Missouri Stream Team

Introduction to Volunteer Water Quality Monitoring

LEVEL 1 NOTEBOOK

2023

MDC STR 404

Missouri Stream Team

PO Box 180, Jefferson City, MO 65109

800-781-1989

StreamTeam@mdc.mo.gov

StreamTeam@dnr.mo.gov

MoStreamTeam.org

YouTube.com/@MissouriStreamTeam

Facebook.com/mostreamteams/

IF YOU DISCOVER A SERIOUS WATER POLLUTION EVENT OR FISH KILL, REPORT IMMEDIATELY TO:
MISSOURI DEPARTMENT OF NATURAL RESOURCES
EMERGENCY RESPONSE UNIT 573-634-2436
mdc.mo.gov/fishkills

Chapter 1

Introduction to Volunteer Water Quality Monitoring Training: Level 1

Welcome to Missouri Stream Team! This program is made possible by a strong partnership between the citizens of Missouri and the following organizations:

Since you are participating in a training on water quality monitoring, you likely have an interest in clean water and protecting our state's waterways. This chapter will explain the Missouri Stream Team and Volunteer Water Quality Monitoring programs. The following will also be covered:

- Requirements for VWQM certifications
- Define watersheds and how streams affect a watershed's overall health
- Completing Stream Team Activity Reports

Missouri Stream Team Program and Goals

Beginning in 1989, the Missouri Stream Team provides opportunities for all citizens to get involved in river and stream conservation. The program has three main goals:

- ***Education:*** Learning about Missouri's 110,000 miles of flowing water enables volunteers and their communities to better understand stream systems and the challenges faced conserving them.
- ***Stewardship:*** Becoming good stewards of our natural resources ensures future generations will enjoy the benefits of Missouri's streams.
- ***Advocacy:*** Citizens who have gained firsthand knowledge of stream needs, problems, and solutions are best equipped to speak out on behalf of Missouri's stream resources. Stream Teams United is a program partner that assists with advocacy. For more information on advocating for Missouri waterways, visit StreamTeamsUnited.org.

Whatever your ambitions, the Missouri Stream Team program has many opportunities for you to get involved. We welcome your volunteer efforts and sincerely appreciate the work you do to protect and conserve Missouri's streams.

VWQM Program and Goals

One of the most popular Stream Team activities is the Volunteer Water Quality Monitoring (VWQM) program. This activity was added in 1993 at the request of Stream Team volunteers who wanted to participate in stream monitoring.

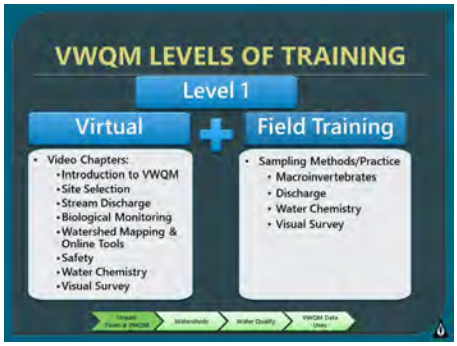
The VWQM Program provides volunteers with training and equipment to monitor the quality of Missouri's rivers and streams. The VWQM Program was established to achieve four goals:

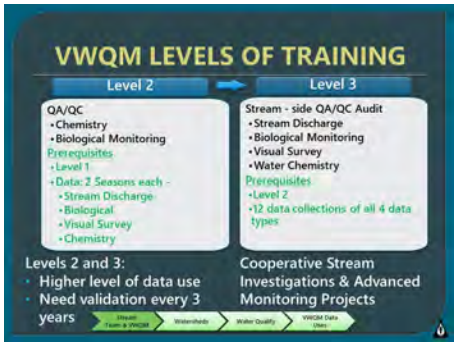
VWQM Program Goals			
Inform and educate about the conditions of Missouri's rivers and streams	Establish a network of trained volunteers to monitor the quality of Missouri's rivers and streams	Enable citizens to help local, state, and federal leaders make informed decisions about Missouri's waterways	Halt water quality degradation of Missouri's water resources

VWQM Levels of Training and Requirements

To become a water quality monitor, volunteers engage in training to acquire the knowledge and skills they need to evaluate water quality accurately. Currently, there are four levels of training. Each level of training is a prerequisite for the next. Structuring the training in this way allows volunteers to choose their own level of participation and commitment in monitoring activities.

Volunteers who wish to advance from one level to the next must meet certain requirements. The table below describes the content of each training level and the requirements that allow you to advance to the next level.



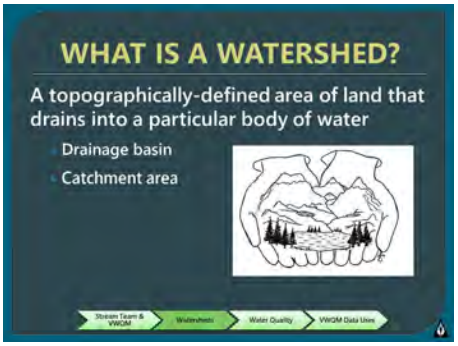


VWQM Levels of Training and Prerequisites

Level 1	
Content Site Selection, Stream Discharge, Biological Monitoring, Visual Survey, Water Chemistry	***Prerequisite*** None

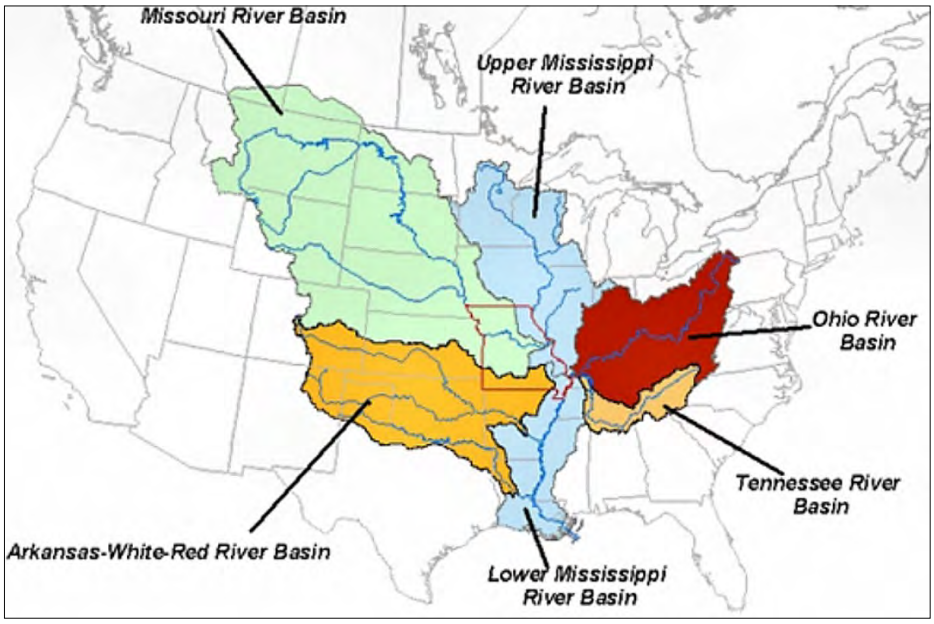
Level 2	
Content Quality Assurance/Quality Control (QA/QC) of chemical monitoring and macroinvertebrate identification	***Prerequisite*** Level 1 certification and submission of 2 seasons of all data

Level 3	
Content Stream-side QA/QC of all data collection methods	***Prerequisite*** Level 2 certification and submission of 12 seasons of all data

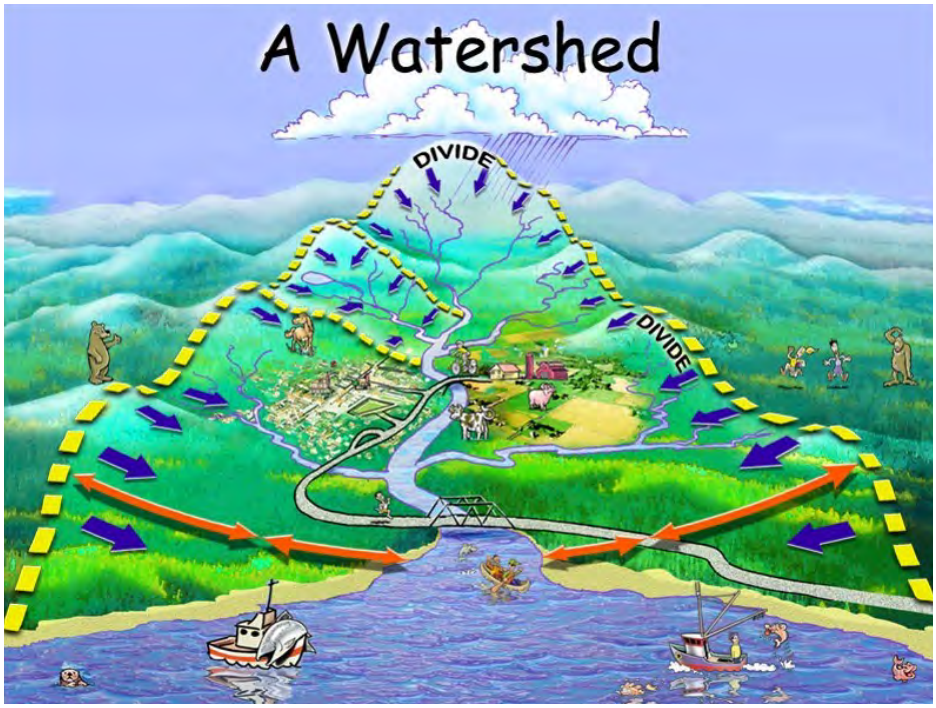


What is a Watershed?

A watershed is a topographically defined area of land that drains into a particular body of water. Watersheds are interconnected. For example, the Mississippi Watershed includes the Missouri, Mississippi, Ohio, Tennessee, Arkansas, White, and Red river basins.

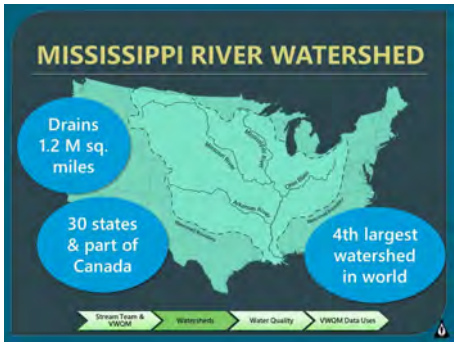


As shown in the diagram below, the quality of a stream is a direct reflection of its watershed. Since humans live, work, and play in watersheds, we directly and indirectly alter them and our water resources. As water flows across urban areas or pastures, it picks up sediment, pollutants, and even heat. These



Mississippi River Watershed

Watersheds range in size from less than an acre to millions of square miles. The Mississippi River watershed is the fourth largest in the world, covering 1,247,000 square miles. It crosses many political boundaries too. For example, the Mississippi River watershed includes portions of 30 states and a small part of Canada.



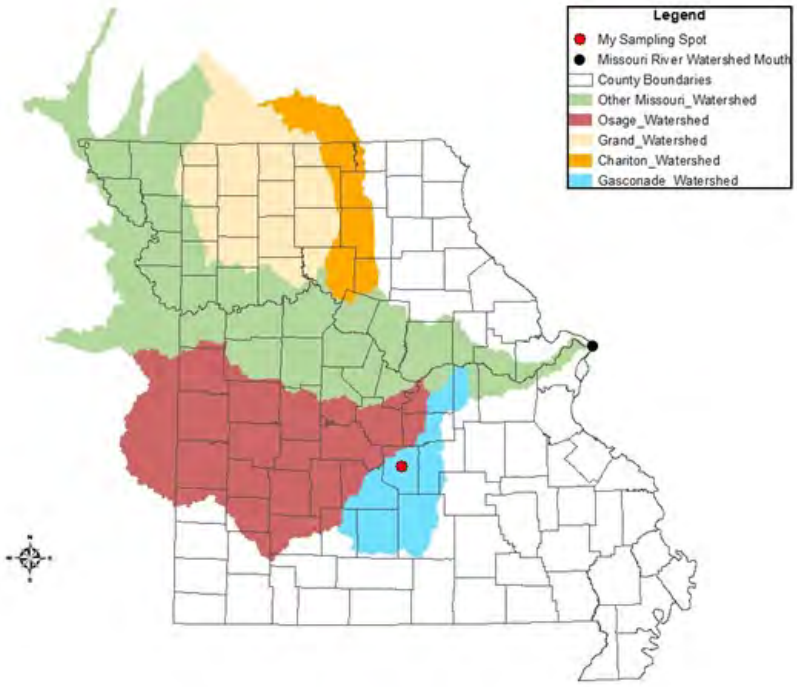
Missouri River Watershed

The Missouri River is the longest river in North America, stretching 2,341 miles. As the largest tributary to the Mississippi River, it has the largest reservoir system in North America. At normal water levels, this system stores approximately 55 times the amount of water stored in Truman Reservoir. With its channelization, major reservoirs, and systems of levees, it is also one of the most altered rivers in the world. More than half of Missourians get their drinking water from the river or its underground aquifer. The Missouri River watershed is actually a sub-watershed of the Mississippi. It covers 529,350 square miles, portions of 10 states, and a small part of Canada.

