such, MWR is an authentic “science to service” program.

Four **MWR units** can be tailored to address individual school goals. They are:

- ***Waterbugs*** (benthic macroinvertebrates) – indicators of river health and water quality
- ***Crayfish*** – key members of river and riparian food webs that may be impacted by the arrival of invasive crayfish species
- ***Riverbank Trees*** – riparian trees planted to prevent erosion and improve river health
- ***Riparian Tracks & Sign*** – evidence of wildlife activities along river corridors

A *Watershed Restoration Unit* is currently under development that highlights on-the-ground projects implemented by the White River Partnership and other partners. It includes riparian tree plantings, culvert replacement/retrofits, and erosion control projects.

Each of these units can be tailored to meet the specific goals of schools and their districts. Whenever possible, we promote collaborative programming among grades within a school and between various schools.

Participating schools are invited to borrow an *MWR Teaching Kit* for each unit, which includes all or most of the supplies needed for the activities described in the unit.

The White River Partnership (WRP) is a non-profit organization that was created in 1996 by local community members who were concerned about the long-term health and sustainability of the White River and its watershed. That same year, the Partnership organized a series of public forums to help identify community concerns about the watershed. Streambank erosion, water quality, declining fish populations, and public access to the river were the major concerns. The WRP addressed these concerns through the implementation of programs. Currently, the programs focus on monitoring the health of the watershed through various assessments, restoring and protecting the river watershed, and promoting education and long-term stewardship. The WRP encourages local communities, businesses, and organizations to become involved, and also provides public information on a range of issues relating to the watershed.

Verdana Ventures LLC (VV) is an educational consulting company based in Randolph, VT, focused on sustainable development and environmental literacy. VV partners with local non-profit organizations (such as the WRP) to offer watershed education programming, focused on student fieldwork, to schools in central Vermont. VV has conducted school and community programs in the U.S and Asia.

The White River Watershed

The uneven **topography** of the land creates natural basins that drain rain, snowmelt, springs, and groundwater into a water body at the lowest elevation, such as a stream, river, wetland, pond, or lake. These basins are called **watersheds**. The boundary, or divide, of a watershed is the “rim” of the basin, which can be drawn by connecting the highest points of land around it. Streams and rivers function as the “arteries” of the watershed by carrying water downhill.

The White River watershed encompasses 710 square miles in central Vermont, draining portions of 5 counties (Addison, Orange, Rutland, Washington, and Windsor) and all or part of 23 towns (see map below). About 50,000 acres of the Green Mountain National Forest are contained within it. The **White River mainstem** is one of the last free-flowing rivers in Vermont. It begins in the Town of Ripton, where it flows in a southeastern manner until it merges with the Connecticut River in the Town of Hartford. The main stem is 56 miles long and has 5 major tributaries:

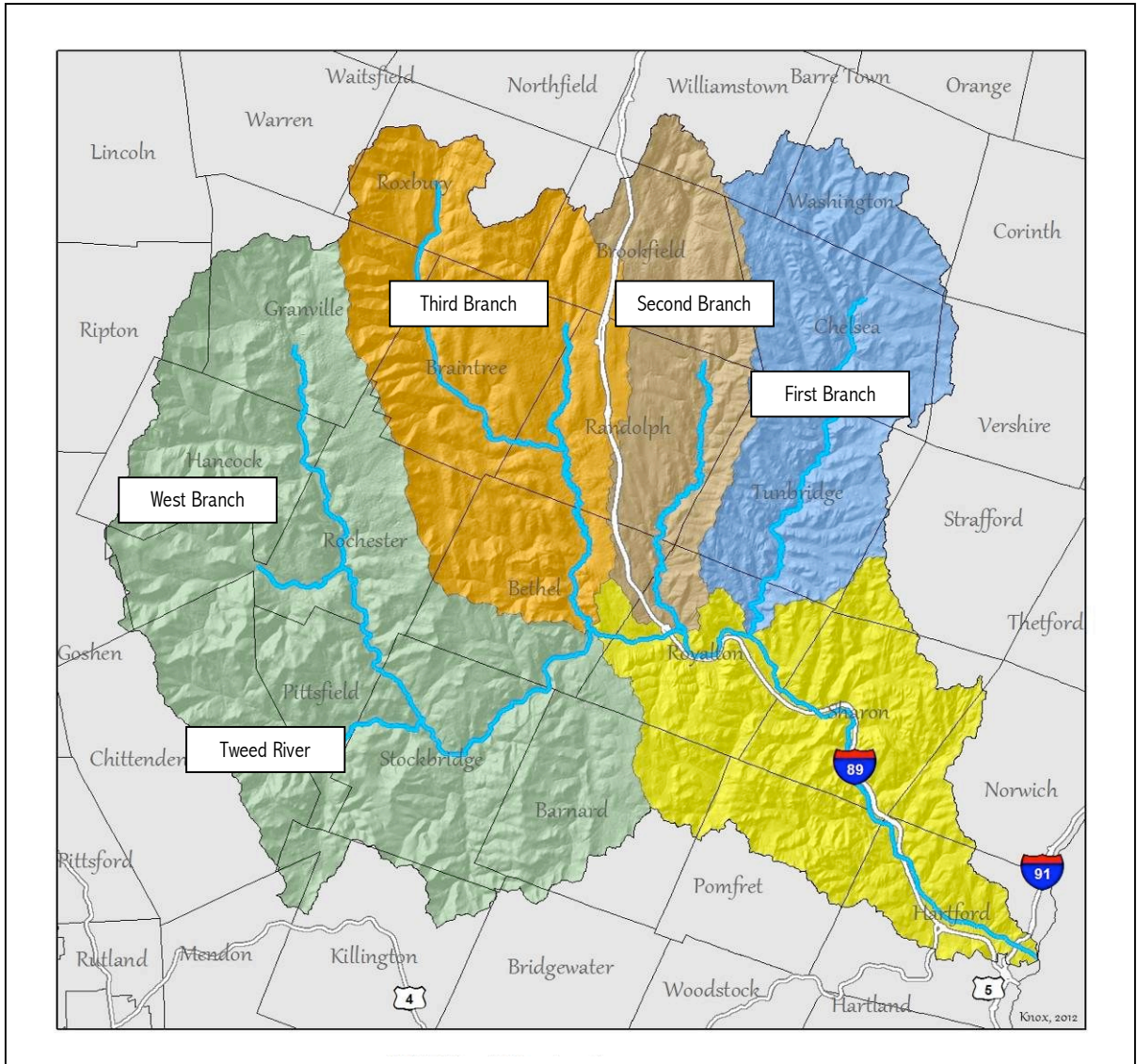
1. First Branch
2. Second Branch
3. Third branch
4. West Branch
5. Tweed River

The White River watershed is important both locally and nationally. The State of Vermont has implemented programs for the protection, restoration, and management of the White River in order to enhance its ecological and economic functions. It is a subset of the Connecticut River watershed, which is wholly contained by the Silvio O. Conte National Fish & Wildlife Refuge. The White River has been designated a *Special Focus Area* within this refuge because it provides a nursery and rearing habitat for juvenile Atlantic salmon and spawning habitat for the adults.

The **Connecticut River** begins in northern New Hampshire and travels south 410 miles, forming much of the border between Vermont and New Hampshire, then coursing through Massachusetts and Connecticut before emptying into the Atlantic Ocean at Long Island Sound. On its way to the ocean, the Connecticut River collects the waters of many other rivers that drain forests, wetlands, farmlands, towns, and cities while providing food, power, and transportation for human communities across the region. Many animals, plants, and other organisms find habitats and water sources within its boundary. Its

designation as one of 14 American Heritage Rivers protects such values as ecological diversity and cultural heritage for a significant portion of New England.

The White River Watershed and Its 5 Main Tributaries



For more information on the White River watershed, please visit the website of the White River Partnership: <http://www.whiteriverpartnership.org>.

Why Monitor Your River?

It is said that a river is a reflection of the land through which it flows. Water and land are interwoven to create a dynamic natural system, so monitoring a river is a good way to check the overall health of the landscape. Evidence of land and water uses shows up in river monitoring data, which can determine that a landscape is healthy or reveal that human activities are impairing it.

A healthy Vermont river has a variety of trees and other plants growing along its banks, lots of dissolved oxygen in its waters, and a diverse food web that includes resident aquatic organisms and terrestrial organisms that visit the river to find resources. A healthy river can recover from stressors (such as polluted runoff) more readily than an unhealthy river, so good river health generally correlates with high water quality.

Water quality is defined by the United States Geological Service (USGS) as follows:

Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. To determine water quality, scientists first measure and analyze characteristics of the water such as temperature, dissolved mineral content, and number of bacteria. Selected characteristics are then compared to numeric standards and guidelines to decide if the water is suitable for a particular use. (<http://pubs.usgs.gov/fs/fs-027-01/>)

For more information on water quality, please consult the USGS website above or the Water Quality Standards website of the United States Environmental Protection Agency (USEPA) (<http://water.epa.gov/scitech/swguidance/standards/>).

Monitoring and Assessments

When we *monitor* something, we assess it at regular intervals to see whether and how it is changing. Monitoring shows trends over time, which can help us to maintain a healthy condition, detect a change in condition, or improve a poor condition. Scientific *assessments* measure the status of particular components of the river system. A river monitoring program uses specific scientific assessments at regular intervals to gather information about the health of the river's ecosystem and its water quality.

River assessments fall into 3 broad categories: biological assessments, physical assessments, and chemical assessments. Each of these categories provides a particular set of water quality data, and many river monitoring programs incorporate two or all three categories. Each kind of assessment is briefly described below. Please consult other resources for more detailed information.

Biological assessments. Examples: benthic macroinvertebrates (waterbugs), crayfish, riparian wildlife tracks and sign, riverbank trees. These assessments measure elements of natural communities in and along a river and are contained in the four MWR units.

The composition of a river's natural communities offers a lot of information about the health of that river and its water quality. A natural community occupies a particular area because conditions, over time, are conducive to its survival. Therefore, assessments of

biological communities can help to determine the overall condition of a river and its landscape. Biological assessments conducted at regular intervals over time (biomonitoring) contribute to a useful record of the river's overall health and water quality.

In general, good river health is indicated by the following community profiles:

- a high diversity of natural species
- the presence of species that are sensitive to pollution and/or physical disturbance
- the presence of native species and the absence of invasive species

Chemical assessments. Examples: dissolved oxygen, pH, nitrates, phosphates.

Each chemical assessment measures a specific parameter of the river's chemistry at a particular moment in time. Chemical conditions are constantly changing as the water flows along, so one chemical assessment does not indicate the overall chemical condition of a river. Chemical assessments conducted at regular intervals over time (chemical monitoring) contribute to a useful record of the river's water quality.

Physical assessments. Examples: velocity, river discharge, embeddedness of the streambed.

Because the physical environment influences both water quality and river health, physical assessments are often used in conjunction with chemical and biological assessments.

Promoting Environmental Literacy

Monitoring the White River (MWR) encourages schools and communities to monitor one or more natural components in their part of the watershed to build their own knowledge base about their unique place, and then to share their knowledge with other groups across a broader area. MWR promotes environmental literacy by:

1. Connecting students to their place so that they feel invested in the well-being of their environment and their community.
2. Helping students learn how to use scientific inquiry to explore their world (see E. CULMINATING ACTIVITIES, USING THE SCIENTIFIC METHOD).
3. Helping students achieve pertinent academic standards in the Common Core and Next Generation Science Standards (see G. HELPFUL TOOLS, CRAYFISH RESOURCES).
4. Helping students understand how society uses scientific information and collaboration to make informed decisions as democratic citizens.
5. Helping students gather useful information about their place, which contributes to thoughtful river stewardship. This service learning approach builds a positive alliance between the school and its community.