Watersheds in Missouri

The image below depicts the portions of the Missouri River watershed in the State's boundaries. To give a point of reference, the mouth of the Missouri River is indicated by the black dot on the map, and the sampling location is indicated by the red dot.

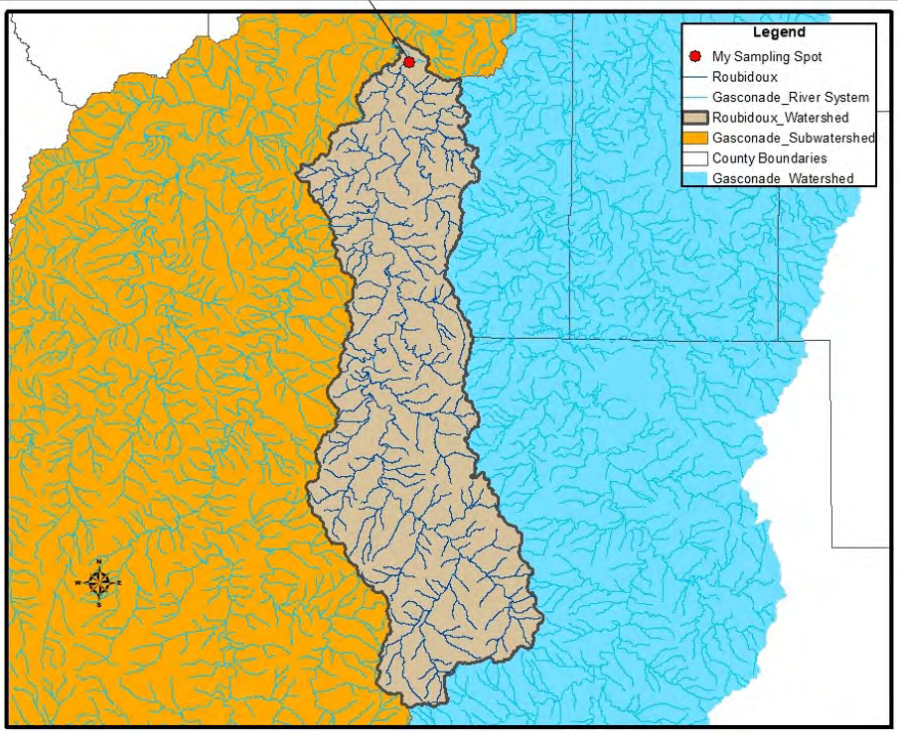
The Missouri River has many tributaries including the Gasconade, Grand, Chariton, and Osage rivers. The image below illustrates these tributaries' watersheds within the Missouri River watershed. The watershed influences from these tributaries will affect the water quality of the Missouri River.

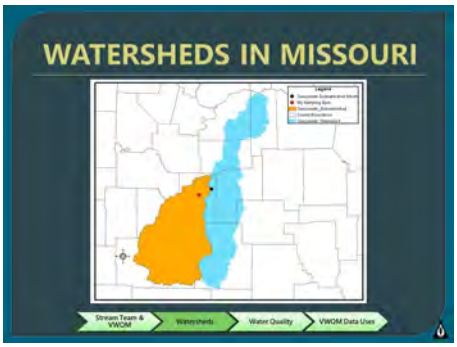


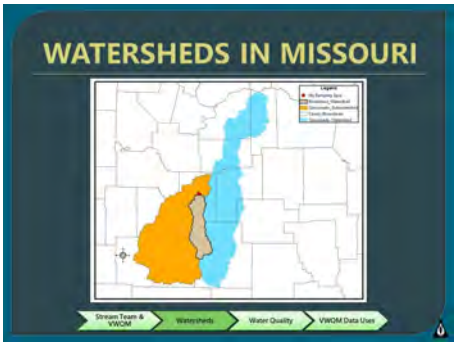
Watersheds in Missouri

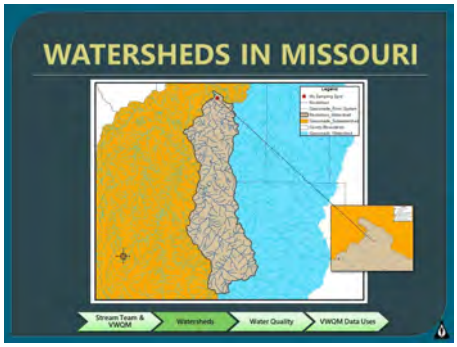
The red point indicating a sampling location is along the Roubidoux Creek in Pulaski County. The Roubidoux watershed is a subwatershed of the Gasconade River watershed. The water quality at the mouth of the Roubidoux watershed reflects the influences of its entire drainage area and show what is entering the larger watershed in the Gasconade River. When selecting a monitoring location, think of how it fits in the local watershed.

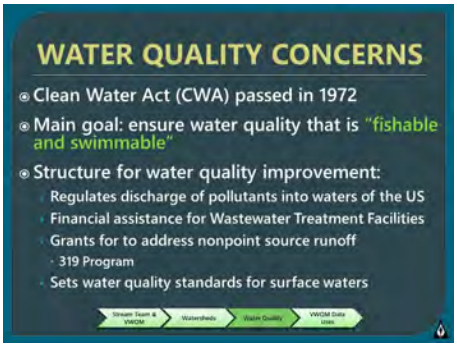
Conditions of watersheds directly affect the quality of water resources where we live, work, and play. If we are able to keep our watersheds healthy, it's likely the streams within those watersheds will remain healthy as well. It is important to protect local waterbodies for a healthy regional watershed and to help with national or even global water quality concerns.





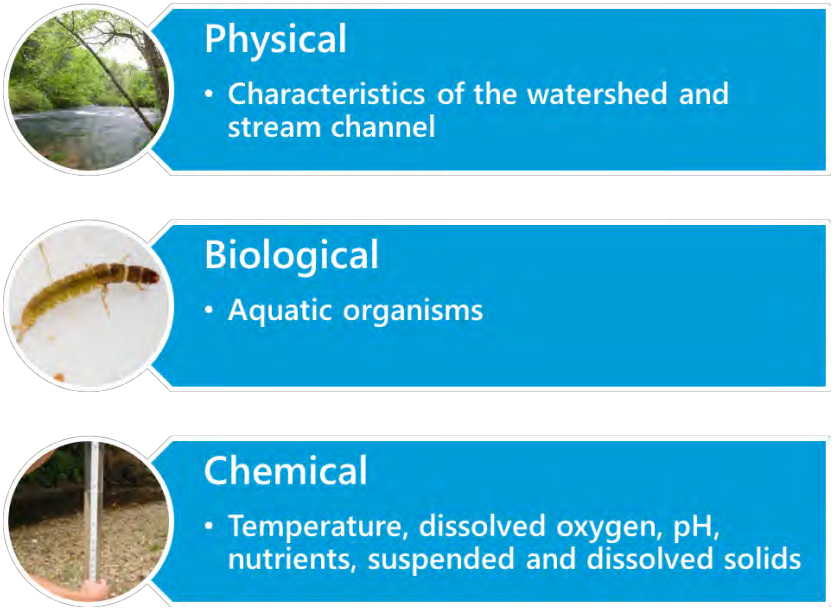






What is Water Quality?

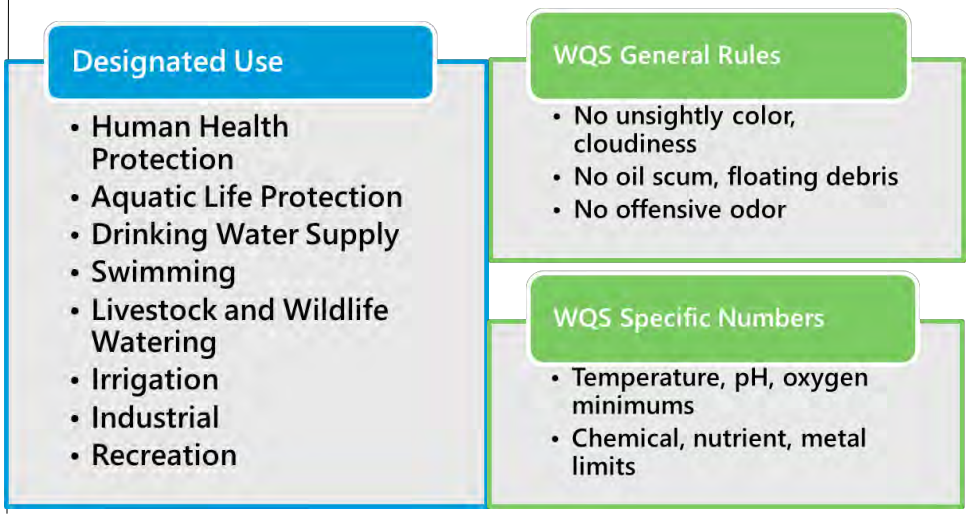
The quality of Missouri's water resources is reflected in the physical, chemical, and biological characteristics of our rivers and streams. Today's training will introduce you to the physical and biological components of a stream. Chemical characteristics will be covered in the VWQM Level 1 training.



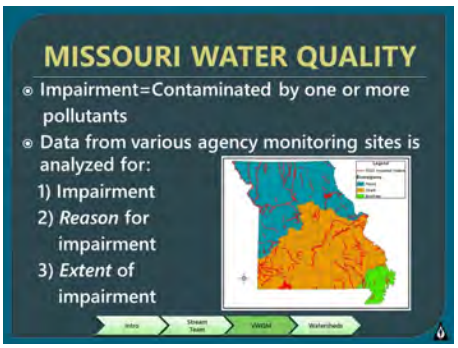
Clean Water Act Goals in Missouri

The primary goal of the Clean Water Act is to ensure water quality that is fishable and swimmable. This means aquatic life can thrive, fish from waters can be consumed without harming human health, and people can swim without negative affects.

All waters in Missouri have presumptive uses of human health protection, swimming, and aquatic life protection. Water quality standards are established to protect waters for their designated uses. These standards provide protection with narrative and numeric criteria.



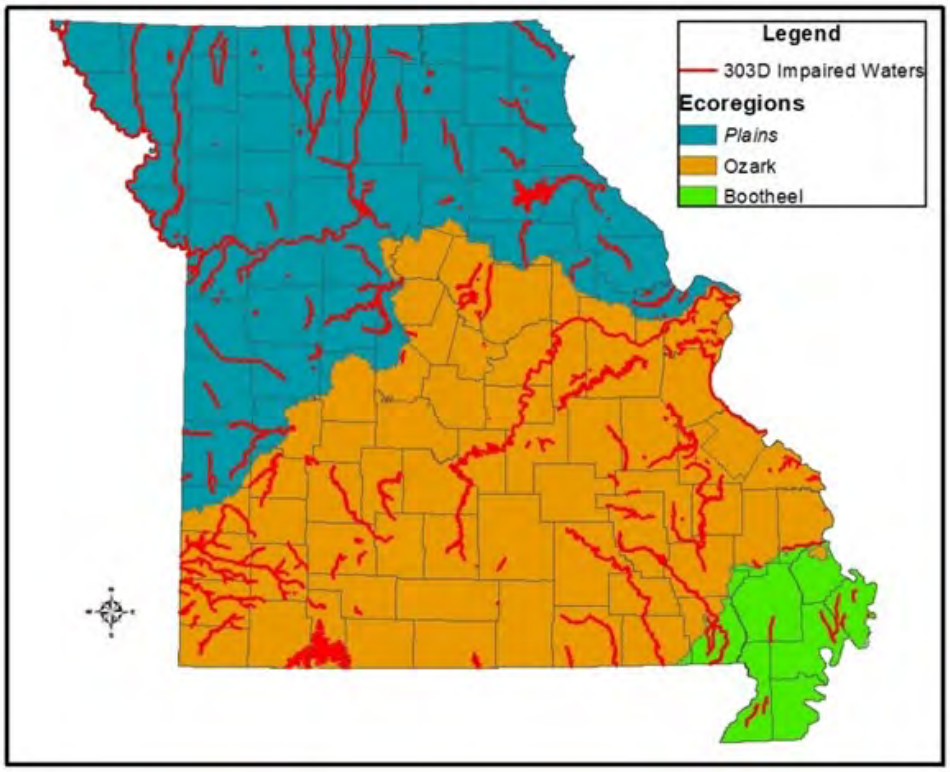
Missouri Water Quality



Here is another way to look at water quality in Missouri. The red on this map outlines the streams, rivers, and lakes listed as impaired on Missouri's 2016 303(d) Impaired Waters listing.

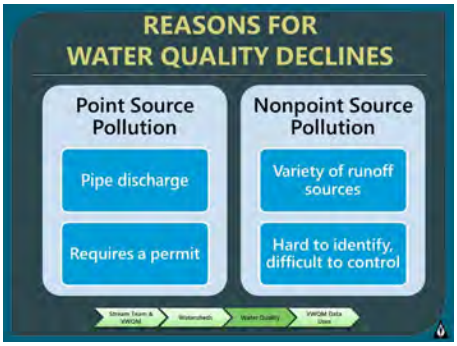
Impaired means that the waterbody is contaminated by one or more pollutants.