B. UNIT BACKGROUND

WATERBUGS: IMPORTANT RIVER INDICATORS

Waterbugs = Aquatic Macroinvertebrates

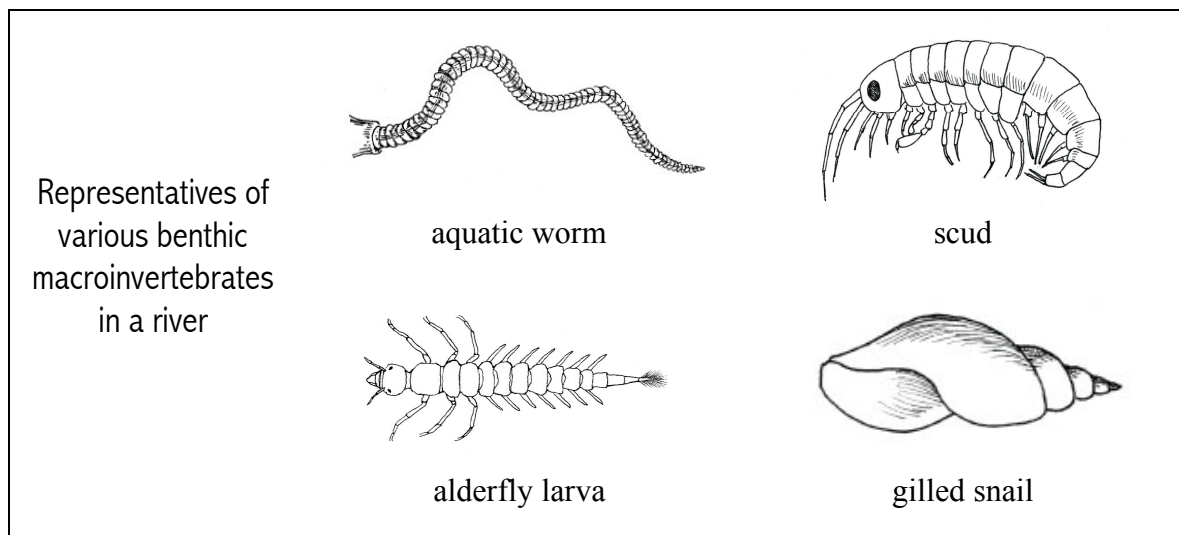
A river harbors communities of aquatic organisms that reflect the physical, chemical, and biological components of that river. A healthy river supports a great diversity of organisms, including organisms that are sensitive to sudden changes in conditions. By contrast, an unhealthy river is home to only a few kinds of organisms that can tolerate poor conditions. River scientists have developed ways to use various aquatic organisms as indicators of river health. Since river health often correlates with water quality, these organisms can indicate water quality as well. (For more information, see A. SETTING THE STAGE, WHY MONITOR YOUR RIVER?)

Biological indicators (*bioindicators*) in rivers include fish, amphibians, aquatic plants, and aquatic invertebrates. The latter group – the subject of this unit - is especially useful as a general river bioindicator.

Aquatic invertebrates – known as “waterbugs” - include many diverse groups of organisms, such as insects, worms, snails, crustaceans, and bivalves (clams and mussels). As invertebrates, they all lack vertebrae that comprise a “backbone.” Macroinvertebrates are large enough to see with the unaided eye, while microinvertebrates can only be seen with magnification. In a river, the bottom-dwelling (benthic) macroinvertebrates are used as bioindicators.

In summary, the parts of the term *benthic macroinvertebrate* mean:

- *benthic* – associated with the riverbed (or any solid object in a river)
- *macro* – big enough to see with the unaided eye
- *invertebrate* – lacking a backbone



Why Are Benthic Waterbugs Good Indicators?

Benthic waterbugs are useful indicators of river health and water quality because:

- Many kinds are sensitive to changes in the physical, chemical, and/or biological conditions of the river.
- They cannot travel easily to escape pollution or change events.
- They are a critical part of the river's *food web*, serving as food for fish and other aquatic predators.
- They are easy to collect with inexpensive equipment that can be used repeatedly.

Waterbugs and Dissolved Oxygen

Oxygen that is dissolved into the water (dissolved oxygen) is required by most – but not all – waterbugs. Oxygen dissolves into river water from the air above the water. Certain factors cause dissolved oxygen levels to go up and other factors cause it to go down; it fluctuates widely depending on the interplay of these factors. The table below lists the main factors that affect DO in a river.

Factors that <u>increase</u> dissolved oxygen (DO) levels in a river	Factors that <u>decrease</u> dissolved oxygen (DO) levels in a river
turbulence (it mixes air, which contains oxygen, into the water)	slow or still current (minimal friction with air; not much air, which contains oxygen, is drawn into water)
fast current (it creates friction with the air and draws in air, which contains oxygen)	decomposition of plants and animals (the main decomposers - bacteria – require high levels of oxygen)
aquatic plants (they release oxygen into the water through photosynthesis)	organic pollution (such as human sewage, animal wastes, excessive aquatic plants, sawdust from sawmills, etc., which require bacterial decomposers; see above)
cold temperatures (cold water hold more DO)	warm temperatures (warm water loses DO)
shade (cools off water – see cold temps above)	exposure to sun (it warms up water – see warm temps above)
	aquatic animals with gills (they use dissolved oxygen from the water)

The waterbugs that require high levels of dissolved oxygen draw in DO through various gill structures. They are sensitive to dropping levels of DO, organic pollution (which lowers DO and degrades water quality), and physical changes in the river (like gravel mining or serious erosion).

The waterbugs that can survive at low levels of dissolved oxygen have various strategies for dealing with this stressful condition: many have lungs, or lung-like structures, and periodically come to the surface to breathe; some have hemoglobin in their blood, which helps to store oxygen in their bodies; and others can drill into plant stems and find oxygen reserves within them. These waterbugs can also tolerate organic pollution and physical changes in the river.

Between the extremes, there are waterbugs that are moderately sensitive to low DO, organic pollution, and physical changes.

The Sensitivity Index

For benthic waterbugs, sensitivity refers to the inability to survive degraded conditions (physical, chemical, and/or biological) in the river. Over many decades, various *sensitivity indices* have been developed to assess benthic waterbugs. Most indices recognize 3 levels:

- *sensitive waterbugs* are able to survive only in excellent to very good water quality; they require unpolluted water and high levels of dissolved oxygen in the water.
- *moderately sensitive waterbugs* are able to survive in somewhat degraded water quality; they can be found in excellent to fair water quality.
- *tolerant waterbugs* are able to survive in seriously degraded water quality; they can be found in all water quality conditions, from excellent to poor.

This information is summarized in the table below.

Please note: Sensitivity indices for waterbugs pertain to waterbugs found in flowing waters only. They do not pertain to waterbugs found in still waters.

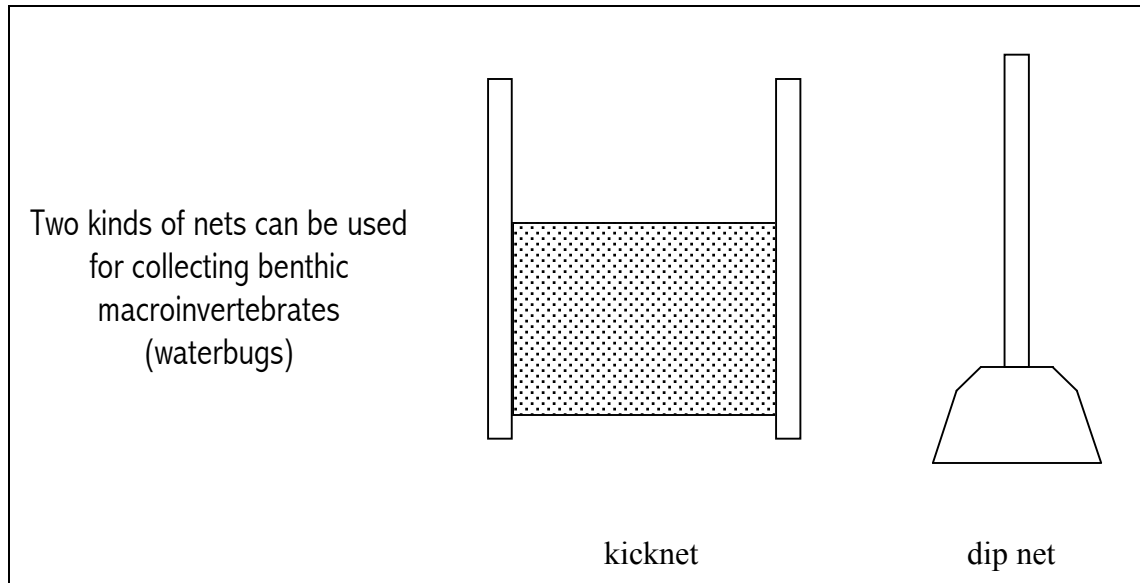
WATER QUALITY & WATERBUG SENSITIVITY

Sensitivity Groups	Water Quality (WQ)		
	Excellent to Very Good WQ	Good to Fair WQ	Poor WQ
sensitive waterbugs	present	absent	absent
moderately sensitive waterbugs	present	present	absent
tolerant waterbugs	present	present	present
<i>Explanations</i>	Excellent to very good water quality contains all 3 waterbug groups because it is free of contaminants and contains high DO. All groups survive and many thrive.	Good to fair water quality does not support sensitive waterbugs. Moderately sensitive and tolerant waterbugs can survive and many thrive.	Poor water quality does not support sensitive and moderately sensitive waterbugs; only tolerant waterbugs can survive and some even thrive.

Collecting and Assessing Waterbugs

To sample the benthic waterbug community in a river, investigators follow a carefully-developed scientific protocol that involves a “kicknet” or a “dipnet” (see below). In this unit, we use a kicknet because it samples a large area of riverbed - one square meter - and allows more students to get involved in the process.

Please contact the White River Partnership to receive training in our kicknet protocol.



In benthic waterbug assessments, a series of well-executed steps are required to produce valid data results that lead to a useful Water Quality Score. These steps are:

1. Choosing an appropriate collection site in the river: a *riffle* with fast-flowing, turbulent water and a gravelly or rocky substrate (streambed).
2. Carefully following a scientific protocol for collecting benthic waterbugs using a kicknet or dip net.
3. Accurately identifying all of the kinds of waterbugs in your collection.
4. Counting up each kind of waterbug collected (or producing a good estimate if numbers are high)
5. Calculating the mathematical formula correctly to produce a valid Water Quality Score.

The Waterbug Assessment used in this unit comes from *Volunteer Stream Monitoring: A Methods Manual*, developed by the U.S. Environmental Protection Agency for volunteer and school groups that are interested in helping to generate information on water quality in rivers. For more information on this source document, please visit <http://www.epa.gov/volunteer/stream/>.

The Waterbug Assessment generates a Water Quality Score that reflects these concepts:

1. *Sensitive waterbugs* are worth more points than *moderately sensitive waterbugs*, which are worth more points than *tolerant waterbugs*. Each group of waterbugs is assigned a range of “weighting factors” (WF) that imparts the greatest value to sensitive waterbugs and the least value to tolerant waterbugs, as follows:
 - ♦ Sensitive waterbugs have weighting factors that range from 5.6 to 5.0
 - ♦ Moderately sensitive waterbugs have weighting factors that range from 3.4 to 3.0
 - ♦ Tolerant waterbugs have weighting factors that range from 1.2 to 1.0
2. Greater overall waterbug diversity produces a higher Water Quality Score than lower overall waterbug diversity.

A Water Quality Score for a Waterbugs Assessment falls within this range:

41 and above	Excellent WQ	No impairment
31 - 40	Good to Very good WQ	Slight impairment
21 - 30	Fair WQ	Much impairment
0 - 20	Poor WQ	Serious impairment

Waterbug Anatomy

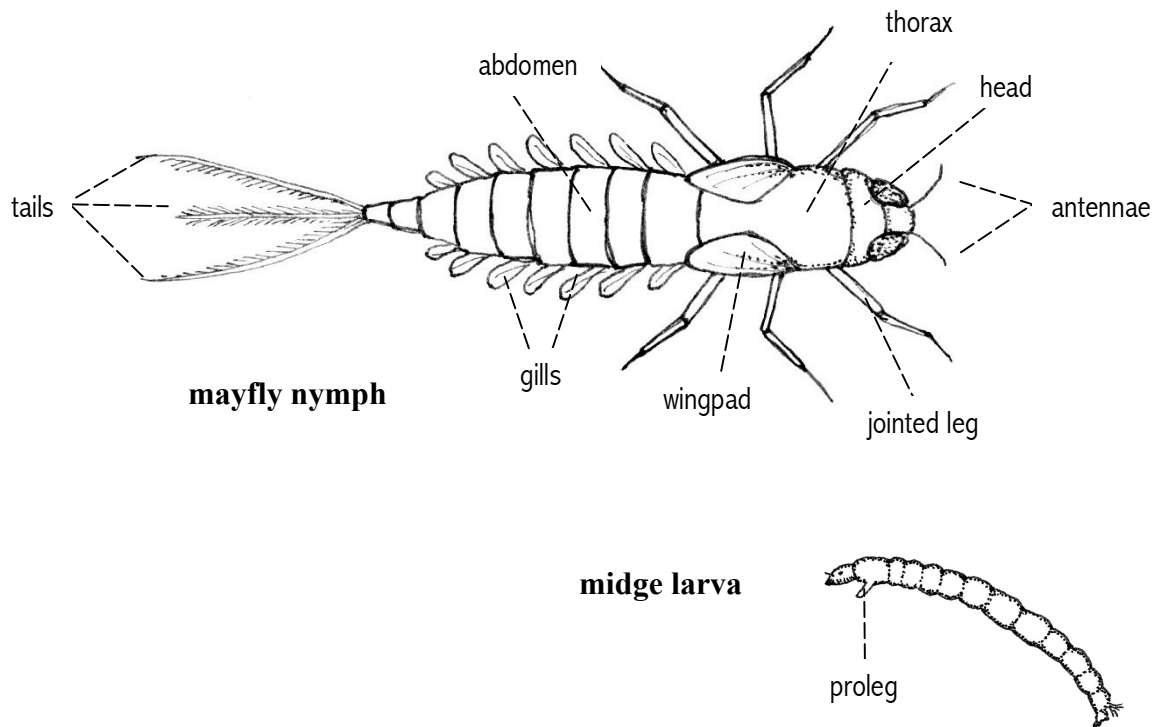
It is essential that students learn basic waterbug anatomy and identification before they conduct their fieldwork. The classroom lesson *Waterbug Clues* helps to build observation skills as a first step in this process.

Waterbugs have evolved a surprising variety of approaches to survive the river environment’s changing depth and velocity patterns, complex chemistry, and highly volatile dissolved oxygen levels. Habitat, behavior, and *functional feeding group* are often reflected in anatomy. So learning a waterbug’s anatomy can teach students a lot about that waterbug’s *niche* in the river. The diagram Anatomy of an Aquatic Insect below gives an overview of typical anatomical parts.

Field Marks

Identifying waterbugs requires students to learn specific anatomical *field marks* of individual kinds of waterbugs. The classroom lesson *Identifying Waterbugs* asks students to use a set of field marks to identify the waterbugs that they are apt to see in their collection.

Anatomy of Aquatic Insects



Nymph or Larva?

Most benthic waterbugs are immature insects. Many of them will become air-breathing, flying adults that leave the river to mate, but then return to the river to lay their eggs to begin the next generation. (Some, like aquatic beetles, remain in the river for their entire lives.)

The terms “nymph” and “larva” reveal the particular lifecycle of an aquatic insect.

- Insects that experience *gradual* (or *incomplete*) *metamorphosis* have 3 life stages: egg, **nymph**, and adult.
- Insects that experience *complete metamorphosis* go through 4 distinct stages of life: egg, **larva**, pupa (a resting stage), and adult.

Nymphs often have features that hint at adulthood, such as wingpads, which grow into functional wings in the adults. Larvae (plural of larva) never have wingpads, even though their adults also have wings.

In the illustration above, the immature mayfly goes through gradual metamorphosis and is therefore called a nymph. The immature midge goes through complete metamorphosis and is therefore called a larva.

Please note: Some aquatic invertebrate field guides use “larva” as a general term for the immature stage of insects that go through either complete or gradual metamorphosis.

C. CLASSROOM ACTIVITIES

Waterbugs PowerPoint Slideshow

Materials <ul style="list-style-type: none">• Waterbugs PowerPoint Slideshow• computer• projector or smart board	Set-Up: Prepare PowerPoint slideshow
	Timeframe: 50 min

Overview

Students learn the term *benthic macroinvertebrate* and why these aquatic organisms are useful indicators of river health and water quality.

Instructions

Show the slides to students, using the Notes associated with each slide.

Waterbug Clues

Materials <ul style="list-style-type: none"> • Waterbug Picture Cards, Sheets #1 and #2 • Waterbug Clue Boxes • scissors • pencils/pens 	Set-Up: <ul style="list-style-type: none"> • Each student needs one Waterbug Picture Card; cut apart the Waterbug Picture Cards. • Each student needs one Clue Box; photocopy the sheet as many times as needed, and cut apart the Clue Boxes. <hr/> Timeframe: 40 minutes
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Overview

Students practice observing physical features of waterbugs and distinguishing between different kinds of waterbugs. This lesson does not focus on identification, which will be the focus of the next lesson.

Instructions

1. Explain that students need to develop observation skills to learn how to identify a range of waterbugs. In this activity, they will focus on describing a waterbug so that someone else can pick it out of a pack of waterbug cards. This will give them practice learning clues for identification and introduce them to some of the waterbugs they may see at the river.
2. Give each student a *Waterbug Picture Card* and tell them not to let anyone else see it.
3. Give each student a *Waterbug Clue Box* and ask them to write up to 4 clues on the lines provided that could help someone else identify the waterbug on their card.
4. When everyone is finished writing their clues, collect all *Waterbug Picture Cards*, mix them up, and spread them out on a table so that all pictures are visible.
5. Ask each student to exchange their *Clue Box* with someone else and silently read the clues they just received.
6. Ask students to come to the *Waterbug Picture Cards* table, a few at a time, look at all the cards, and find the card that matches the clues in the *Clue Box* they received. (You may want to have 2 sets of cards spread out on the table in case one student takes a card that matches another student's clues.)
7. When they have matched a *Waterbug Picture Card* to their clues, ask them to write the number of the *Waterbug Picture Card* in the small "Answer" space in the lower right hand corner of the *Clue Box*.
8. When all students are done, ask each student to read the clues in his/her *Clue Box* and hold up the *Waterbug Picture Card* they chose. Go through all Clue Boxes and Cards before discussing the answers.
9. When everyone has answered, discuss the activity (see below).

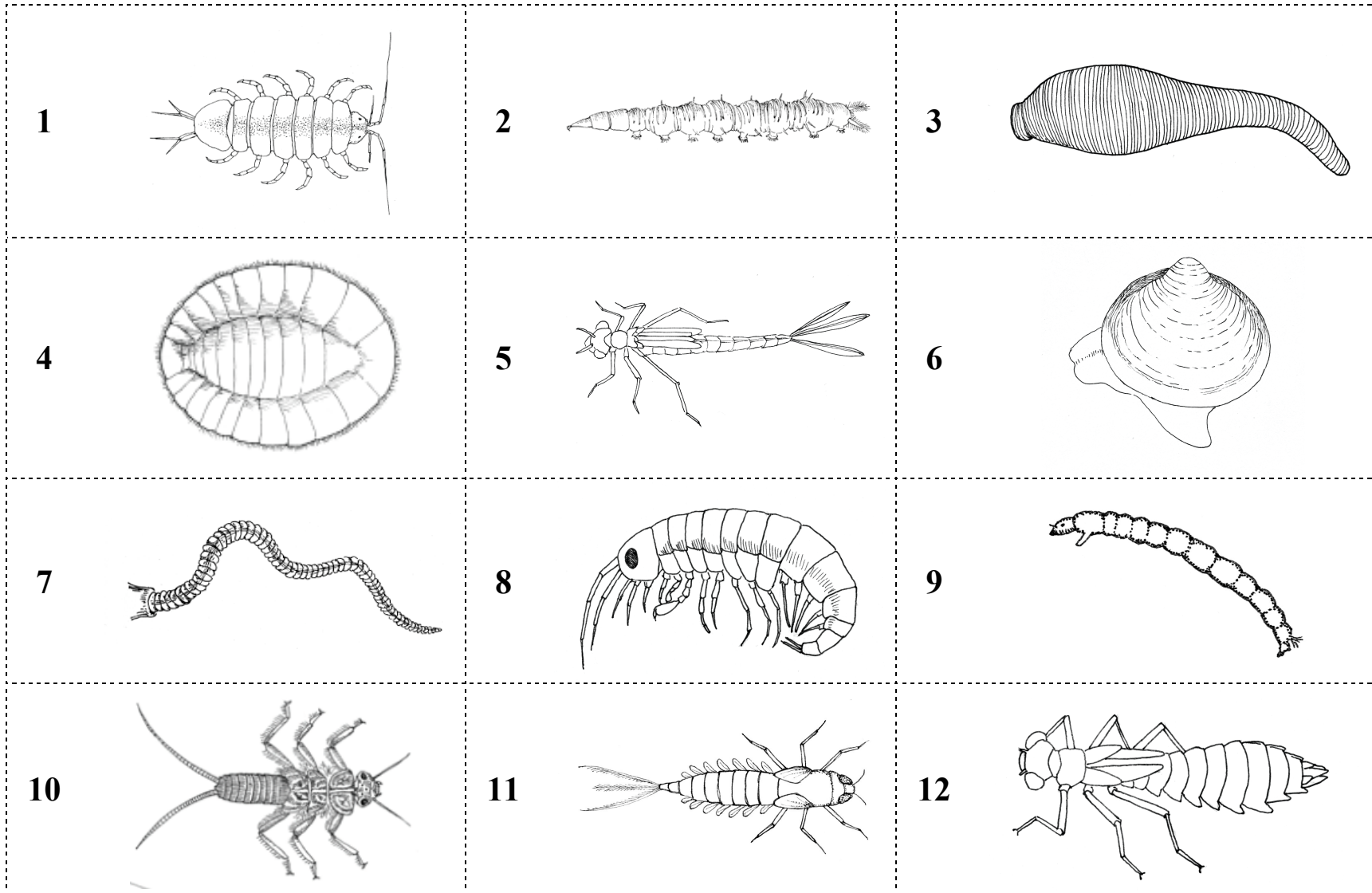
10. If there is enough time, mix up the *Waterbug Picture Cards* and hand them out again. Give each student a new *Clue Box* and have the class repeat the activity.

Possible Discussion Questions

1. Did anyone correctly choose their card using only one clue? If so, what allowed them to find the correct card with only one piece of information? (Some waterbugs are so unique that only one clue is needed. For instance, the clue “spiral shell with a point” would tell them that the correct card is #23, the gilled snail.)
2. Did anyone need to read 3 or 4 clues before they could choose the correct card? (Several of the waterbugs have many of the same body parts, so several clues are needed to choose the correct one. For instance, #5, 10, 11, 12, 13, 14, 15, 17, 19, and 24 all have a head and 6 legs, so more information is needed.)
3. Can someone read a clue that was particularly helpful? (Have students take turns reading helpful clues. This will teach them the physical features that are important to notice and give them practice describing these features effectively).

WATERBUG PICTURE CARDS, SHEET #1 OF 2

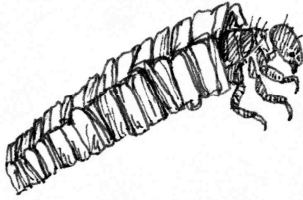
Cut along dotted lines to make cards. Use these cards for the following lessons: Waterbug Clues and Identifying Waterbugs.



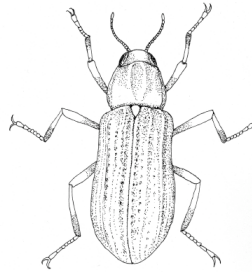
WATERBUG PICTURE CARDS, SHEET #2 OF 2

Cut along dotted lines to make cards. Use these cards for the following lessons: Waterbug Clues and Identifying Waterbugs.