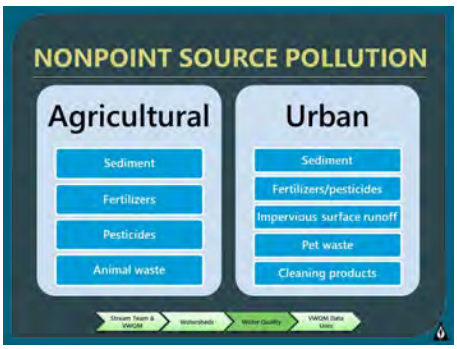
When an agency assesses water quality data for an impairment they look for 1) Is there contamination and what are the contaminants 2) the reason for the impairment and 3) the extent of the impairment.



This map illustrates the stream sections listed as impaired. Once a stream is listed as impaired, a Total Maximum Daily Load (TMDL) is developed for a watershed based plan to improve water quality. For more information on Missouri's waters you can check out the 305 (b) report which provides an overview of waterbodies in Missouri, the 303 (d) report which lists impaired waters, and TMDL's which outline watershed based improvement plans at:

https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/standards





Reasons for Water Quality Declines

The Clean Water Act mandates how our nation must manage the two major types of water quality pollution:

- ***Point Source Pollution*** is characterized by an entry point or source, such as a pipe. This type of pollution requires a permit, so it can usually be identified and regulated through the permitting process.
- ***Nonpoint Source Pollution*** refers to contaminants that do not come from specific conveyances, such as pipes or other permitted sources. It includes contaminants carried in runoff from fields, roads, parking lots, etc., as well as more specific sources such as improperly functioning septic systems. Nonpoint source pollution is much more challenging to identify and control than point source pollution.

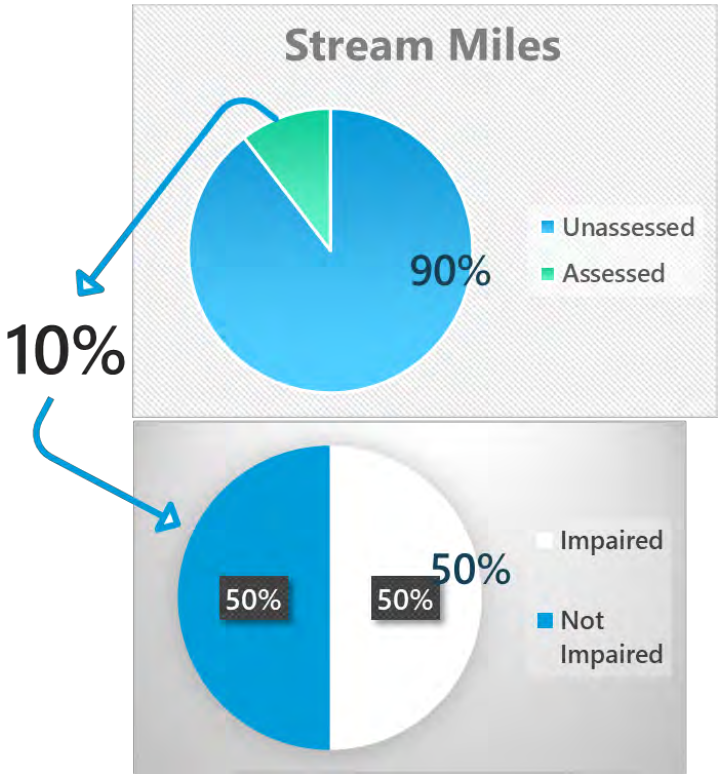
Nonpoint Source Pollution

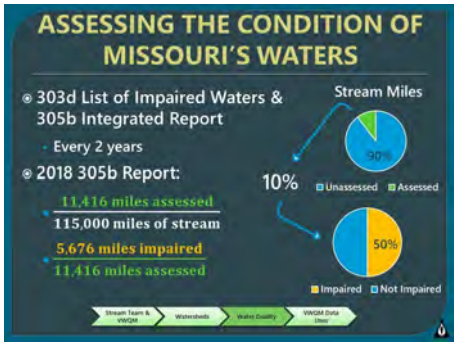
Nonpoint source pollutants come from a wide variety of land uses across a landscape and can cause water quality degradation. The following are examples of nonpoint source pollutants from two broad types of land use:

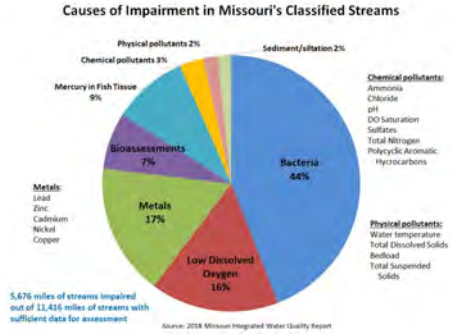
Assessing the Condition of Missouri Waters

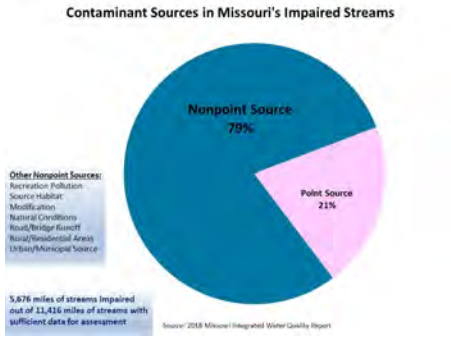
The Clean Water Act requires states to assess their waters every two years and report findings to the Environmental Protection Agency (EPA) in the form of the 305(b) Integrated Report that describes the overall status of the state's waters and includes the 303(d) list of impaired waters.

The 303(d) list is developed by using available data collected using EPA approved methods to assess the state's waters against specific Water Quality Standards (WQS). Only about 10% of streams in Missouri have enough data to be eligible for assessment. VWQM data is not used for the 305 (b) report, but can be used for screening data for agency staff to follow-up on.









Causes of Impairment in Missouri's Streams

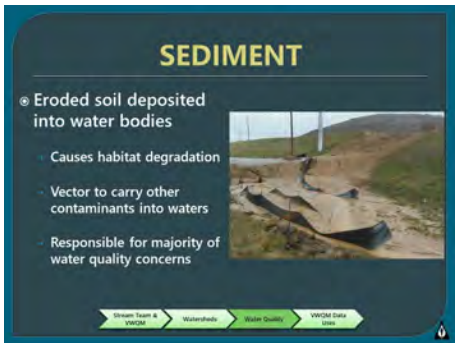
Impaired streams on the 303(d) list are unable to meet the Water Quality Standards for their designated uses. Rather than an entire stream being impaired, only segments of a stream that are non-supporting of its designated use is considered impaired.

Top causes of impairment in Missouri's classified steams are bacteria, low dissolved oxygen, and metals. Contaminants originate from numerous sources. More than three-quarters of contaminant sources are nonpoint source. This means that its caused by stormwater runoff and a discrete source is difficult to identify — and harder to address.

More information on Missouri's impaired waters and Water Quality Standards can be found on Missouri Department of Natural Resources website.

Water Quality Improvements

Once a stream is listed as impaired, a total maximum daily load (TMDL) is written to provide a framework for identifying and improving impaired waters. TMDLs will include allocations of the acceptable load for all sources of the pollutant. It will also include an implementation plan to identify how the load will be reduced to a level that will protect water quality.

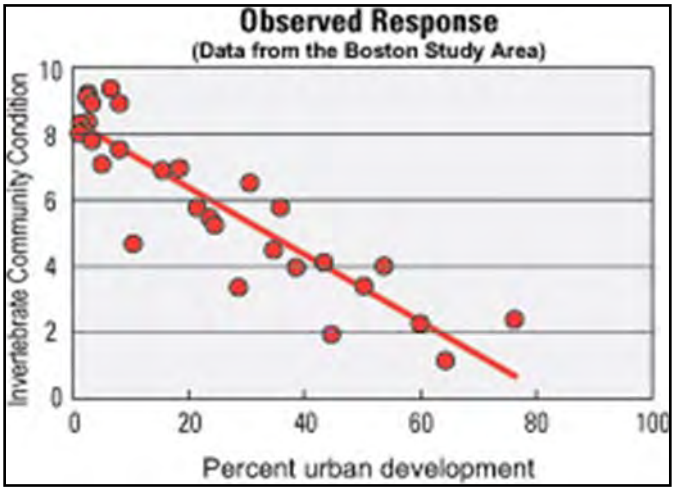


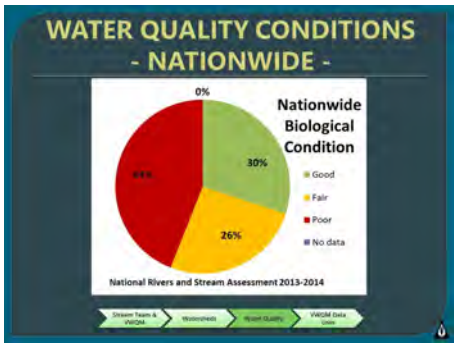
Sediment

Sediment is eroded soil that is deposited into water bodies. Sediment enters water bodies from improperly managed crop, forest lands and construction sites, and eroding streambanks. But sediment has a significant role in a majority of water quality impairments because it acts as a vector to carry other contaminants into receiving water bodies – including pesticides, fertilizer, bacteria, and others. This shows that even though pollutants and stressors are listed separately on the impaired waters list, in reality, water quality suffers from the combined effects of several pollutants and processes.

Urban Development

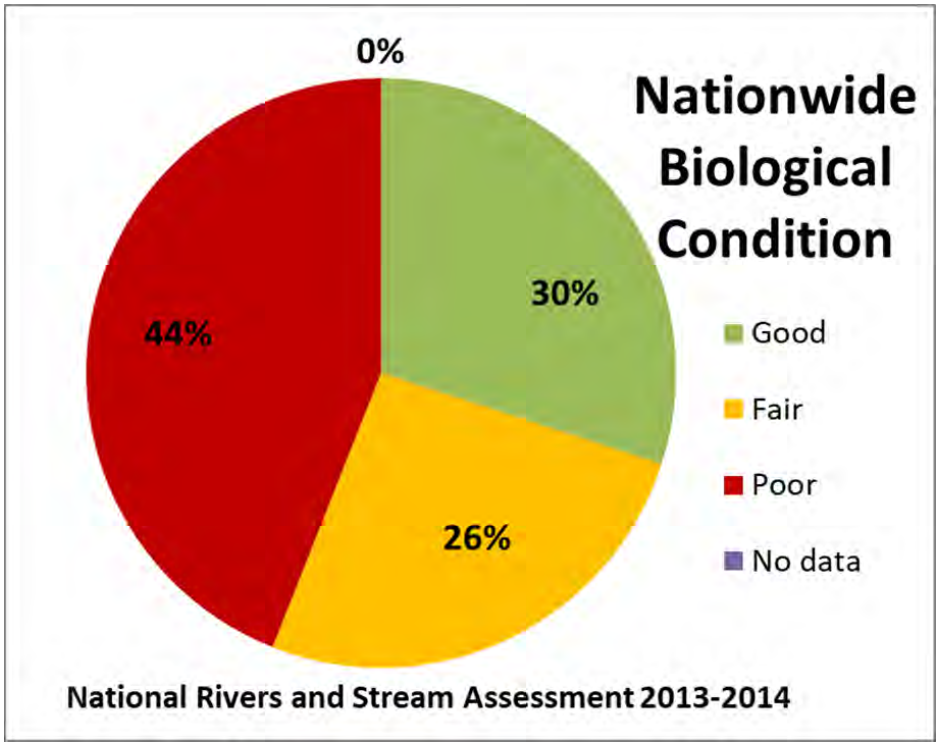
A United States Geological Survey (USGS) study assessed the physical, chemical, and biological responses of stream systems to a gradient of increasing urban intensity. Results showed benthic macroinvertebrate communities experienced degradation as soon as land cover was disturbed. By the time a watershed reaches 10% impervious cover in urban areas, aquatic invertebrate communities degrade by as much as 33% compared to those in forested watersheds.

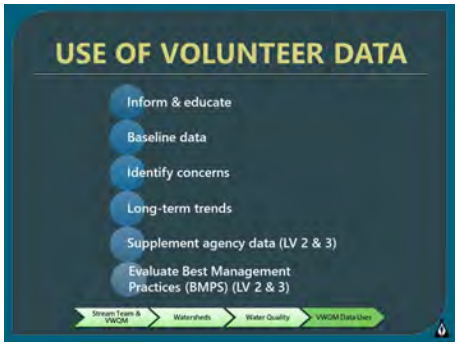




Water Quality Conditions Nationwide

A National Rivers and Streams Assessment found that 44% of rivers and streams nationwide were in poor biological condition. This data suggests there is room for water quality improvement in the United States.