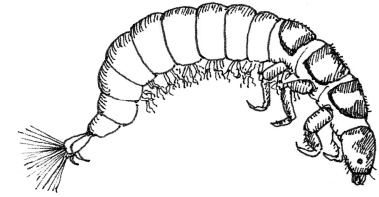
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14



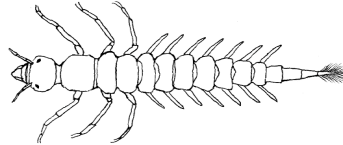
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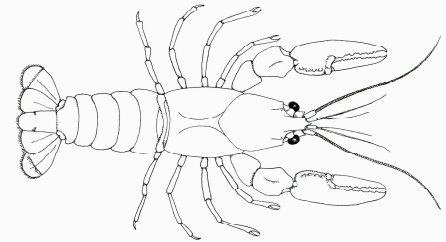
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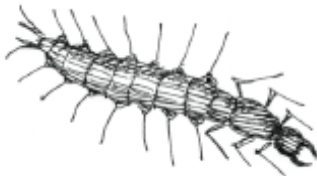
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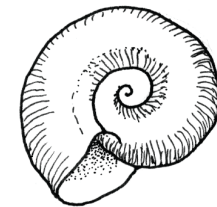
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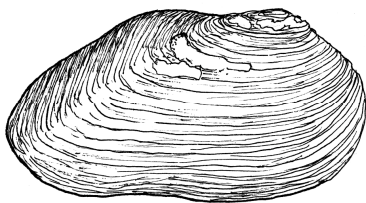
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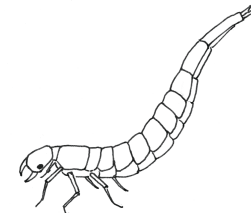
22



23



24



WATERBUG CLUE BOXES

Each student needs 1 Clue Box. Copy this page as many times as needed, then cut boxes along dotted lines and give one box to each student.

Waterbug Clue Box

Clue Writer's Name _____

Write up to 4 Clues for your Waterbug:

1. _____
2. _____
3. _____
4. _____

Clue Reader's Answer: *Waterbug Picture Card #*

Waterbug Clue Box

Clue Writer's Name _____

Write up to 4 Clues for your Waterbug:

1. _____
2. _____
3. _____
4. _____

Clue Reader's Answer: *Waterbug Picture Card #*

Identifying Waterbugs

<p>Materials</p> <ul style="list-style-type: none"> • Waterbug Picture Cards, Sheets #1 and #2 • Waterbug Fieldmark Sheets #1 - #4 • Waterbug Gallery • Water Quality & Waterbug Sensitivity (in B. UNIT BACKGROUND) • Anatomy of Aquatic Insects (in B. UNIT BACKGROUND) • scissors • glue or scotch tape 	<p>Set-Up:</p> <ul style="list-style-type: none"> • Make 4 copies of the following (one set of copies per group of students): <ul style="list-style-type: none"> ○ Waterbug Picture Cards, shrunk to 50% size and cut apart (each set will have 24 individual pictures). ○ Waterbug Field Mark Sheets (#1, #2, #3, #4) ○ Waterbug Gallery • Optional: Make an extra set of Waterbug Picture Cards (full size) and draw the Waterbug Gallery onto a large sheet of flipchart paper for the final discussion. <p>Timeframe: 60 minutes</p>
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Overview

Students learn to use *field marks* to identify waterbugs in preparation for waterbug fieldwork, then receive an introduction to waterbug *sensitivity* as a way to determine the water quality of a river.

Instructions

PART A – WATERBUG FIELD MARKS

1. Explain to students that *Waterbug Clues* was designed to help them observe the physical features that distinguish one waterbug from another. Now they will focus on identification by learning important *field marks* for each kind of waterbug on their fieldwork sheet.
2. Show students the *Anatomy of Aquatic Insects* diagram and go over all parts and labels. Explain that this illustration shows a typical aquatic insect; other waterbugs don't have some of these parts or may have different parts altogether. About 80% of the waterbugs in a river are insects.
3. Divide students into 4 groups. Give each group a set of (shrunk) *Waterbug Picture Cards* and ask them to cut them out.
4. Give each group a set of *Waterbug Field Mark Sheets* and a *Waterbug Gallery*. Ask them to work together to read each waterbug's field marks and use them to identify each picture, then place that picture in the correct box in the *Waterbug Gallery*.
4. When all groups have finished their galleries, discuss the results as a whole class. Have groups confirm their identifications or correct any mistakes in identification. (Optional: Use an extra set of picture cards and a large gallery on flipchart paper to have students confirm their identifications together.)

PART B - SENSITIVITY

1. Remind students that some benthic waterbugs require good water quality to survive; these waterbugs are *sensitive* to pollution or abrupt physical changes in the river. Other waterbugs are *moderately sensitive* and still others are *tolerant* of poor water quality conditions. (This information is introduced to students in the slideshow.)
2. Review the *Water Quality & Waterbug Sensitivity* diagram in B. UNIT BACKGROUND (you may want to sketch it on the board) to ensure that students understand it. This information will be important for understanding how the *Waterbug Assessment Field Sheet* works.

WATERBUG FIELD MARK SHEET #1 OF 4

<p style="text-align: center;">Damselfly Nymph</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • head is wider than thorax and abdomen • lower lip is long and folded under head (not visible on picture card) • 3 pairs of jointed legs • 2 claws on the end of each leg • 2 pairs of folded wingpads on thorax • 3 flat, blade-like tails 	<p style="text-align: center;">Dobsonfly & Fishfly Larva</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • 3 pairs of jointed legs on thorax • long body slightly flattened from top to bottom • large head with toothed jaws that project forward • long, pointed filaments along each side of abdomen • 1 pair of prolegs on the end of the abdomen project to the rear, with 2 claws on each proleg 	<p style="text-align: center;">Leech</p> <ul style="list-style-type: none"> • long body with no appendages • muscular and soft with many segments • flattened from top to bottom • 1 sucker at the front and 1 sucker at the rear
<p style="text-align: center;">Aquatic Worm</p> <ul style="list-style-type: none"> • long, narrow, tube-like, soft body • many ring-like segments around body from end to end • no eyes or suckers • tiny hairs all over body 	<p style="text-align: center;">Net-spinning Caddisfly Larva</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • head has thick, hardened skin • very short antennae, often not seen • no wingpads on thorax • 3 hardened plates on thorax • 3 pairs of jointed legs on thorax • soft abdomen with rows of gills along belly • 1 pair of prolegs on the end of the abdomen, each with a brush of long hairs • weaves a net and lives within it 	<p style="text-align: center;">Midge Larva</p> <ul style="list-style-type: none"> • oval head with short antennae • long, thin, worm-like body with segments • 1 pair of prolegs on the underside of the thorax, and 1 pair of prolegs on the underside of the abdomen at the end • tiny hooks at the ends of the prolegs

WATERBUG FIELD MARK SHEET #2 OF 4

<p>Riffle Beetle Adult</p> <ul style="list-style-type: none"> • head, thorax, and abdomen are all covered with hardened skin • elongated body • color is usually dark brown or red-brown • antennae are sometimes clubbed at the end • 3 pairs of long, jointed legs • 2 claws at the end of each leg • no tails 	<p>Lunged Snail</p> <ul style="list-style-type: none"> • a single shell that may be coiled in a spiral, coiled flat, or shaped like a low, wide cone • a pair of tentacles (like antennae) come out of the head when it is active • large, muscular foot projects from shell when it is active • no flat plate (operculum) in the opening of the shell, just the soft foot 	<p>Water Penny Larva</p> <ul style="list-style-type: none"> • oval (almost circular) flat body • head, thorax, abdomen, and 3 pairs of jointed legs are seen on the underside (not visible on picture card) • there is a fringe of gills along each side of the abdomen on the underside
<p>Dragonfly Nymph</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • head is narrower than thorax and abdomen • lower lip is long and folded under head (not visible on picture card) • 3 pairs of jointed legs • 2 claws on the end of each leg • 2 pairs of folded wingpads on thorax • 3 short, stiff, pointed structures at end of abdomen 	<p>Stonefly Nymph</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • 3 pairs of jointed legs • 2 claws on the end of each leg • 2 pairs of wingpads on thorax • gills on underside of thorax (not visible on picture card) • 2 tails on end of abdomen 	<p>Clam</p> <ul style="list-style-type: none"> • 2 shells (valves) that are generally round, attached by a muscular hinge • color is white, cream, light tan, or light gray • growth rings on each shell

WATERBUG FIELD MARK SHEET #3 OF 4

<p style="text-align: center;">Alderfly Larva</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • 3 pairs of jointed legs • large head with toothed jaws that project forward • long, pointed filaments along each side of abdomen • long, tapering tail at end of abdomen with fine, tapering hairs on either side 	<p style="text-align: center;">Gilled Snail</p> <ul style="list-style-type: none"> • a single coiled, pointed shell with an opening • a pair of tentacles (like antennae) come out of the head when it is active • a large, muscular foot projects from shell when it is active • a flat, hard plate (operculum) fits into the opening and seals off the shell with the snail inside 	<p style="text-align: center;">Water Snipe Fly Larva</p> <ul style="list-style-type: none"> • long body that tapers to a cone-shaped point • head is partly pulled into the thorax • prolegs along the underside of the abdomen • a forked tail fringed with hair
<p style="text-align: center;">Mayfly Nymph</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • 3 pairs of jointed legs on thorax • 1 claw on the end of each leg • 1 pair of wingpads on thorax • a row of gills along each side of abdomen • 3 tails, sometimes 2 tails 	<p style="text-align: center;">Crayfish</p> <ul style="list-style-type: none"> • 2 body parts: cephalothorax (head attached to thorax) and abdomen • 1 pair of long antennae • 1 pair of shorter antennules • 1 pair of stalked eyes • 5 pairs of jointed legs (including 1 pair of large claws) • tail is a broad flipper 	<p style="text-align: center;">Mussel</p> <ul style="list-style-type: none"> • 2 thick shells (valves) attached by a muscular hinge • shape is variable: round, oval, elongate, triangular, rectangular, etc. • color is usually dark green, brown, or blackish • many have bumps, wrinkles, or ridges on their shells • old shells may be worn away in places to reveal the lighter-colored inner shell

Waterbug FIELD MARK Sheet #4 of 4

<p style="text-align: center;">Blackfly Larva</p> <ul style="list-style-type: none"> • round or oval head, with two big clumps of long hairs on top of head which can be opened and closed like a folding fan • 1 proleg on the underside of the thorax • lower abdomen is swollen • end of abdomen has a tiny ring of hooks 	<p style="text-align: center;">Sowbug</p> <ul style="list-style-type: none"> • 2 pairs of antennae; 1 pair is very long • 2 small eyes • 7 pairs of jointed legs • body is flattened from top to bottom • abdomen has 2 forked tails 	<p style="text-align: center;">Case-building Caddisfly Larva</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • head has thick, hardened skin • very short antennae, often not seen • no wingpads on thorax • top of the first thorax segment has hardened plate; sometimes second segment of thorax also has hardened plate • 3 pairs of jointed legs • soft abdomen • 1 pair of prolegs on the end of the abdomen, each with 1 claw • builds a case and lives within it
<p style="text-align: center;">Beetle Larva</p> <ul style="list-style-type: none"> • head, thorax, and abdomen • 3 pairs of jointed legs • most kinds have long, tapering body • no wingpads on thorax • no appendages on the sides of the abdomen 	<p style="text-align: center;">Crane fly Larva</p> <ul style="list-style-type: none"> • long, thick worm-like body with segments • whitish or grayish color • head is pulled into thorax and is not visible, but sometimes two small mouthparts project from it • no wingpads or jointed legs on thorax • there is a cluster of fleshy tentacles on the end of the abdomen 	<p style="text-align: center;">Scud</p> <ul style="list-style-type: none"> • 2 pairs of antennae • 2 small eyes • 7 pairs of jointed legs • body is flattened from side to side

WATERBUG GALLERY

*Use the **Waterbug Field Mark Sheets** to place each **Waterbug Picture Card** in the correct spot in this Gallery.*