Uses of Volunteer Data

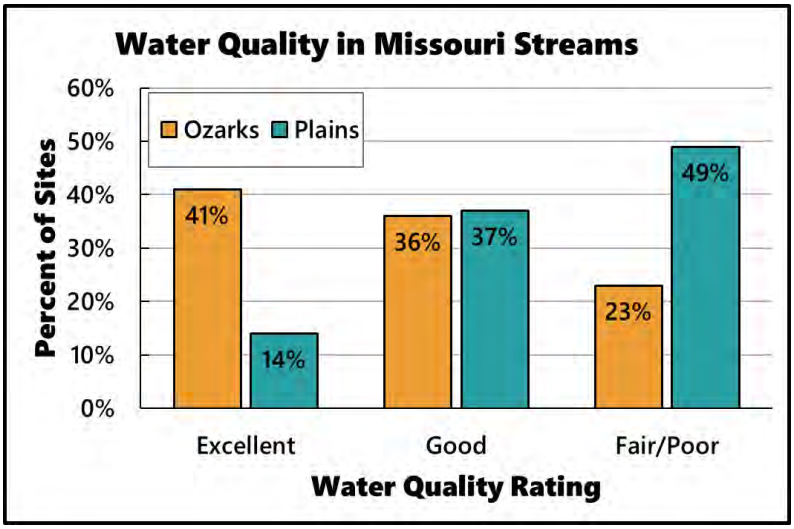
Volunteer data has several uses:

- Inform & educate
- Baseline data
- Identify concerns
- Long-term trends
- Supplement agency data (LV 2 & 3)
- Evaluate Best Management Practices (BMPS) (LV 2 & 3)

VWQM Summary of Data

Missouri is divided into 3 broad ecoregions: the Plains region in the north, the Ozarks in the south, and the Mississippi Alluvial Basin in the bootheel. These ecoregions are determined based on topography, soils, geology, and many other factors.

Stream Teams United compiled a summary report of VWQM data from 1993-2016. The graph of volunteer data below illustrates that there are some differences in water quality in the different ecoregions of Missouri. There was not enough data from the Mississippi Alluvial Basin to be included in this graph. The rankings of excellent, good, and fair/poor water quality are based off of the VWQM biological ranking system.

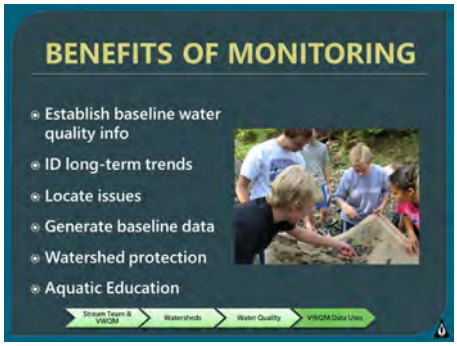


Missouri Stream Team VWQM Summary of Data: 1993-2016

VWQM data shows that the water quality for the majority of streams in the Ozark region have excellent to good biological water quality rating and majority of the streams in the Plains region have fair/poor and good ratings. The differences in ratings for these ecoregions are in part due to natural resources as well as anthropogenic, or human-made, alterations.

VWQM Summary of Data

VWQM data shows that the water quality for the majority of streams in the Ozark region have excellent to good biological water quality rating and majority of the streams in the Plains region have fair/poor and good ratings. The differences in ratings for these ecoregions are in part due to natural resources as well as anthropogenic, or human-made, alterations.



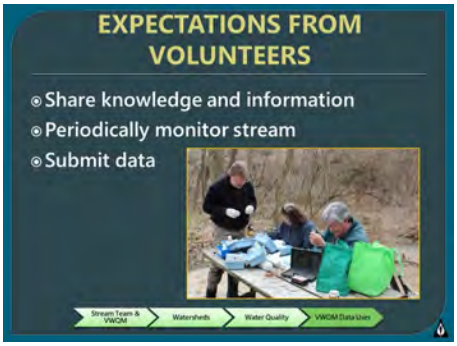
Benefits of Monitoring

There are several benefits to monitoring the water quality of our streams:

- ***Establish Baseline Water Quality Information:*** Missouri has nearly 110,000 miles of classified streams. Many of these streams have little or no information about water quality. If a pollution event should occur, a baseline of information serves as a comparison to what conditions were like before the incident.
- ***Identify Long-Term Trends:*** Submitting consistent data over a span of many years reveals if the stream conditions are improving, declining, or staying the same.
- ***Locate Issues:*** With over 9,000 trained volunteers, there are numerous examples of volunteers who discover pollution events and alert the appropriate authorities.
- ***Watershed Protection:*** Monitoring your stream gives you a richer understanding and appreciation of our waterways. This allows for better decision making regarding the protection of your local watershed.

Data Uses

- VWQM data can be used by monitors to educate themselves and their community, and advocate for improvements in their local watershed.
- All VWQM data is used by DNR and MDC to establish baseline information about streams in the state, screen for and locate any potential problems, and educate the public about water quality. Data collected for at least 5 years can be used to begin to identify long -term water quality trends.
- Higher levels of VWQM data can be used to help prepare two reports that the DNR submits to the Environmental Protection Agency (EPA) every two years: the Missouri Water Quality 305(b) Report and the 303(d) List of Impaired Waters.
- Citizen data can be used to identify projects needed in MDC priority watershed areas.



Expectations from Volunteers

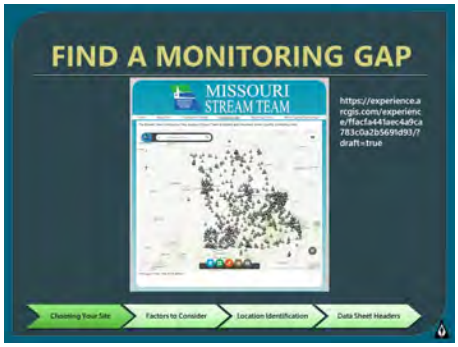
- Share knowledge about water quality with others
- Periodically monitor a stream
- Submit data

NOTES

Chapter 2
Site Selection

Before you start monitoring water quality, you must first select a site to monitor. This chapter will explore many factors for selecting an appropriate stream site to monitor. Specifically, we will discuss:

- Varying reasons for selecting a specific site
- Factors to consider when selecting a stream site
- How to identify your site on data submissions
- How to acquire your biological monitoring equipment

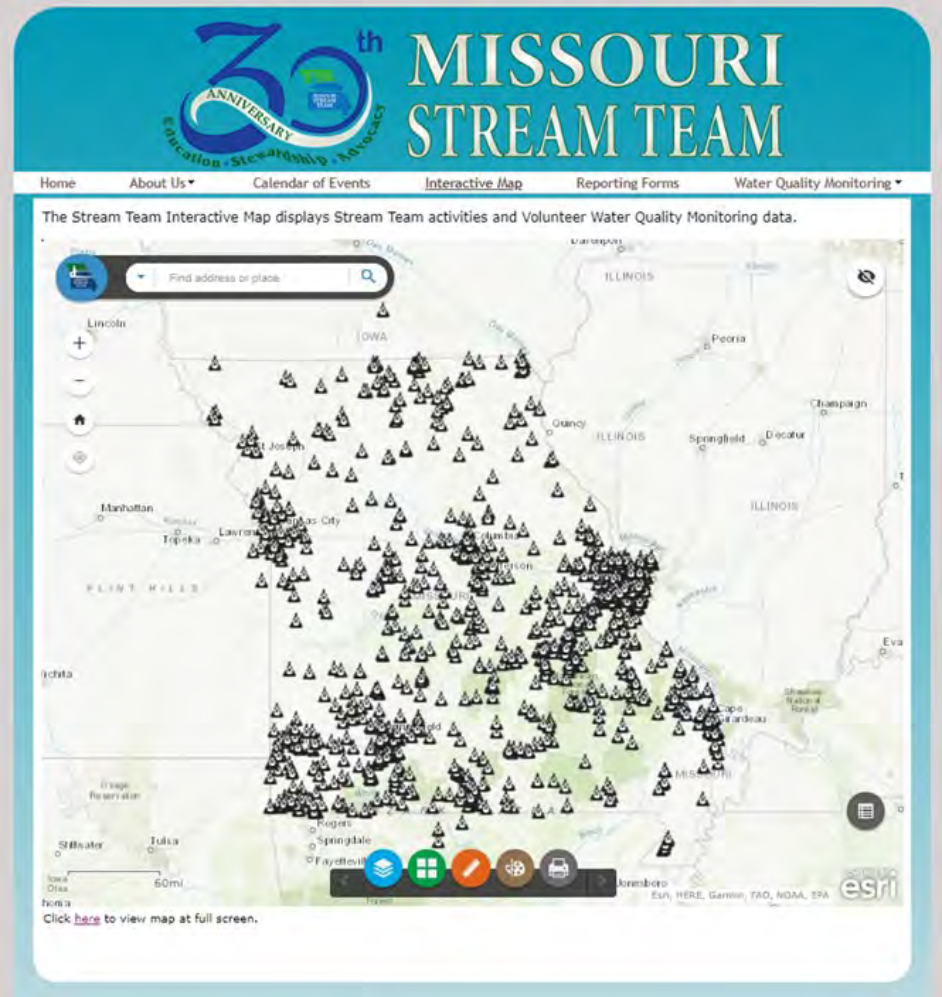


Choosing a Stream Site to Monitor

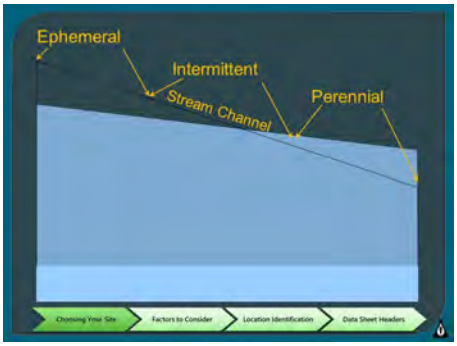
When selecting a site to monitor, choose one you are invested in or that is special to you. Monitors often choose a local stream, maybe one in their own back yard or city park. Monitors are often anglers or paddlers and select their preferred recreational stream. Other volunteers may be concerned about a heavily polluted stream or may want to fill a gap in the Stream Team's current water monitoring efforts. Whatever your reasons, we appreciate your efforts in monitoring the quality of the state's water resources.

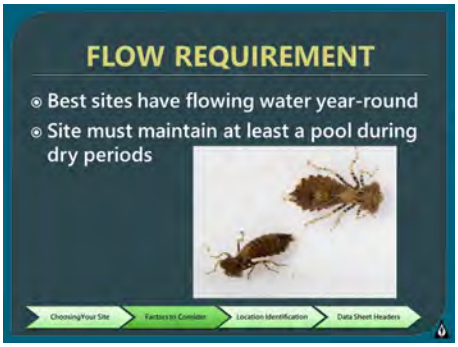
With approximately 110,000 miles of rivers and streams in Missouri, there are numerous stream sites to monitor. Do not be discouraged if the site you have in mind has already been selected by another monitor. If a site does not have data for the last 5 years it is likely abandoned and open for monitoring. You can also contact Stream Team staff to help find a monitoring site. To help you locate those gaps, use the Stream Team Interactive Map at:

mostreamteam.org/interactive-map.html



Factors to Consider When Choosing a Site

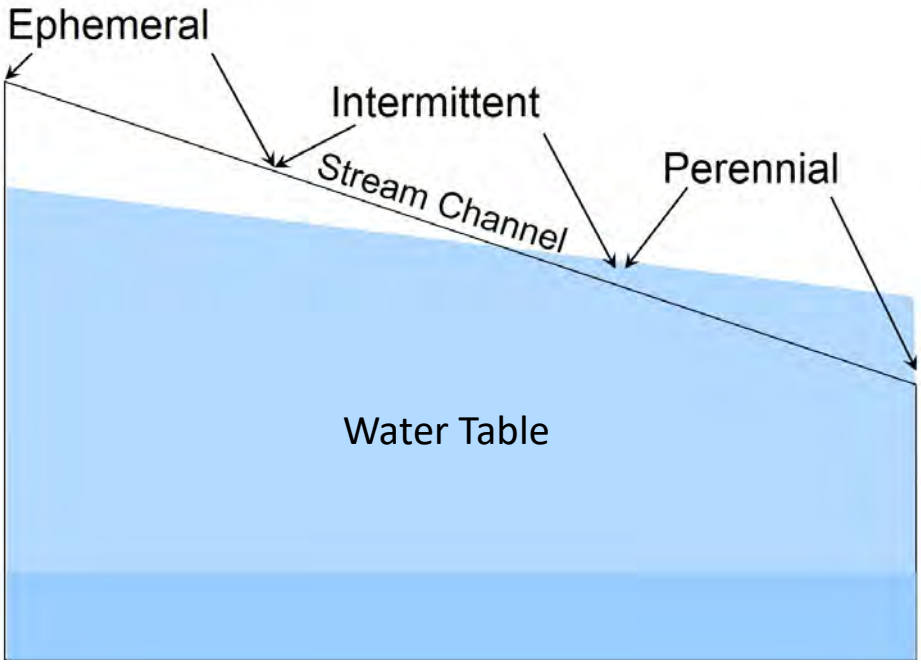




The diagram below describes three types of streams:

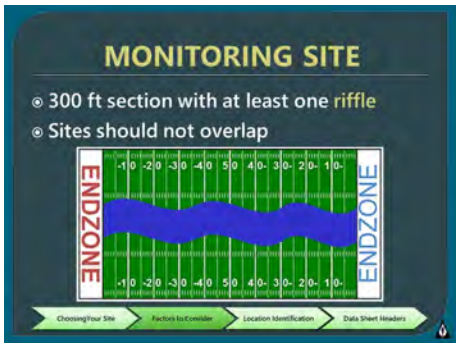
- ***Perennial Streams*** are fed continuously by a water table and will flow all year long.
- ***Ephemeral Streams*** exist above a water table. These streams only contain water after a precipitation or snow melt event. They are sometimes called wet-weather streams.
- ***Intermittent Streams*** receive groundwater flow only part of the year. The flow stops when the water table drops below the channel.