Case-Building Caddisfly Larva	Mayfly Larva	Stonefly Larva	Water Snipe Fly Larva	Water Penny Larva	Gilled Snail	Riffle Beetle Adult
Dragonfly Nymph	Damselfly Nymph	Sowbug	Alderfly Larva	Fishfly and Dobsonfly Larva	Scud	Beetle Larva
Crayfish	Clam	Mussel	Crane fly Larva	Net-Spinning Caddisfly Larva		
Aquatic Worm	Blackfly Larva	Midge Larva	Leech	Lunged Snail		

WATERBUG GALLERY – TEACHER’S KEY

*Use the **Waterbug Field Mark Sheets** to place each **Waterbug Picture Card** in the correct spot in this Gallery.*

Case-Building Caddisfly Larva Waterbug Picture Card #13	Mayfly Larva Waterbug Picture Card #11	Stonefly Larva Waterbug Picture Card #10	Water Snipe Fly Larva Waterbug Picture Card #2	Water Penny Larva Waterbug Picture Card #4	Gilled Snail Waterbug Picture Card #23	Riffle Beetle Adult Waterbug Picture Card #14
Dragonfly Nymph Waterbug Picture Card #12	Damselfly Nymph Waterbug Picture Card #5	Sowbug Waterbug Picture Card #1	Alderfly Larva Waterbug Picture Card #17	Fishfly and Dobsonfly Larva Waterbug Picture Card #19	Scud Waterbug Picture Card #8	Beetle Larva Waterbug Picture Card #24
Crayfish Waterbug Picture Card #18	Clam Waterbug Picture Card #6	Mussel Waterbug Picture Card #22	Crane fly Larva Waterbug Picture Card #16	Net-Spinning Caddisfly Larva Waterbug Picture Card #15		
Aquatic Worm Waterbug Picture Card #7	Blackfly Larva Waterbug Picture Card #20	Midge Larva Waterbug Picture Card #9	Leech Waterbug Picture Card #3	Lunged Snail Waterbug Picture Card #21		

Assessing Practice Streams

Materials <ul style="list-style-type: none"> • completed <i>Waterbug Gallery</i> • <i>Practice Streams</i>, #1 to #5 • <i>Waterbug Assessment Sheet, Part A</i> (in D. FIELDWORK ACTIVITIES) • <i>Waterbug Assessment Sheet, Part B</i> (in D. FIELDWORK ACTIVITIES) 	Set-Up: <ul style="list-style-type: none"> • Optional: Draw the template from Waterbug Assessment, Part B, on a large sheet of flipchart paper. This will allow the class to work together to complete the Water Quality Score for the Class Practice Stream. Timeframe: 45 minutes
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Overview

To teach students how to complete a Waterbugs Assessment and allow them to practice before their fieldwork session.

Instructions

1. Explain to students that they will use a specially designed formula to generate a Water Quality Score, based on the kinds of waterbugs they collect and the overall waterbug community represented by their sample.
2. Review the class' *Waterbug Gallery* with students, and explain that it is organized by sensitivity: row 1 waterbugs are sensitive, row 2 and row 3 waterbugs are moderately sensitive, and row 4 waterbugs are tolerant.
3. Hand out the *Waterbug Assessment Field Sheet, Part A*, which is organized like the Gallery. Go over the **Instructions** in the lower right hand corner and make sure that students understand the sequence of steps involved.
4. Introduce students to the data results for the Class Practice Stream (below) and complete the *Waterbug Assessment Sheet, Part A* together as a class.

Class Practice Stream Results

Kind of Waterbug	Total Counts	Kind of Waterbug	Total Counts
damsel fly nymphs	2	mayfly nymphs	50
midge larvae	12	dobsonfly larvae	6
stonefly nymphs	10	crayfish	4
gilled snails	2	water pennies	4
dragonfly nymphs	2	scuds	1

5. Introduce students to the *Waterbugs Assessment Field Sheet, Part B*, which contains the mathematical formula that produces the Water Quality Score. Go over it carefully with the students, then have them work together to calculate a Water Quality Score for the Class Practice Stream. (Optional: Draw the *Waterbug Assessment Sheet, Part B* on a large sheet of flipchart paper so that the class can complete it together.)
6. Divide the class into 4 groups and have each group do one of the other Practice Streams (#1, #2, #3, or #4).
7. When all groups are done, have each group report their Water Quality Score to the class. Discuss why the scores are different for each stream. (For instance, some streams contain more sensitive waterbugs, which are worth more points, or have a greater diversity of waterbugs, which is also worth more points.)

PRACTICE STREAMS – TEACHER’S KEY

Practice Stream	Water Quality Score	Water Quality Rank
Class Practice Stream	38.3	Very Good
Practice Stream #1	28.1	Fair
Practice Stream #2	18.7	Poor
Practice Stream #3	24.0	Fair
Practice Stream #4	37.8	Very Good

PRACTICE STREAMS #1 AND #2

Names: _____ Date: _____

Instructions

1. Check the box next to the Practice Stream that your group is assessing.
2. Using the Total Count for each waterbug in your Practice Stream, circle the Abundance Code for each kind of waterbug you collected on the *Waterbugs Assessment Sheet, Part A*.
3. Use the *Waterbugs Assessment Sheet, Part B* to calculate the Water Quality Score for your Practice Stream.

☐ Practice Stream #1 Results

Kind of Waterbug	Total Counts	Kind of Waterbug	Total Counts
beetle larvae	2	leeches	4
net-spinning caddisfly larvae	13	crayfish	8
case building caddisfly larvae	7	midge larvae	20
clams	10	aquatic worms	4
crane fly larvae	1	alderfly larvae	2
Water Quality Score:			
Check one:	<input type="checkbox"/> Excellent WQ	<input type="checkbox"/> Good to Very Good WQ	<input type="checkbox"/> Fair WQ <input type="checkbox"/> Poor WQ

☐ Practice Stream #2 Results

Kind of Waterbug	Total Counts	Kind of Waterbug	Total Counts
net-spinning caddisfly larvae	13	midge larvae	20
blackfly larvae	20	scuds	4
crane fly larvae	1	lunged snails	7
leeches	11	rat-tailed maggot	1
mussels	2	mayfly nymphs	10
Water Quality Score:			
Check one:	<input type="checkbox"/> Excellent WQ	<input type="checkbox"/> Good to Very Good WQ	<input type="checkbox"/> Fair WQ <input type="checkbox"/> Poor WQ

PRACTICE STREAMS #3 AND #4

Names: _____ Date: _____

Instructions

1. Check the box next to the Practice Stream that your group is assessing.
2. Using the Results from your Practice Stream, circle the Abundance Code for each kind of waterbug you collected on the *Waterbugs Assessment Sheet, Part A*.
3. Use the *Waterbugs Assessment Sheet, Part B* to calculate the Water Quality Score for your Practice Stream.

☐ Practice Stream #3 Results

Kind of Waterbug	Total Counts	Kind of Waterbug	Total Counts
crane fly larvae	1	black fly larvae	21
midge larvae	101	scuds	4
lunged snails	7	net-spinning caddisfly larvae	62
leeches	15	damselfly nymphs	5
clams	11	beetle larvae	2
Water Quality Score:			
Check one:	<input type="checkbox"/> Excellent WQ	<input type="checkbox"/> Good to Very Good WQ	<input type="checkbox"/> Fair WQ <input type="checkbox"/> Poor WQ

☐ Practice Stream #4 Results

Kind of Waterbug	Total Counts	Kind of Waterbug	Total Counts
dragonfly nymphs	5	water pennies	4
scuds	12	mayfly nymphs	105
stonefly nymphs	1	gilled snails	2
fishfly larvae	1	midge larvae	20
crayfish	2	alderfly larvae	10
Water Quality Score:			
Check one:	<input type="checkbox"/> Excellent WQ	<input type="checkbox"/> Good to Very Good WQ	<input type="checkbox"/> Fair WQ <input type="checkbox"/> Poor WQ

Learning Student Fieldwork

Materials <ul style="list-style-type: none">• copies of <i>Waterbug Student Fieldwork Packet</i>, one per student	Set-Up: <ul style="list-style-type: none">• Assemble all fieldwork supplies and display them in the classroom for students to see.
	Timeframe: 40 minutes

Overview

To familiarize students with the *Waterbug Student Fieldwork Packet* and the method they will use to assess the benthic waterbug community at their river site.

Instructions

1. Explain that students will visit a river site, collect benthic macroinvertebrates (waterbugs) using a specific scientific method (protocol), and calculate a Water Quality Score for that site.
2. Review the information contained in B. UNIT BACKGROUND and D. FIELDWORK ACTIVITIES, STUDENT FIELDWORK GUIDELINES with students.
3. Give a copy of the student packet to each student and review it with the class. Important ideas to discuss:
 - ♦ It is very important that you follow all steps carefully in order to get valid results.
 - ♦ Recording general information about your fieldwork site and following the standard protocol in this unit allows you to exchange your data with others who conduct waterbug assessments in your area. This gives you and them more information about river health and water quality in your area.
 - ♦ When you identify the waterbugs you've collected, confirm all identifications using a field guide and/or a knowledgeable resource person. DO NOT GUESS ON IDENTIFICATIONS! If you guess wrong, your Water Quality Score is not valid.
 - ♦ Periodic waterbug assessments conducted regularly over time (waterbug monitoring) can provide useful information on trends in water quality at a site.
 - ♦ The White River Partnership is interested in your waterbug data. The organization maintains a website with datasets from volunteer groups and schools. Please contact them about sending in your data.
5. Demonstrate for students the scientific protocol for collecting a sample of waterbugs (contact the White River Partnership for training). Discuss logistics for your fieldwork day (see D. FIELDWORK ACTIVITIES, STUDENT FIELDWORK GUIDELINES). Explain that they will enter the stream *downstream* of their riffle site and walk *upstream* to the site. They do not want to disturb the substrate until they step in front of their net to conduct their kick.
6. Review with students the formula for determining a Water Quality Score; they used this formula on their Practice Streams.

D. FIELDWORK ACTIVITIES

Student Fieldwork Guidelines

Before your students' fieldwork day:

1. Choose a river site with several *riffles*. The site should:
 - have solid riverbanks that will not collapse when students walk on them
 - be easily accessed by a group of students during the school day (either on foot, by car, or by bus)
 - offer space for a group of students to move around and work comfortably
 - have a water flow that is brisk but not too strong (watch out! flow can be more powerful than expected)
 - be wider than 2 meters and not more than knee-deep
2. Schedule your fieldwork date and time and make arrangements with the school for students to leave. Also schedule a rain date (see #8 below). If the fieldwork site is relatively close, 2 hours is usually adequate to cover indoor preparations (getting dressed for outside work, gathering supplies, etc.), traveling to the site, doing fieldwork, and traveling back to the school. More time is better (3 hours would allow students to settle into their fieldwork and take a break for snacks if desired).
3. Arrange transportation and line up adult chaperones. We recommend 1 adult per 5 students (less adults for high school students).
4. Develop a plan to evacuate students from the fieldwork site quickly in the event of an emergency. Consider:
 - how to get students' attention right away (a whistle would be a good tool for this)
 - how to move one or more students out of the site and back to safety quickly (if you arrived on a bus, will it wait for you or come back when you are done? if you are on foot, how can you move a student in an emergency?)
 - how to use the other adult chaperones effectively to help organize students and make decisions
 - how you will notify the school of the emergency (do you have a cell phone? does it have reception at your fieldwork site? is there another phone nearby?)
5. Tell students how to dress for a productive fieldwork session. They should wear/bring:
 - comfortable, warm layers that they can peel off if they get too warm
 - warm, waterproof boots
 - a backpack to store items
6. Arrange to borrow the *Waterbugs Teaching Kit* from the White River Partnership, or gather the supplies you will need (see *Waterbugs Student Fieldwork Packet* for a list).