Stream Team protocol is designed for perennial streams, or streams with continuous flow.



There are some important factors to consider when selecting your site:

- ***Flow Requirement:*** The best monitoring locations have permanent water flow throughout the year. However, you can still use a stream site if it maintains pools that can support aquatic life during dry periods. This is important so that you will still be able to sample macroinvertebrates during dry periods. If a stream site completely dries up at any time of the year, it will not be a suitable monitoring location.



Factors to Consider When Choosing a Site

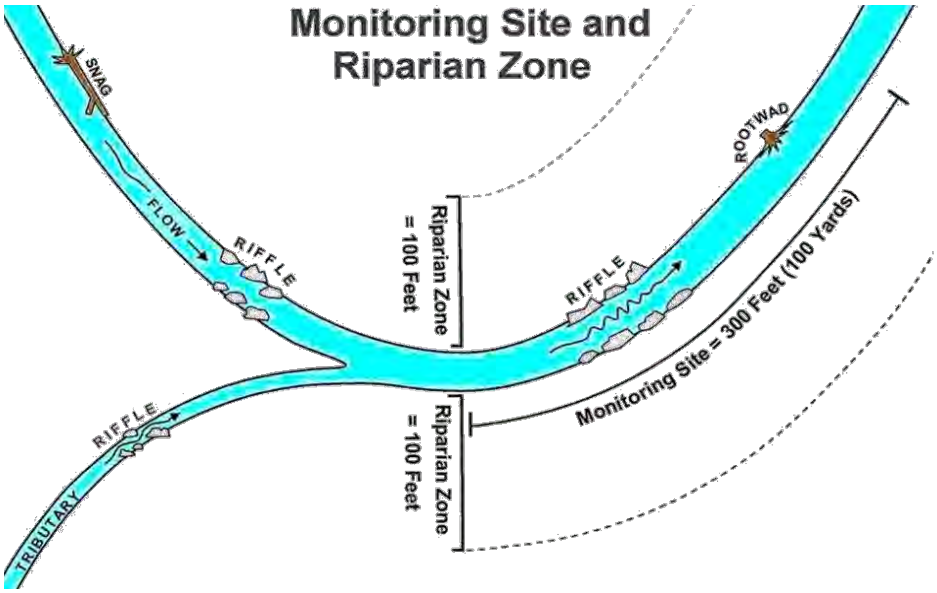
Another important factor to consider when selecting your site:

- ***300-Foot Section With at Least One Riffle:*** Your stream site should be approximately 300 feet long, about the same length as a football field, and not overlap with another stream site. If you decide to monitor two sites on the same stream, be sure the two sites do not overlap. Additionally, your proposed site should include at least one riffle. A riffle is where water breaks over rocks, indicating an elevation drop in the stream bed. Riffles provide an excellent environment when monitoring for macroinvertebrates.

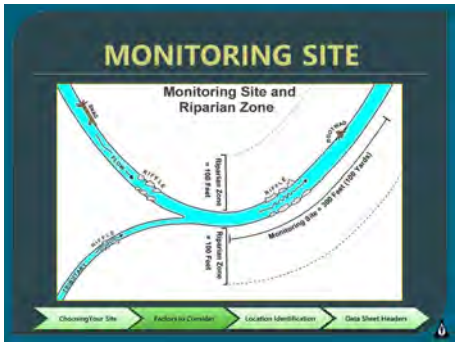
Factors to Consider When Choosing a Site

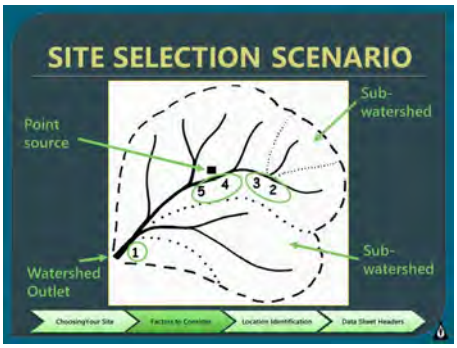
Other factors to consider when selecting your site include:

- ***Goals:*** Choose a site that best reflects your personal goals for monitoring a stream.
- ***Habitat:*** Choose a site that has suitable habitat. The best sites contain riffles. If riffles are not found, you may consider looking for alternative habitats such as a root mat or woody debris.
- ***Point and Nonpoint Sources:*** If you are concerned about a point or nonpoint source of pollution, you may consider choosing two sites. One above and one below a potential pollution source. The upstream site can be used as a reference to compare downstream data.
- ***Tributaries:*** To determine the impact of a single tributary, select sites above and/or below the confluence of the tributary. For example, consider the diagram of a proposed site below. The site sits downstream from a tributary and contains a riffle and a root wad. When monitoring your site, always use the same 300-foot stretch. By doing so, your efforts will produce reliable data.



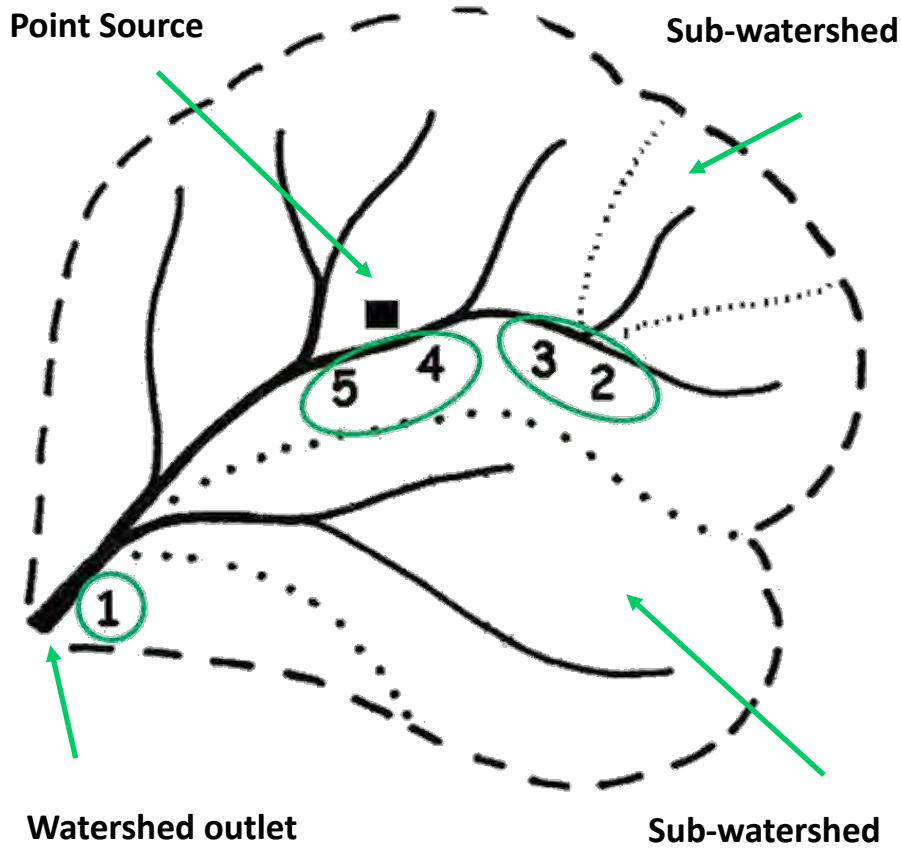
- ***Site Accessibility:*** You cannot monitor a site you cannot access. Whether your site is on private or public land, you will need to seek permission to access the stream. Use the ***Streamside Property Owner Permission Request*** (found on the stream team website at mostreamteam.org) to let a private landowner know who you are, what you are doing, and to gain permission to be on their property. To gain permission to monitor along public land, contact the area manager. Stream Team staff can facilitate communication with public land managers.





Site Selection Scenario

Consider the diagram of a watershed and the proposed sites below where the black square indicates a point source for pollution. Then, complete the table by describing the rationale for choosing each proposed site.



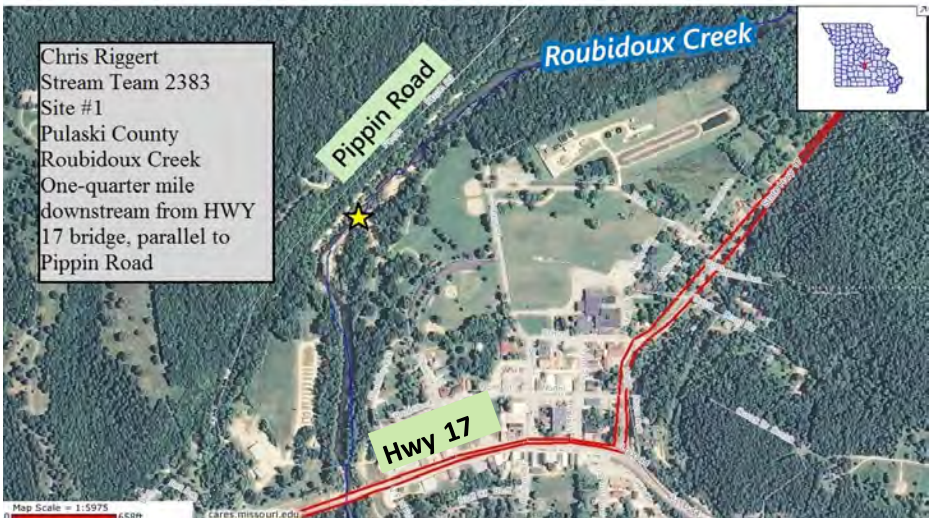
Proposed Monitoring	Rationale for Monitoring Proposed Site
Site 1	
Sites 2 & 3	
Sites 4 & 5	

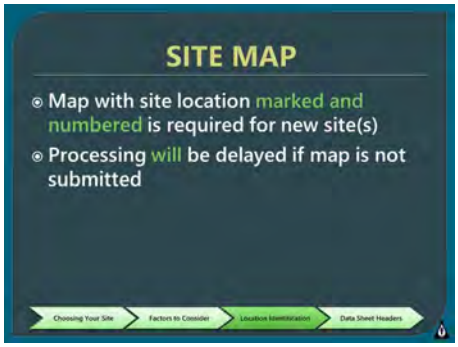
Site Number and Description

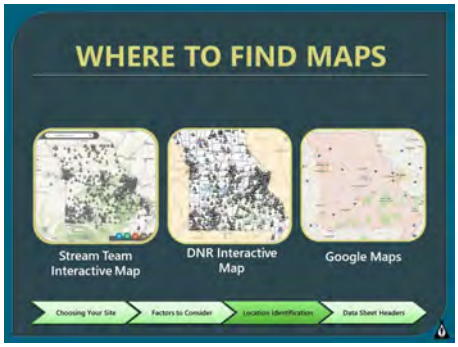
Once you have chosen an appropriate site to monitor, you will need to refer to the site each time you submit data:

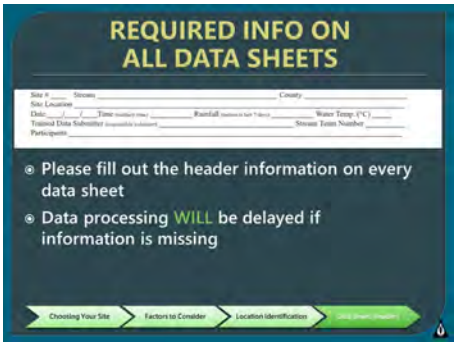
- ***Site Numbers*** are specific to each volunteer monitor. Even though the same site can be monitored by two different volunteers, each volunteer will have an independent number identifying it. For each volunteer monitor, these sites are numbered chronologically starting at Site #1. Everyone's first site will be Site #1. If you decide to monitor an additional site or abandon your first site for another, the next site will be Site #2.
- ***Site Descriptions*** enable Stream Team staff to locate your site on a map. It is important to be consistent with your site description each time you submit data. When describing your site, use the distance upstream or downstream from roadway crossings, distance and direction from major intersections, or distance and direction from permanent landmarks. For example, *300 feet downstream from Highway AA.* Avoid using physical features such as trees or buildings as these are not on maps and can change.
- **Site Map:** For each new site you monitor, you must submit a map with the monitoring site clearly marked and labeled along with your data for the new site. There are many online mapping tools to aid you:
    - Stream Team Interactive Map can be accessed at ***mostreamteam.org***
    - Department of Natural Resources Interactive Map can be found at ***dnr.mo.gov***
    - Google maps can be found at ***maps.google.com***

Below is an example of a map from the Stream Team website with the volunteer's site marked on it. The required information listed on the map will ensure program staff are able to locate your site.









Header Information

All data sheets contain a header, which need to be filled out in its entirety or else data submission will be delayed. The header consists of the following required sections:

- ***Site #:*** The site number is specific to the trained data submitter. Every monitor's first monitoring site is Site #1. Additional sites monitored are numbered chronologically.
- ***Stream:*** State the name of the stream you are monitoring.
- ***County:*** This is the county your stream monitoring site falls within. Some streams cross county boundaries, so reference a map for the exact county of your site.
- ***Site Location:*** Provide a physical description of the monitoring site which will allow staff to find the site on a map.
- ***Date & Time:*** Date is required in month-day-year format. Time is required in military time. For example, 2 PM in military time is 1400 hours.
- ***Rainfall:*** Provide amount of rainfall (in inches) for the 7 days preceding the monitoring date. This information can be measured with a rain gauge near the monitoring site or found online at:

  wunderground.com

  weather.com

  noaa.gov
- ***Water Temperature:*** Record water temperature in degrees Celsius. Always take temperature measurements in the shade. Temperature is not required on the *Initial Site Selection Form* since thermometers are not issued to monitors until this form is submitted.
- ***Trained Data Submitter:*** This is the name of the person responsible for the data who has completed the appropriate level of training. Only the trained data submitter may fill out the data sheets.
- ***Participants:*** List the names of anyone who assisted in collecting the data. These individuals may be trained or untrained.
- ***Stream Team Number:*** State the Stream Team of the trained data submitter.

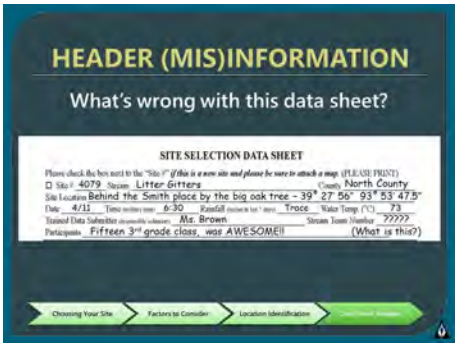
Header Information Scenario

Consider the header information on this data sheet below. Identify 11 inaccuracies of the submitted data.

INITIAL SITE SELECTION FORM

Submit this form with a map and Stream Discharge data sheet to receive biological monitoring equipment.
To establish subsequent monitoring sites, submit a map only.

Site # ~~1~~ 4079 Stream Litter Gitters County North County
Site Location Behind the Smith place by the big oak tree 39° 27' 56" 93° 53' 47.5"
Date 4 /11/ Time (military time) 6:30 Rainfall (inches in last 7 days) trace Water Temp. (°C) 73
Trained Data Submitter (responsible volunteer) Ms. Brown Stream Team Number ?????
Participants Fifteen 3rd grade class, was AWESOME!! (What is this?)



1.

2.

3.

4.

5.

6.

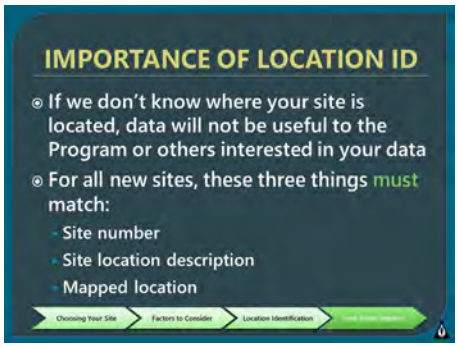
7.

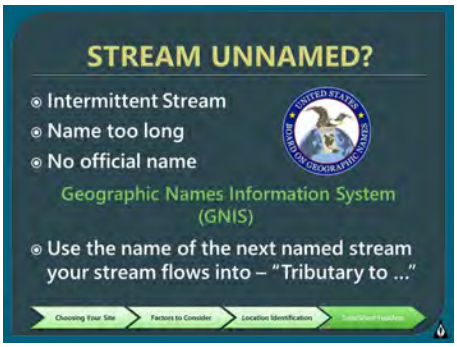
8.

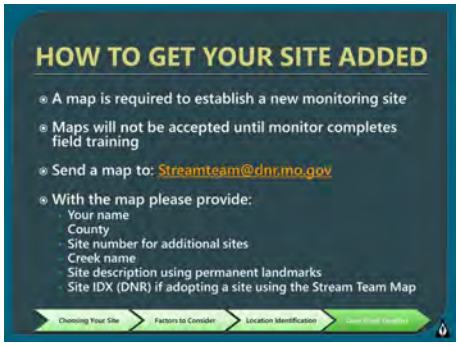
9.

10.

11.







Required Information on All Data Sheets

Each time you submit any data sheet, be sure to include the following required information. Data processing will be delayed if any information is missing from the data sheet header:

- Stream Name
- Site Number
- Verbal Site Description
- Date Monitored
- Name of Trained Data Submitter
- Stream Team number

Unnamed Streams

The sampling protocol for Missouri Stream Team is designed for perennial streams that have permanent flow throughout the year, but it is possible your stream may not have an official name. In this case, your stream is a tributary to the nearest named stream into which it flows. Most intermittent streams are not officially named on a map, even though it may be known to a local community by a certain name. If this is the case, you may want to research your proposed site online with:

Geological Names Information System (GNIS)
geonames.usgs.gov/domestic/index.html

Importance of Location Identification

It is extremely important to the validity of the data you collect that the location of your site is accurately identified. If your site cannot be located, data will not be useful to the program or other interested parties. All new sites must accurately match their site number, site description, and mapped location. Remember to always submit a map with each new site you adopt.

How to Get Your Site Added

To enter data, you must first send a map to Stream Team staff.

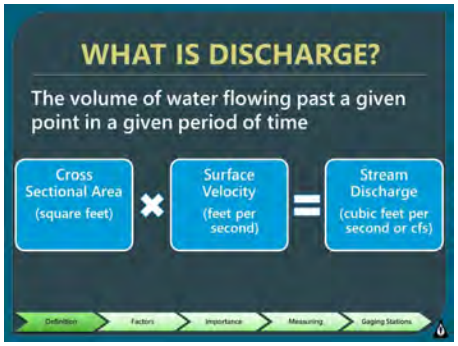
A map with your monitoring site clearly marked can be sent to StreamTeam@dnr.mo.gov with the following information:

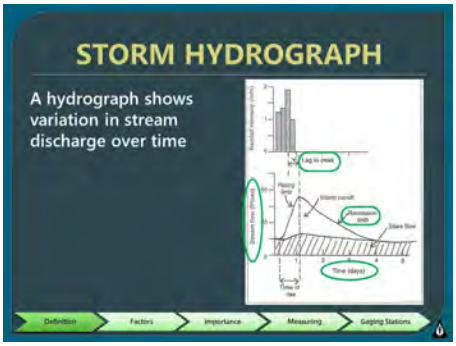
- Monitor's name
- Monitor's site number
- Stream name
- Stream county
- Verbal site description
- Site IDX number from Stream Team interactive map may be used if adopting an existing site

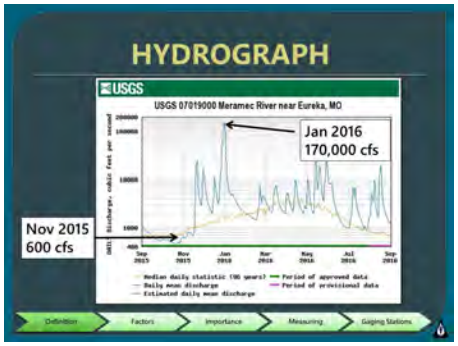
Chapter 3
Stream Discharge

Once a site has been determined, the next step in monitoring is to determine the volume and velocity of water flowing in your stream. This is called stream discharge. In this chapter, you will:

- Define stream discharge
- Understand the factors affecting discharge
- Understand the importance of discharge
- Measure stream discharge
- Know how to use United States Geological Survey (USGS) Gage Stations







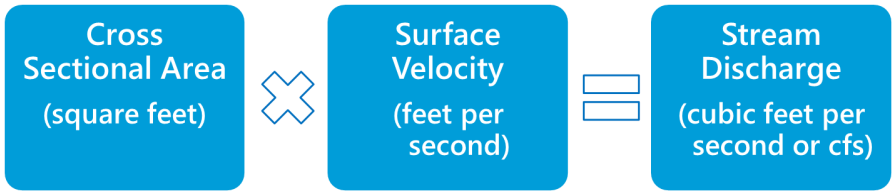
What is Stream Discharge?

Stream discharge is also referred to as flow. It measures the volume of water flowing past a given point in a given period of time. Stream discharge is expressed as a rate with two components:

- Volume of water, expressed in cubic feet.
- Time, expressed in seconds.

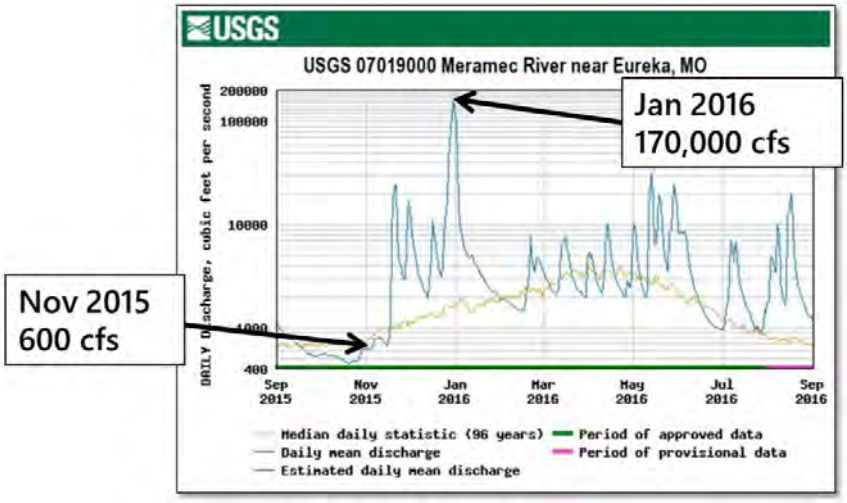
For example, one cfs refers to one cubic foot of water flowing past a given point every second.

Although it sounds difficult, calculating stream discharge is easy. The mathematical formula can be articulated as the cross-sectional area of a stream multiplied by the surface velocity of the water.

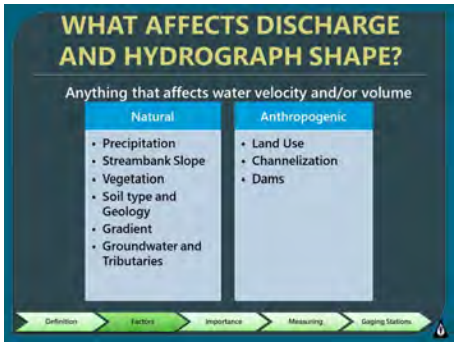


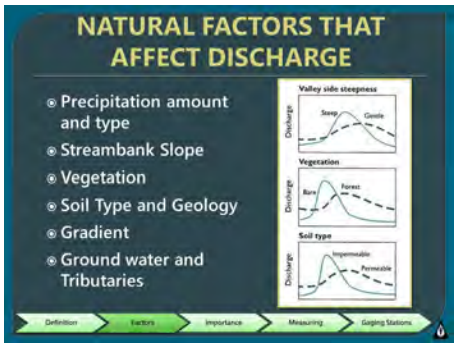
Hydrographs

A stream's discharge changes over time. When stream discharge measurements are collected over time, they can be used to create a hydrograph. In the example below, time is represented on the X axis of the graph. The discharge is represented on the Y axis and is measured in cubic feet per second (cfs). This hydrograph shows the variation in discharges for different seasons of the year for the Meramec River near Eureka, MO. As you can see, the daily mean discharge in November of 2015 was 600 cfs, while the discharge in January was much higher at 170,000 cfs.



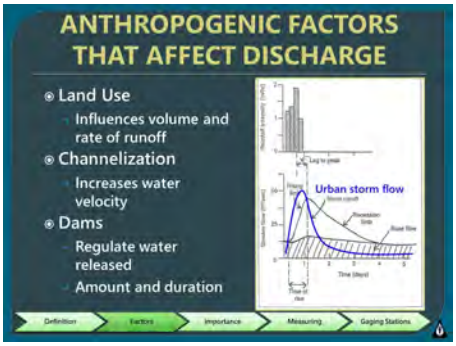
Natural Factors Affecting Stream Discharge





There are many natural factors that can affect the stream discharge:

- ***Precipitation:*** The type and amount of precipitation determines how much water is introduced into the system and how quickly it is released over time. A downpour of rain will introduce a lot of water flowing into the system very quickly, whereas snow or ice will release the moisture more slowly into the system.
- ***Streambank Slope:*** If the streambanks are steep, water will be confined to a smaller stream channel and will travel faster through the channel, resulting in an increased stream discharge after a storm event. With gently sloping streambanks, the influx of water after a storm event has more room to spread out. This slows the stream's discharge.
- ***Vegetation:*** Vegetation absorbs water and releases it to the atmosphere through evapotranspiration. It increases the water storage capacity of soil, making it like a sponge. This allows the soil to store water during dry periods and will increase your flow. Vegetation also adds surface roughness to the stream channel, streambanks, and flood plain, which will slow down the stream discharge. Removing vegetation from the land or replacing it with concrete removes that surface roughness and the absorption of water into the soil, allowing a dramatic increase in discharge in a short period of time.
- ***Soil Type:*** Permeable soils, such as gravel and sand, allow greater absorption of water into the ground, regulating increased stream discharges and smoothing out the shape of a hydrograph. Impermeable soils, such as clay or bedrock, do not allow for absorption and act more like concrete, increasing stream discharge.
- ***Channel gradient:*** High-gradient streams occur in steep topography, such as in areas of the Ozarks. Lower gradient streams tend to move water more slowly, while higher gradient streams move water faster.
- ***Other Factors:*** Groundwater, springs, adjacent wetlands, and tributaries contribute to portions of the total flow of a stream and can be crucial during dry times.