7. Receive training from the White River Partnership to learn the scientific protocol required for collecting a sample of waterbugs, and to practice your identification skills.
8. *Optional:* Invite a benthic macroinvertebrate specialist to accompany your class during fieldwork to help confirm identifications of the waterbugs you catch. Please remember that correct IDs are essential to produce an accurate Water Quality Score.
8. Check the weather forecast for the period in which you intend to do fieldwork – both the day before and the day of fieldwork.
 - If heavy rain is predicted during the day before fieldwork, the river may rise quickly and gather a lot of speed. This is not a safe situation for your students. If the swell from heavy rain passes through your site before your fieldwork time, you may be able to go out. But if you are not sure about this, please use your rain date.
 - If heavy rain is predicted during the day of fieldwork, the river may not rise during your time there, but the wet conditions would make it difficult for students to complete their field sheets. If it is rainy and cold, students might get uncomfortable or even hypothermic. Please use your rain date.
 - Lightning on the day of fieldwork is very dangerous, especially since students will be in the water. *Do not take students to the river if lightning is forecasted!* Please use your rain date.
 - Light rain is generally not a problem, as long as the day is very warm. (On hot days, kids seem to find ways to dunk themselves in the river anyway!) But consider how to protect your field sheets from the wet conditions.

On the day of fieldwork:

1. Have students gather general fieldwork supplies, including:
 - a clipboard and pencil
 - a backpack (optional but very helpful)
 - a water bottle
 - snacks (optional, but they keep people happy!)
2. The teacher/adult leader should gather:
 - extra fieldwork sheets and pencils (students are very creative at destroying fieldwork sheets and losing pencils)
 - first aid kit
 - whistle (optional, but it really gets their attention!)
3. Have students get ready for fieldwork at least 15 minutes before you leave the school, including visiting the bathrooms.

For more information, please see

G. HELPFUL TOOLS, RIVER FIELDWORK SUPPLIES & SAFETY PLANNING

WATERBUGS

STUDENT FIELDWORK PACKET

Fieldwork Overview

- You will find at least 2 good *riffles* at your river site in which you can sample 1 square meter of substrate. This means that you will collect waterbugs within a total of 2 square meters of substrate.
- You will conduct 2 kicks with your kicknet, the first kick downstream of the second riffle (see diagram at bottom of page).
- You will sort and identify all waterbugs in both collections, and count up the number of each kind of waterbug in both collections. In this way, you will aggregate the data from both kicks into one dataset.
- With the aggregated data, you will calculate the Water Quality Score for your site.

Instructions for Fieldwork

1. Organize your fieldwork supplies (see box at right). Using the *Waterbugs Assessment Supplies Checklist*, confirm that you have each item that you need, and put a check mark next to that item in the “Start” column of the checklist.
2. Locate your two good kicknet riffle sites. Enter the river downstream of your first riffle so as not to disturb the substrate in your first riffle and corrupt your data.
4. Walk upstream to your first riffle. Conduct a kick, following the scientific protocol used in this unit.
5. Empty all collected waterbugs into a large white basin with water. Sort and identify all waterbugs.
6. Walk further upstream to your second kicknet riffle and repeat the process.
7. Count all individuals of each kind of waterbug you collected from the two kicks. Complete the Total Counts and Abundance Codes on the *Waterbug Assessment Sheet, Part A*.
8. On the *Waterbug Assessment Sheet, Part B*, calculate the Water Quality Score.

FIELDWORK SUPPLIES

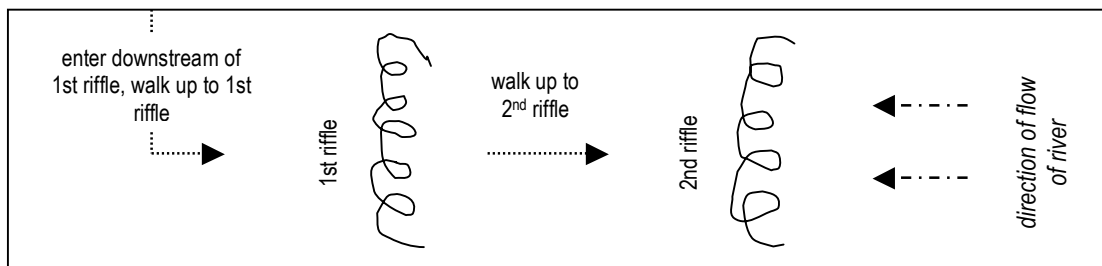
See Supplies Checklist on next page

PERSONAL SUPPLIES

(provided by teachers and/or students)

- boots or close-toed footwear* that can get wet and dirty
- an extra layer of warm clothing in case the weather turns cold
- an extra set of dry clothes
- water bottles (1 per student)
- sun hats and/or sunscreen

*Close-toed footwear protects toes from getting stubbed on rocks while walking in river, and are essential for the “kickers.”



WATERBUG FIELDWORK SUPPLIES CHECKLIST

Start (check)	End (check)	Items for each of 4 Groups
From Waterbugs Teaching Kit & Waterbugs Unit		
<input type="checkbox"/>	<input type="checkbox"/>	General Information Sheet
<input type="checkbox"/>	<input type="checkbox"/>	Waterbug Assessment Sheet, Part A
<input type="checkbox"/>	<input type="checkbox"/>	Waterbug Assessment Sheet, Part B
<input type="checkbox"/>	<input type="checkbox"/>	1 large white basin
<input type="checkbox"/>	<input type="checkbox"/>	1 small white basin
<input type="checkbox"/>	<input type="checkbox"/>	1 ice cube tray
<input type="checkbox"/>	<input type="checkbox"/>	2 white spoons
<input type="checkbox"/>	<input type="checkbox"/>	2 pipettes
<input type="checkbox"/>	<input type="checkbox"/>	2 forceps
<input type="checkbox"/>	<input type="checkbox"/>	1 two-way viewer
<input type="checkbox"/>	<input type="checkbox"/>	1 Field Guide to Aquatic Macroinvertebrates (Izaak Walton League)
To be gathered by class		
<input type="checkbox"/>	<input type="checkbox"/>	1 pouring container (a large yogurt container works well)
<input type="checkbox"/>	<input type="checkbox"/>	a map of the fieldwork site (from Google Earth or another source)
<input type="checkbox"/>	<input type="checkbox"/>	camera (to take photos of fieldwork site, students at work, unknown waterbugs, etc.)
Start (check)	End (check)	Whole Class Items (for all groups to use)
From Waterbugs Teaching Kit		
<input type="checkbox"/>	<input type="checkbox"/>	1 kicknet
<input type="checkbox"/>	<input type="checkbox"/>	2 poles
<input type="checkbox"/>	<input type="checkbox"/>	1 Guide to Common Freshwater Invertebrates of North America, by J. Reese Voshell
To be gathered by teacher/adult leader		
<input type="checkbox"/>	<input type="checkbox"/>	clipboards and pencils, 1 each per student
<input type="checkbox"/>	<input type="checkbox"/>	first aid kit
<input type="checkbox"/>	<input type="checkbox"/>	class emergency plan (see G. HELPFUL TOOLS)
<input type="checkbox"/>	<input type="checkbox"/>	whistle (optional, but helpful!)
<input type="checkbox"/>	<input type="checkbox"/>	snacks for students (optional, but helpful!)

GENERAL INFORMATION SHEET

School Name	Date _____	Time: _____
Community name:	Site Name:	
Investigators:		

Location
County:
River/Stream name:
River System name:
Watershed description:
Directions on how to find this site:
Map with site marked attached to this sheet? <input type="checkbox"/> Yes <input type="checkbox"/> No

Weather; check (✓) one:	
<i>During the past 24 hours:</i> <input type="checkbox"/> Storm (heavy rain) <input type="checkbox"/> Rain (steady rain) <input type="checkbox"/> Showers (intermittent rain) <input type="checkbox"/> Snow <input type="checkbox"/> Overcast <input type="checkbox"/> Clear/sunny	<i>Now:</i> <input type="checkbox"/> Storm (heavy rain) <input type="checkbox"/> Rain (steady rain) <input type="checkbox"/> Showers (intermittent rain) <input type="checkbox"/> Snow <input type="checkbox"/> Overcast <input type="checkbox"/> Clear/sunny

Air temperature: _____ ° F	Water temperature: _____ ° F	pH: _____
Photographs taken? <input type="checkbox"/> Yes, attached here <input type="checkbox"/> No		


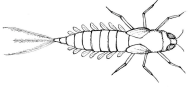






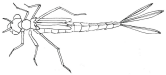

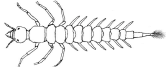



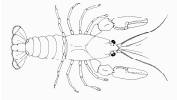







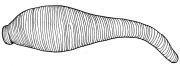

Site Sketch

Please make a careful sketch of your investigation site. Note important physical features, such as vegetation, roads, human settlements, livestock activities, wetlands, dams, tributaries, etc.

When you choose your 2 waterbug collecting sites, please mark them on this sketch and number them in the order in which they are sampled. (#1 is the first site you sample and should be downstream of #2.)

Draw an arrow to indicate the direction of flow.

WATERBUGS ASSESSMENT FIELD SHEET – PART A: IDS, TOTAL COUNTS, & ABUNDANCE CODES

Group I: Sensitive	<input type="checkbox"/> Caddisfly larvae (except net spinners)  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Mayfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Stonefly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Water snipe fly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Water pennies  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Gilled snails  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Riffle Beetles  Total Count _____ Abundance Code: R C D						
	<input type="checkbox"/> Dragonfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Damselfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Sowbugs  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Alderfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Fishfly and Dobsonfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Scuds  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Beetle Larvae  Total Count _____ Abundance Code: R C D						
Group II: Moderately Sensitive	<input type="checkbox"/> Crayfish  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Clams  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Mussels  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Crane fly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Net-spinning caddisfly larvae  Total Count _____ Abundance Code: R C D	<h2 style="text-align: center;">Instructions</h2> <p><i>For each kind of organism you collect:</i></p> <ol style="list-style-type: none"> Check the box next to its name. Count (or estimate) the number of individuals of this kind and enter this number in the “Total Count” space. Circle Abundance Code R, C, or D for this kind. <h2 style="text-align: center;">Abundance Codes</h2> <table style="width: 100%; text-align: center;"> <tr> <td>1 to 9 organisms:</td> <td>10 to 99 organisms:</td> <td>over 100 organisms:</td> </tr> <tr> <td>Rare (R)</td> <td>Common (C)</td> <td>Dominant (D)</td> </tr> </table>		1 to 9 organisms:	10 to 99 organisms:	over 100 organisms:	Rare (R)	Common (C)	Dominant (D)
	1 to 9 organisms:	10 to 99 organisms:	over 100 organisms:										
Rare (R)	Common (C)	Dominant (D)											
Group III: Tolerant	<input type="checkbox"/> Aquatic worms  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Blackfly larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Midge larvae  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Leeches  Total Count _____ Abundance Code: R C D	<input type="checkbox"/> Lunged snails  Total Count _____ Abundance Code: R C D								

Investigator(s): _____ Site Name: _____ Date: _____

WATERBUGS ASSESSMENT FIELD SHEET - PART B: WATER QUALITY SCORE

Investigator(s): _____

Site Name: _____ Date: _____

1. Calculate the Index Value for each Group.

- a. Look at the Sensitivity Groups on Part A. In each Group box below, count the number of R's and write that number in the space to the left. Do the same for C's, then D's.
- b. Multiply each number by its *Weighting Factor (WF)*. Write that number to the right.
- c. Add the numbers in the Value column on the right to get the Index Value for that Group.

Group I: Sensitive	W F	Value for each Abund Code	Group II: Moderately Sensitive	W F	Value for each Abund Code	Group III: Tolerant	W F	Value for each Abund Code
— (# of R's)	X 5.0	= _____ +	— (# of R's)	X 3.2	= _____ +	— (# of R's)	X 1.2	= _____ +
— (# of C's)	X 5.6	= _____ +	— (# of C's)	X 3.4	= _____ +	— (# of C's)	X 1.1	= _____ +
— (# of D's)	X 5.3	= _____ ↓	— (# of D's)	X 3.0	= _____ ↓	— (# of D's)	X 1.0	= _____ ↓
Group I Index Value: _____			Group II Index Value: _____			Group III Index Value: _____		

2. Calculate the Water Quality Score for the river site.

Add all Group Index Values together:

Group I Index Value	+	Group II Index Value	+	Group III Index Value	=	Water Quality Score
_____		_____		_____		_____

3. Compare your score to the following range of scores to determine the water quality of your river site.

Water Quality Score	Check (✓) one box:	Explanation:
41 and above	<input type="checkbox"/> Excellent WQ	No impairment
31 - 40	<input type="checkbox"/> Good to Very good WQ	Slight impairment
21 - 30	<input type="checkbox"/> Fair WQ	Much impairment
0 - 20	<input type="checkbox"/> Poor WQ	Serious impairment

E. CULMINATING ACTIVITIES

Debriefing Student Fieldwork Sheets

Back in the classroom, have students review their fieldwork sheets. Go over student observations and data. Discuss the waterbugs they found. Did they find anything unusual or surprising? Observe any interesting behaviors?

After this discussion, have students write a *Conclusion* to their fieldwork. Their Conclusion should include the following:

- ♦ A summary of the important findings of their fieldwork, based on the new knowledge they built about waterbugs at their river site.
- ♦ One or more questions that have arisen from their fieldwork experience that could be addressed with another waterbug assessment. (For instance: What would be our Water Quality Score if we collected waterbugs downstream of a cow pasture?)

Working with Datasets

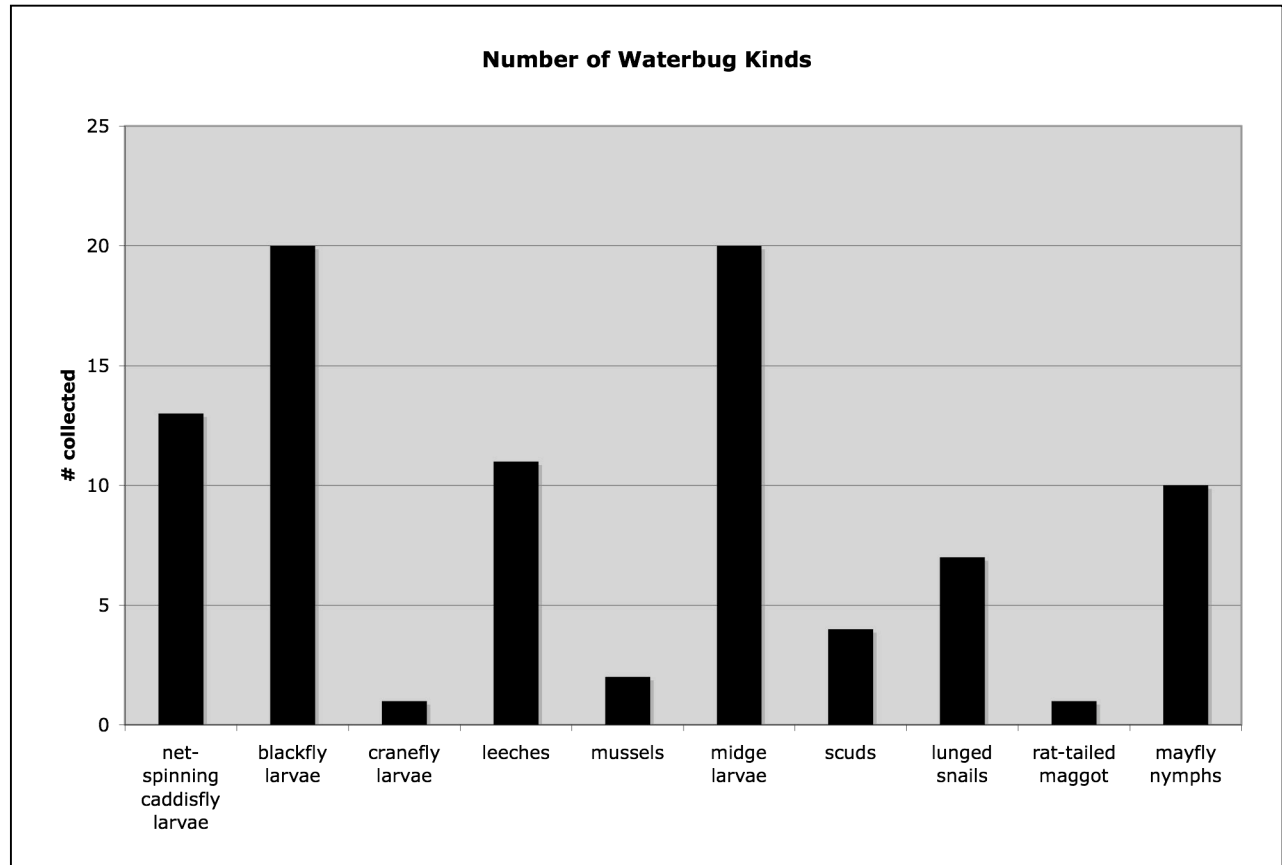
Waterbug fieldwork offers lots of opportunities for working with simple datasets. Students can generate tables that summarize certain kinds of data, and then graph these data to create visual representations of the data. These graphs may reveal information that is less obvious in tables of numbers. In what situations are tables more useful? In what situations are graphs more useful?

Example of a table of data:

Practice Stream #2

Kind of Waterbug	# Collected	Kind of Waterbug	# Collected
net-spinning caddisfly larvae	13	midge larvae	20
blackfly larvae	20	scuds	4
crane fly larvae	1	lunged snails	7
leeches	11	rat-tailed maggot	1
mussels	2	mayfly nymphs	10

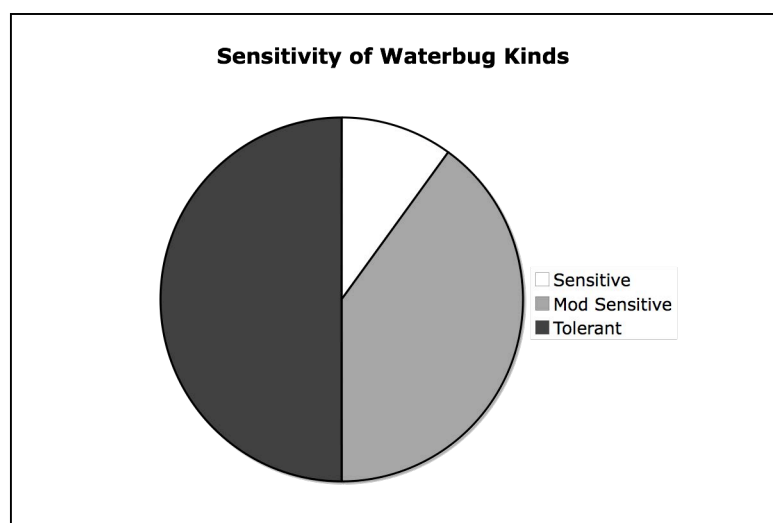
These same data can be graphed using an excel spreadsheet, which gives you a clear “picture” of the data:



This **bar graph** allows you to see the number of each waterbug collected, and also gives you immediate information, such as the most numerous and the least numerous.

A **pie graph** can be used to indicate the relative percentage of each group within the collection. The pie graph of Practice Stream #2 on the right can be interpreted as follows:

Of the 10 waterbug kinds collected, 1 was sensitive, 4 were moderately sensitive, and 5 were tolerant.



Water Quality Outreach

Students can research the causes of water quality problems in their area and then educate others by designing posters that can be hung in their school, their town hall, or at local river access sites. They can find lots of information on the Vermont Water Quality Division of the Department of Environmental Conservation website: http://www.anr.state.vt.us/dec/waterq/lakes/htm/ans/lp_ans-index.htm. They can also talk to community groups such as the conservation commission, the local fish and game club, riparian landowners, town officials, or others.

Using the Scientific Method

This monitoring program can be used to teach the *scientific method*, which strives to answer a question about the world using a systematic approach. In science, the conclusion of an investigation raises more questions, which can be explored in subsequent cycles of investigation. Introduce students to the scientific method (outlined below) and talk about some ways in which our society uses the information that scientists generate. What happens when we use information from scientific investigations that are not carefully designed and carried out? (We generate poor information that can be misleading.)

Based on their waterbugs assessment, what new questions do students have? Ask the class to brainstorm a list. Here are some sample questions that teachers might use to start the brainstorm:

- ◆ What is the water quality downstream of a cow pasture? How does it compare with water quality upstream of the cow pasture?
- ◆ Does human activity in our swimming hole degrade water quality?
- ◆ What does soil eroding into the river do to the waterbug community?

Students can choose a question from the brainstorm list and follow the scientific method to investigate it. They can use one or more of these research techniques:

- ◆ Design an experiment and implement it.
- ◆ Interview people with expertise in the subject.
- ◆ Conduct a literary search.

If students want to design their own experiment, they must develop a hypothesis that is *testable* – that is, a hypothesis that they can test readily. Some hypotheses are out of students' reach because they lack the needed scientific training and supplies, so encourage students to choose a simple question that can be investigated easily.

The Scientific Method

- Step 1: Ask a question that can be answered through experimentation or investigation.
- Step 2: Form a hypothesis (a proposed explanation), based on personal observations and information found on the topic. The hypothesis must be *testable* by the investigators.
- Step 3: Design a test (experiment or investigation) for your hypothesis.
- Step 4: Carry out your test and record your results as data or other forms of information.
- Step 5: Analyze your results, looking for patterns and trends in your data.
- Step 6: Review your original question and your hypothesis. Was your hypothesis supported by your work? If not, why not?
- Step 7: Ask one or more new questions, based on your experience with your experiment or investigation.
- Step 8: If there is time, choose one of your new questions, form a hypothesis that may explain it, and conduct another round of experimentation/investigation (Step 1).

The scientific method can be seen as a *spiral of inquiry* that links successive cycles of experimentation/investigation. Each cycle generates new information that helps to build more knowledge over time. This is how scientists help us increase our understanding of our world.

Sharing the Learning

After completing your culminating activities, hold an Open House or a Science Celebration that invites other students, parents, and community members to learn about the students' work. When students have opportunities to share their learning, their understanding is deepened and they feel the satisfaction of helping to educate others. We also encourage you to share your results with the White River Partnership or other organizations interested in waterbugs, water quality, and river ecology. (see G. HELPFUL TOOLS, WATERBUG RESOURCES)

F. GOOD MONITORING PRACTICES

Quality Assurance

Schools have many reasons to monitor their river. Usually, the primary motivation is to help students achieve certain academic goals. This kind of fieldwork-based program can also connect students to their place as they keep tabs on the area and get to know its wild inhabitants. Sharing monitoring data with nearby schools and groups increases student investment in their place and weaves their place into the larger landscape.

River monitoring can offer students a meaningful service learning opportunity that allows them to contribute information to local decision-making efforts. If schools decide to generate useful data for decision-making, they should develop a quality assurance system for their program. This can be an informal system or a more formal “quality assurance project plan” as defined by the U.S. Environmental Protection Agency (USEPA) in their publication, *The Volunteer Monitor’s Guide to Quality Assurance Project Plans* (http://water.epa.gov/type/rs/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf). The USEPA defines quality assurance as follows.

Quality assurance is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. QA activities involve planning quality control, quality assessment, reporting, and quality improvement.

Many schools that want to share their data decide that they don’t need a full-fledged quality assurance project plan (QAPP). Yet some teachers choose to inform themselves and their students about this process because it helps them to understand how people can use science to generate valid data to help make natural resource decisions. The box below outlines “Steps to Developing a QAPP.” If you are considering writing your own QAPP, please see the document at the USEPA website above.

At a minimum, we recommend that you implement certain QA activities to improve both your students’ science education and their fieldwork results. Below we offer General QA Methods for all four MWR units, then specific QA Methods for the Waterbugs unit.

General QA Methods

- The MWR fieldwork techniques are based on scientific protocols developed by monitoring experts. If you want to share your students’ data with other schools across the MWR network, please use the fieldwork sheets included with the units. (If you don’t share data, please feel free to adapt the fieldwork sheets.)