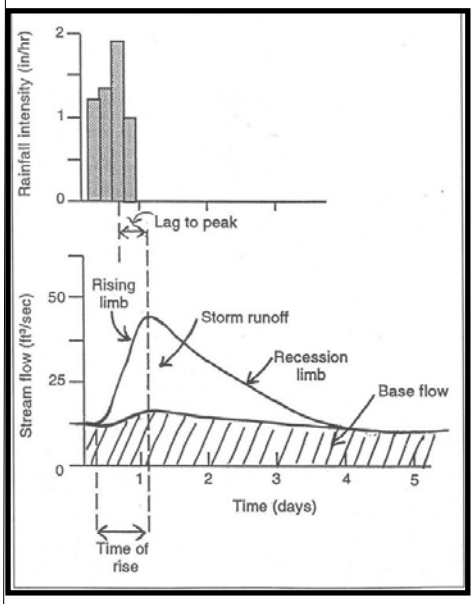
Anthropogenic Factors Affecting Stream Discharge

Anthropogenic or man-made factors affect stream discharge. Land use, channelization, and dams can have a tremendous effect on water velocity and volume.

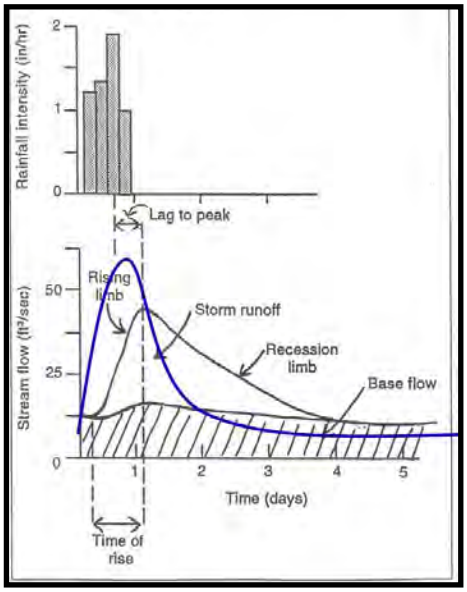
For example, compare the two graphs below. The first one represents the normal storm flow for a stream in a natural, well-vegetated landscape, as it responds to a precipitation event.

However, in an urban setting, vegetation is usually converted to streets, parking lots, and concrete. The second graph shows a blue line, which represents how an urban stream typically responds to a storm event. This type of stream is referred to as "flashy" because water enters and exits the stream much faster than streams in more vegetated areas.

Normal Storm Flow

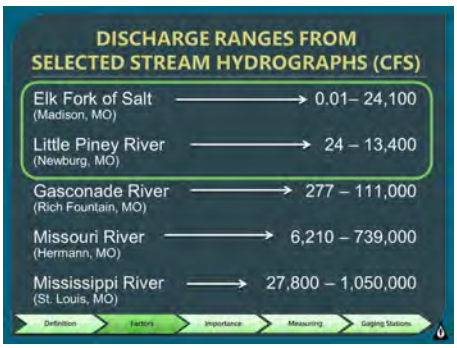


Urban Storm Flow



- ***Land Use:*** When vegetated areas and wetlands are converted to bare soil or impervious surfaces, the volume and rate of runoff and stream discharge dramatically increases during storm events. This leads to flashy streams.
- ***Channelization:*** The straightening of a stream channel and removal of woody debris results in increased water velocity and erosional force.
- ***Dams:*** These man-made (or beaver made) structures change the flow of water by slowing or detaining it. The release of water can fluctuate, dramatically altering the physical and chemical conditions both upstream and downstream of a dam.

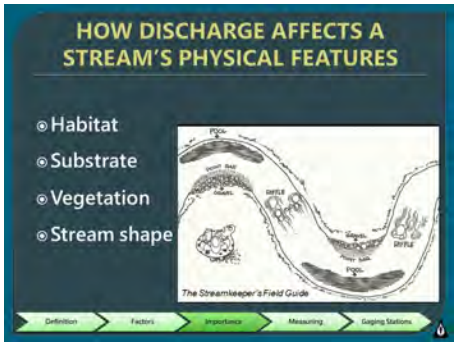
Stream Discharge Ranges of Missouri's Streams

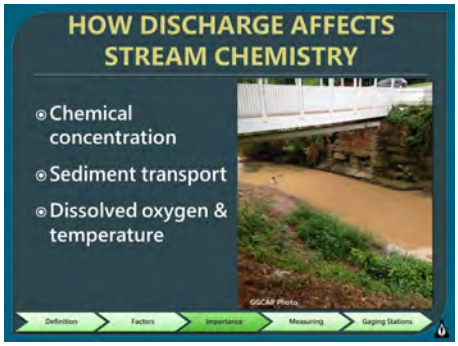


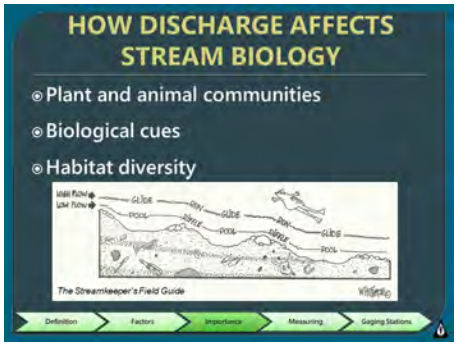
The table below describes the ranges of discharge of a few selected Missouri streams:

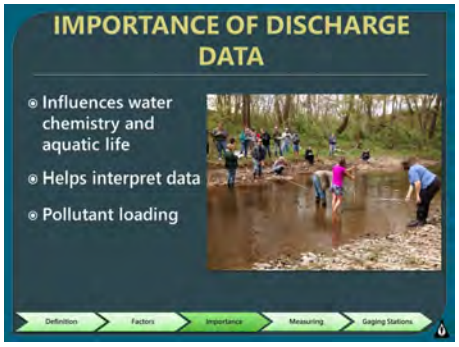
Stream	Range of Discharge (cfs)
Elk Fork of Salt River *Madison, MO*	0.01—24,100
Little Piney River *Newburg, MO*	24—13,400
Gasconade River *Rich Fountain, MO*	277—111,000
Missouri River *Herman, MO*	6,210—739,000
Mississippi River *St. Louis, MO*	27,800—1,050,000

Notice how stream flow varies ***between*** streams and ***within*** them. The differences in discharge between these streams are mainly due to stream and watershed size. The range of flow within each stream can vary due to seasonality. Compare the Elk Fork of the Salt River with the Little Piney River. Both of these watersheds are approximately the same size but have very different flow ranges. The Elk Fork in Northern Missouri receives no groundwater recharge. Additionally, the land use around it is mostly agricultural, so runoff from cleared, non-forested land is higher and contributes to a higher stream discharge. The Little Piney is situated in a karst area and receives groundwater recharge from natural springs. The maximum discharge is lower in the Little Piney because it is located in a heavily forested watershed. This reduces overland flow to the river.









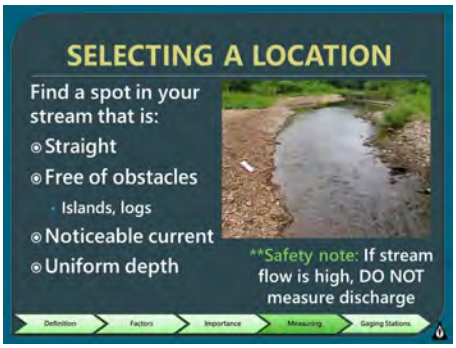
Stream Discharge and Stream Quality

Stream discharge has a large effect on the physical, chemical, and biological characteristics of a stream:

- ***Physical Features:*** The flow of water and other material changes the shape of the stream channel, the size of substrate in the streambed, and the types of riparian vegetation that are able to grow in or near the stream. These characteristics, in turn, influence the types of habitat available for aquatic life.
- As water moves substrate in the streambed, it erodes streambanks and deposits material downstream, shaping the stream channel. Variability in a stream's discharge influences the migration of the stream channel over time.
- ***Stream Chemistry:*** Stream discharge also affects water chemistry. The flow transports sediment and debris. A large volume of fast moving water carries more sediment and larger debris than a small volume of slow moving water. High volume flows have greater erosional energy, while smaller and slower flows allow sediment to be deposited. The concentration of chemicals and sediment is also affected. Larger volumes of water will dilute chemical and sediment pollutants. Stream discharge can also affect dissolved oxygen and water temperature. Fast moving water will tumble over substrate, introduce atmospheric oxygen into the water, and raise the dissolved oxygen of the water. Smaller volumes are influenced more by temperature. Streams with smaller volumes of slow-moving water warm up faster in the sun. Hot water holds less oxygen than cold water.
- ***Stream Biology:*** Stream discharge determines the types of habitat available for aquatic plants and animals. Streams with a variety of velocities can support a more diverse aquatic community. Additionally, fish like trout and salmon and pollution-sensitive macroinvertebrates require high concentrations of dissolved oxygen, low water temperatures, and gravel substrates to lay their eggs. Fish such as carp and catfish and pollution-tolerant macroinvertebrates can survive in warmer water and softer substrates. Variations in stream discharge also provide biological cues for aquatic life to complete their life cycles, including reproduction.

Because of its effect on water quality, stream discharge is an important characteristic of any stream. It influences water chemistry and aquatic life, helps us to interpret other kinds of data collected at the stream, and can aide in determining the severity and extent of a pollutant entering a stream. For these reasons, we encourage monitors to measure stream discharge every time they visit a stream to collect data!

Preparation for Measuring Discharge



In order to calculate stream discharge for your site, you will need to gather some materials:

- A Float (Wiffle Golf Ball)*
- 100-Foot Tape Measure (10ths of a Foot)*
- 2 Sticks or Metal Stakes
- Depth Stick, Marked in 10ths of a Foot
- Stopwatch or Watch with a Second Hand
- 10-Foot Rope
- Stream Discharge Data Sheet

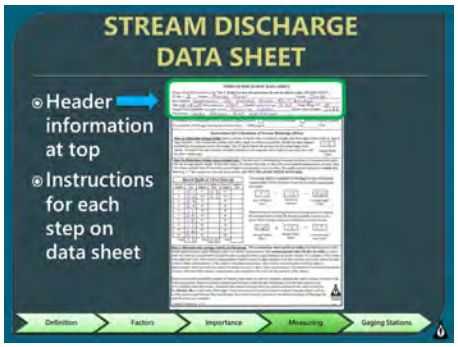
** Items Provided by Missouri Stream Team*

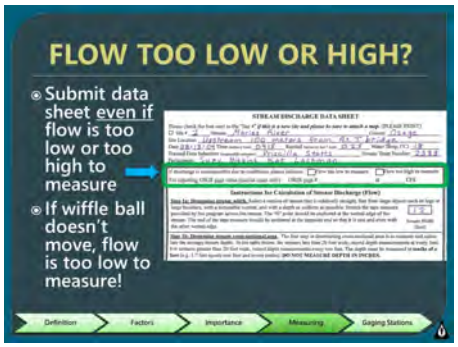
Select a safe and appropriate location within your stream site. Find a spot that is:

- Straight and free of obstacles like sandbars, large rocks or trees
- Has a noticeable current
- Has a uniform depth across the streambed, if possible

If you cannot find such a location in your 300-foot stream site, you can choose a location outside of your designated site in order to measure discharge. However, be sure there are no inputs or outputs such as tributaries or intake pipes between the site location and the discharge measurement location.

Stay safe! If the stream flow is high (over your knees), with a noticeable current, do not risk taking discharge measurements.





Stream Discharge Data Sheet

The ***Stream Discharge Data Sheet*** is a valuable tool when calculating stream discharge. Double check that you have filled out the header information accurately. Incorrect information in the header can delay processing for the data you collect. *Stream Discharge data should be collected every time you monitor your stream site*.

Instructions for calculating stream discharge can be found on this form.

STREAM DISCHARGE DATA SHEET

Please check the box next to the "Site #" ***if this is a new site and please be sure to attach a map.*** (PLEASE PRINT)

☐ Site # 2 Stream Maries River County Osage

Site Location Upstream 100 meters from Rt. T bridge

Date 08/13/04 Time (military time) 0915 Rainfall (inches in last 7 days) 0.25 Water Temp. (°C) 18

Trained Data Submitter (responsible volunteer) Priscilla Stotts Stream Team Number 2383

Participants Suzy Higgins, Kat Lackman

If discharge is unmeasurable due to conditions, please indicate: ☐ Flow too low to measure ☐ Flow too high to measure

For reporting USGS gage value (special cases only): USGS gage # _____ at _____ cfs

Instructions for Calculation of Stream Discharge (Flow)

Step 1a: Determine stream width. Select a section of stream that is relatively straight, free from large objects such as logs or large boulders, with a noticeable current, and with a depth as uniform as possible. Stretch the tape measure provided by the program across the stream. The "0" point should be anchored at the flowing edge of the stream. The end of the tape measure should be anchored at the opposite end so that it is taut and even with the other flowing edge. Do not measure nonflowing water.