Before fieldwork,

- be sure you have the equipment and supplies specified by the fieldwork techniques you are using;
- read the STUDENT FIELDWORK GUIDELINES carefully;

- go over the fieldwork sheets with your students and adult helpers so they understand all parts of the sheet and they know why they are collecting data in a specific way;
- decide what you will do with student data after collecting it (e.g., will it be summarized in a database? graphed and shared with parents? presented at town meeting?);

During fieldwork,

- encourage students to complete all parts of the fieldwork sheet that they can, and add any information that may clarify or explain their data;
- document important observations using photographs or collections of items.
- if possible, invite an expert to accompany you during fieldwork to confirm results.

After fieldwork,

- discuss observations and data as a group to fill in missing information and correct mistakes and misunderstandings;
- recalculate your Water Quality Score, checking that you followed all necessary steps and did the math correctly;
- label and store fieldwork photographs using an organized system so that you can retrieve them as needed;
- store fieldwork sheets for future reference. This is especially important if you plan to compare data results from year to year, or share your data with others.
- if possible, ask an expert to visit your students to check their results and discuss findings and conclusions.

QA Methods for Waterbugs

- During fieldwork, make sure that students accurately identify the waterbugs they catch. We recommend that you invite a benthic macroinvertebrate specialist to accompany your group during fieldwork to confirm identifications (optional but recommended).
- Take photographs of waterbugs whose identification is unclear or confusing and send them to a specialist for an accurate ID.
- Make a *reference collection* that includes important representatives of species caught. Obtain some small glass jars with tight-fitting lids and ethyl alcohol. Put one kind of waterbug in each jar and add the alcohol.

Label each jar with information on location where caught, date, time, and collector(s). You can then show your specimens to an expert to confirm identification and other information.

Steps to Developing a QAPP

(From the Executive Summary of *The Volunteer Monitor's Guide to Quality Assurance Project Plans*, http://water.epa.gov/type/rsl/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf).

Developing a QAPP is a dynamic, interactive process that should ideally involve state and EPA regional QA experts, potential data users, and key members of the volunteer monitoring project. There are 11 steps a volunteer monitoring project coordinator might take to prepare a QAPP. These are:

- Step 1: *Establish a small team* whose members will serve as advisors in helping you develop the QAPP by offering feedback and guidance throughout the entire process.
- Step 2: *Determine the goals and objectives of your project* – why it's needed, who will use the data, and how the data will be used.
- Step 3: *Collect background information* to help you in designing your project.
- Step 4: *Refine your projects goals* once you've collected more information.
- Step 5: *Design your project's sampling, analytical & data requirements* – essential, what, how, when, and where you'll be monitoring.
- Step 6: *Develop an implementation plan* that lays out project logistics.
- Step 7: *Draft your standard operating procedures (SOPs) & QAPP.*
- Step 8: *Solicit feedback on your draft SOPs & QAPP* from state or EPA regional QA contacts and potential data users.
- Step 9: *Revise your QAPP* based on review comments and submit it for approval.
- Step 10: *Once your QAPP is approved, begin your monitoring program.*
- Step 11: *Evaluate and refine your project over time*, and reflect any major changes in a revised QAPP.

Data Management

Work with students to design a sheet (an excel spreadsheet works well) that allows them to summarize their data. Then they can organize their data into tables, charts, graphs, or other formats. Have students compare different formats to see how each one presents their data results in a particular way.

Build a database system for storing datasets from year to year. It's a good idea to maintain both a digital storage system and a paper-based storage system. Contact the White River Partnership (WRP) for more guidance on managing data. Also check the *Resources and Information* page of the WRP website (<http://whiteriverpartnership.org>) to see actual datasets for different water quality parameters.

G. HELPFUL TOOLS

Glossary

abdomen – the rear part of the waterbug body.

antennae – a pair of long, thin organs attached to the front of the head used for touch, taste, and smell.

arthropod – an invertebrate animal that has jointed legs, a segmented body, and a hard exoskeleton. Insects, arachnids, and crustaceans are examples of arthropods.

assess – to examine something (as a river) in order to evaluate it.

benthic – associated with the streambed or other surfaces in a river.

data (singular: datum) – pieces of information that are gathered from experiments, surveys, or other investigations to make calculations or draw conclusions.

ecosystem – a natural system in which all organisms interact with each other and with the physical features of the environment; examples: river, forest, wetland.

ecotone – an ecological zone between two or more ecosystems; an edge habitat

environmental literacy – the capacity to use an understanding of the natural world to make informed decisions about humans' relationship with it.

exoskeleton – the hardened outer shell on an arthropod that is periodically shed (molted) to allow the animal to grow.

field mark – a physical feature on an organism that aides in identification.

food web – the feeding connections between and among organisms in an ecosystem.

functional feeding groups – categories of benthic macroinvertebrates that are based on body structures and behavioral mechanisms used to obtain food.

habitat – the place that provides all the essential resources for an organism's survival.

macroinvertebrate – an organism that has no backbone and is large enough to see with the naked eye; examples: insect, worm, snail.

mainstem – the largest channel of a river system.

monitor – to check something (as a river) at regular intervals in order to find out whether and how it is changing.

niche – the role of an organism in its natural environment that determines its relationships with other organisms and promotes its survival.

protocol (scientific) – a detailed, systematic process that is followed to produce valid scientific data in an investigation.

riffle – a shallow, turbulent area in a stream where water flows rapidly over gravel and rock.

riparian zone – the area of land along a stream channel where vegetation and land uses directly influence stream processes.

substrate – the surface of the streambed and the material that lies upon it, as well as other surfaces within the stream (such as a log) that provide habitat for organisms.

taxonomy - the science of classifying organisms into categories based on shared characteristics and natural relationships.

thorax – the middle section of an insect, between the head and the abdomen.

tributary – a stream that flows into another stream or river.

watershed – a basin of land in which all water drains down to a common body of water (stream, river, lake, pond, wetland, ocean).

Waterbug Resources

The White River Partnership (WRP) – a community-based, 501c3 nonprofit organization bringing together people and local communities to improve the long-term health of the White River and its watershed in central Vermont.

<http://www.whiteriverpartnership.org/>; 802-763-7733

Greg Russ, Project Coordinator: greg@whiteriverpartnership.org

Emily Miller, Monitoring Coordinator: emily@whiteriverpartnership.org

Environmental Literacy and Educational Standards

Environmental Literacy for Vermont <http://www.environmentalliteracyvt.org/>

Environmental Literacy Council <http://www.enviroliteracy.org/>

Developing a Framework for Assessing Environmental Literacy, North American Association of Environmental Education <http://www.naaee.net/framework>

Next Generation Science Standards <http://www.nextgenscience.org/>

Common Core State Standards Initiative <http://www.corestandards.org/>

Waterbug Ecology & Identification

Guide to Aquatic Insects and Crustaceans, by the Izaak Walton League of America, 2006, Stackpole Books.

A Guide to Common Freshwater Invertebrates of North America, by J. Reese Voshell, 2002, McDonald and Woodward Publishing Company.

Stream Macroinvertebrates, Maryland Department of Natural Resources:

http://www.dnr.state.md.us/streams/pdfs/dnr_bugsheet.pdf

Aquatic Macroinvertebrate Identification Key, Virginia Save Our Streams:

<http://www.people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML>

Freshwater Macroinvertebrates of New York, NY Department of Environmental Conservation:

<http://www.dec.ny.gov/animals/35772.html>

Volunteer Stream Monitoring Interactive Verification Program, Chironomidae Research Group,

University of Minnesota: <http://midge.cfans.umn.edu/vsmivp/>

Water Quality

Vermont Watershed Management Division, Vermont Department of Environmental Conservation

<http://www.vtwaterquality.org/>

United States Geological Survey (USGS)

<http://water.usgs.gov/owq/>

United States Environmental Protection Agency (USEPA), Water Quality Standards

<http://water.epa.gov/scitech/swguidance/standards/>

The Volunteer Monitor's Guide to Quality Assurance Project Plans, U.S. Environmental Protection Agency

<http://water.epa.gov/type/rsl/monitoring/qappcovr.cfm>

River Fieldwork Supplies & Safety Planning

Please review this sheet before taking a group to the river for fieldwork.

BASIC RIVER FIELDWORK SUPPLIES

The following items are useful for most river fieldwork sessions. You may also need to collect items geared to your specific fieldwork activities.

- boots or waders
- walking stick to maintain balance in the river (can be used to probe for deep spots and to measure depth)
- sunhat and sunscreen lotion
- refreshments and drinking water
- clipboard
- several pencils
- digital camera to document sites, physical conditions, and/or organisms collected
- plastic gloves (if there is a concern about pollution; see Safety Guidelines below)

SAFETY GUIDELINES

1. Develop a **Safety Plan** for your river fieldwork sessions (see suggested outline below). Make sure that all adults know what to do in an emergency at the river, and bring your Safety Plan with you during every fieldwork session for important information that will help you deal with the emergency.
2. Never do fieldwork in **severe weather**, and *get out of the water during a lightning storm*.
3. If there is a **dam** upstream of your river site, be aware of the dates and times when water is released from the dam since this results in sudden flooding downstream of the dam.
4. Bring **snacks and drinks** if your group will be outside for a while. If the weather is cold, bring warm drinks to guard against hypothermia.
5. Carry a **whistle** with you during fieldwork to communicate with members of your group and to signal for help if needed.
6. Always wear **footgear** in the river – never wade in barefoot because glass and other sharp objects could pose hazards. Footgear with covered toes (such as old sneakers) are ideal.
7. Remember that getting wet increases the chances of hypothermia. During cool or cold weather, have everyone bring **extra dry clothes and footgear** and keep them dry.
8. Confirm that you are at the **correct river site** by checking maps, site descriptions, and/or directions.
9. Always conduct fieldwork with at least one **partner**. Teams of three or four people are best. Always **let someone else know** where you are and when you intend to return.
10. Find a **safe path** down to the river's edge. If the path is too steep, too slippery, lined with poison ivy, or too heavily forested to keep everyone safe, choose another way to get to your fieldwork site or choose another site.
11. Do not walk on **unstable riverbanks**. This can cause erosion and might be dangerous if a bank collapses. Disturb riverside plants as little as possible.
12. Do not touch river water, or wear plastic gloves, if you know or suspect that it is **polluted**. Both organic pollution (caused by human or livestock wastes) and toxic pollution (caused by certain mines, industries, and pesticides) can create unacceptable human health risks.
13. **High and/or fast river water can be very dangerous. Please enter the river only if the water level is below the knee and you can move around in the current without struggling.**
14. Be very careful when **walking in the river**. The riverbed can be very slippery and can contain deep pools. If you must cross the river, use a walking stick to steady yourself and to probe for deep water, soft mud, or unseen rocks. Your partner(s) should wait on dry land to assist you if you fall.
15. After fieldwork, and before eating anything, **wash your hands** thoroughly with soap to remove any pathogens or other pollutants that may be present in the river water.

RIVER FIELDWORK SAFETY PLAN
(Suggested Outline)

Name of person supervising your Safety Plan:	
Contact information for this person:	
Medical facility that is closest to your river fieldwork site(s):	
Will person who accompanies the fieldwork group to the river have a cell phone with him/her?	
<input type="checkbox"/> Yes	
<input type="checkbox"/> No; if not, how will he/she summon help if needed?	
Telephone number of closest medical facility:	
Directions to medical facility:	
Please collect information from all members of your group regarding medical issues that may require attention at the river (e.g., bee sting allergy), and obtain permission to treat members if necessary.	
Please check one box below.	
<input type="checkbox"/> Medical release forms completed and signed for each member (<i>essential for children</i>).	
<input type="checkbox"/> Medical release forms not necessary.	
Please check one box below and complete as necessary.	
<input type="checkbox"/> There are no medical issues in our group.	
<input type="checkbox"/> We have identified the following medical issues and remedies (e.g., bring bee sting kit):	
Medical issue: _____	
Remedy: _____	
Medical issue: _____	
Remedy: _____	
Medical issue: _____	
Remedy: _____	
Medical issue: _____	
Remedy: _____	
Other important notes regarding safety during river fieldwork:	
Safety Plan prepared by: _____	
Date: _____	