12 — Stream Width (Feet)

Step 1b: Determine stream cross-sectional area. The first step in determining cross-sectional area is to measure and calculate the average stream depth. In the table below, for streams less than 20 feet wide, record depth measurements at every foot. For streams greater than 20 feet wide, record depth measurements every two feet. The depth must be measured in **tenths of a foot** (e.g. 1.7 feet equals one foot and seven tenths). **DO NOT MEASURE DEPTH IN INCHES.**

Record Depth at 1-Foot Intervals

Interval Number	Depth in Feet	Interval Number	Depth in Feet	Interval Number	Depth in Feet
1	0.1	11	0.3	21	
2	0.2	12	0.2	22	
3	0.4	13		23	
4	0.9	14		24	
5	1.1	15		25	
6	0.9	16		26	
7	1.2	17		27	
8	1.1	18		28	
9	0.6	19		29	
10	0.7	20		30	
Sum	7.2	Sum	0.5	Sum	

The average depth is calculated by dividing the sum of the depth measurements by the number of intervals at which measurments were taken.

7.7 (Sum of Depths (feet)) ÷ 12 (Number of Intervals) = 0.64 (Average Depth (feet))

The final step in calculating the cross-sectional area is multiply the average depth (in feet) by the stream width (in feet) at the point where the tape measure is stretched across the stream.

0.64 (Average Depths (feet)) x 12 (Stream Width (feet)) = 7.7 (Cross Sectional Area (feet)^2)

Step 2: Determine the average velocity for the stream. A minimum of four velocity measurements should be taken from equal intervals across the stream's width. For example, if the stream is eight feet wide, then velocity measurements should be taken at approximately every foot and a half across the stream in order to derive four measurements. For a stream width of 16 feet, velocity measurements should be taken at approximately three feet increments across the stream to derive four measurements. This method of measuring the stream velocity will ensure that velocity measurements are recorded for the slow and fast portions of the stream. For greater accuracy, more than four measurements are recommended for wider streams.

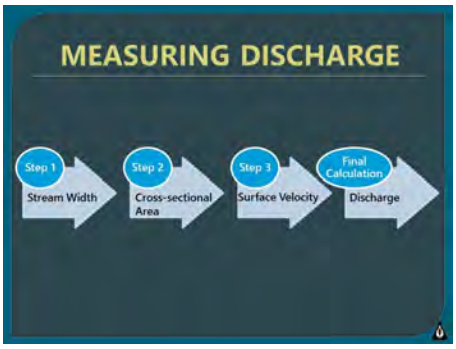
To measure the water's surface velocity, the first step is to select two points located equal distance upstream and downstream from the tape measure you have stretched across the stream. Determine the distance between these two points and record this value (in feet) in the **Distance Box** on the back of this page. A 10-foot total float distance is a recommended starting point. This distance can be lenghtened or shortened depending on stream swiftness. Count the number of seconds it takes a neutrally buoyant object (such as a wiffle practice golf ball) to float this distance. Record this time (in seconds) in the table on the back of this page for each float trial you complete.

Water Quality Volunteer

Volunteer Monitoring - 01/19 Page 1

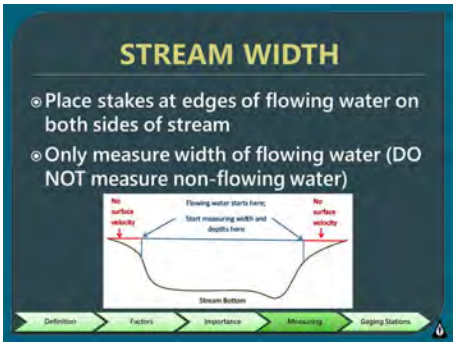
Please submit a discharge data sheet even if the flow is too high or too low to measure. Use your wiffle golf balls to determine if the flow is too low to measure (i.e. if you drop the wiffle ball and it doesn't move, it's too low.) Just check the box at the top of the form and send it in to us!

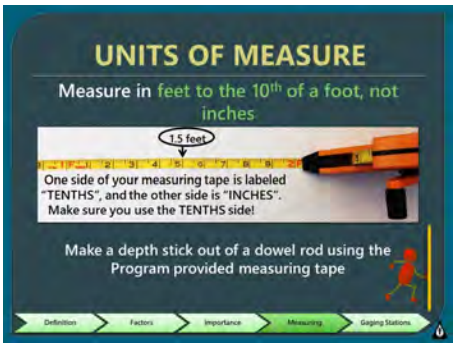
Measuring Stream Discharge

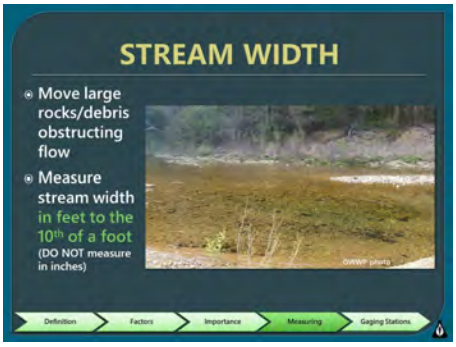


Stream discharge can be measured in just four basic steps:

1. Determine Stream Width
2. Determine Cross-Sectional Area
3. Measure Surface Velocity
4. Calculate Stream Discharge







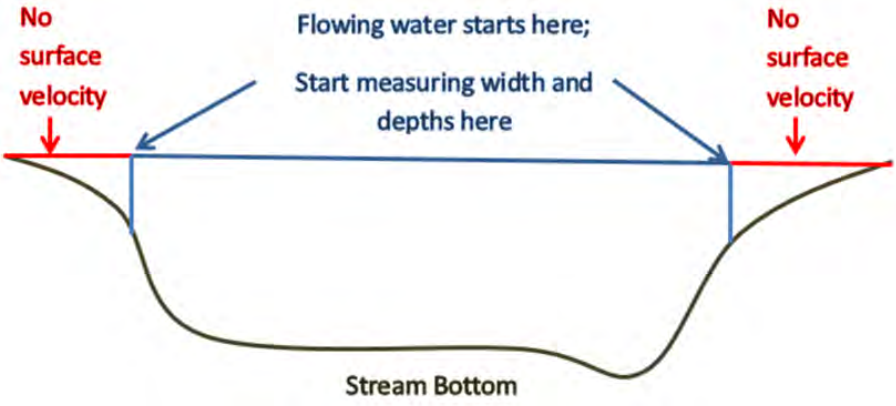
Stream Width

The first step in calculating discharge is to determine the width of your stream. To do this, place two stakes at the edges of the flowing water on each side of the stream. Stretch and anchor the tape measure between the stakes so that it is taut and perpendicular to the flow.

Sometimes, the flowing water is several inches from the edge of a streambank. Dead water, water that is not flowing, or eddies at the edge of a stream should not be counted when determining your stream width. Be sure to measure only where water is flowing. You may want to drop your wiffle ball on the water to determine if the water is flowing.

You should move obstacles obstructing the flow in your stream, if you are able. If you do, be sure to move them downstream from where you are taking your measurement.

Measure the stream width in feet to the 10th of a foot, not inches. To do this, be sure to use the correct side of your tape measure and record the width on the Stream Discharge Data Sheet.



Cross-Sectional Area

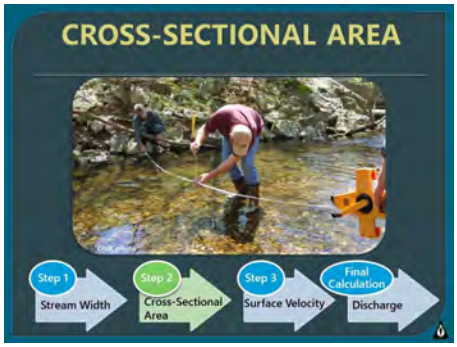
The next step is to determine the cross-sectional area of your stream. To do this, the depth of the stream is multiplied by the width of the stream: ***Area = Depth X Width.*** Unfortunately, stream beds are not flat and even. The depth of a stream varies along the bottom; often being shallower at the edges and deeper in the middle. Consequently, you will take several depth readings across the stream and calculate an average depth in order to determine the cross-sectional area. Use the following guidelines to determine the number of depth readings needed.

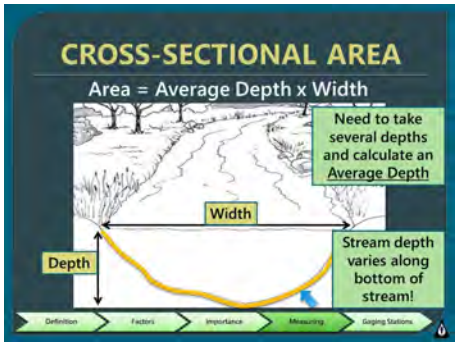
Stream Width	Depths Measurements
< 20 feet	Depth every 1 foot
20 feet to 60 feet	Depth every 2 feet
60 feet to 90 feet	Depth every 3 feet
> 90 feet	Depth every 4 feet

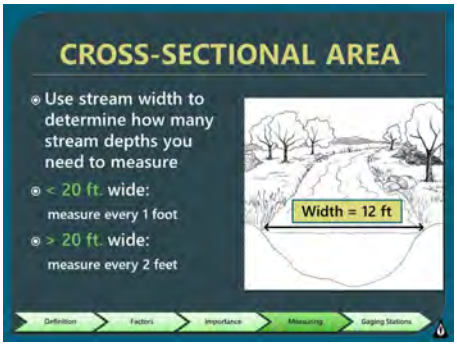
Stream depth is measured in feet to the 10th of a foot, not inches. Make a depth stick out of a dowel rod using the correct side (tenths) of the measuring tape provided.

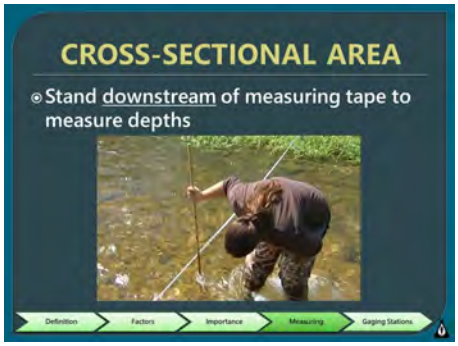
When taking your depth readings, always stand downstream so your legs do not impede stream flow. With the tape measure still anchored to the stakes at the stream banks, measure the stream depth at the appropriate intervals across the transect. Do not measure on top of large rocks or other objects. You want to be sure you are measuring the stream bottom. Record each depth reading on the front of your Stream Discharge Data Sheet.

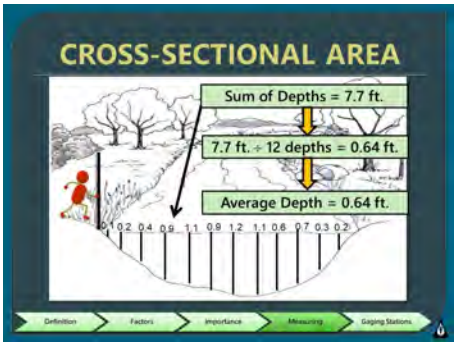
Once all measurements have been taken across your stream, add all the depths and record the ***Sum of Depths***. Divide the sum of depths by the number of depth intervals to determine your ***Average Depth.***

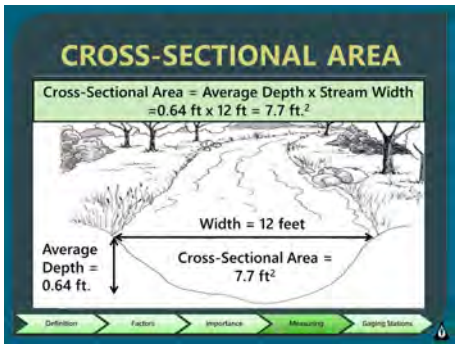


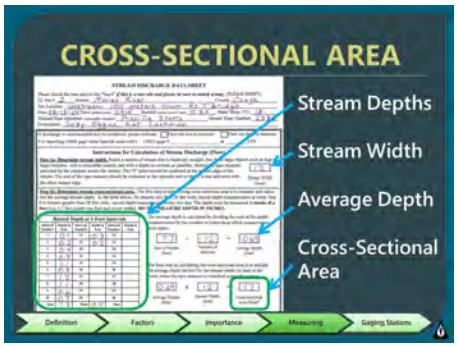












Cross-Sectional Area

Once you have determined the average depth, determining the cross-sectional area is easy. Simply multiply the average depth by the stream width to calculate the cross-sectional area. The following example shows how the cross sectional area is determined on the Stream Discharge Data Sheet.

STREAM DISCHARGE DATA SHEET

Please check the box next to the "Site #" ***if this is a new site and please be sure to attach a map.*** (PLEASE PRINT)

☐ Site # 2 Stream Maries River County Osage

Site Location Upstream 100 meters from Rt. T bridge

Date 08/13/04 Time (military time) 0915 Rainfall (inches in last 7 days) 0.25 Water Temp. (°C) 18

Trained Data Submitter (responsible volunteer) Priscilla Stotts Stream Team Number 2383

Participants Suzy Higgins, Kat Lackman

If discharge is unmeasurable due to conditions, please indicate: ☐ Flow too low to measure ☐ Flow too high to measure

For reporting USGS gage value (special cases only): USGS gage # _____ at _____ cfs

Instructions for Calculation of Stream Discharge (Flow)

Step 1a: Determine stream width. Select a section of stream that is relatively straight, free from large objects such as logs or large boulders, with a noticeable current, and with a depth as uniform as possible. Stretch the tape measure provided by the program across the stream. The "0" point should be anchored at the flowing edge of the stream. The end of the tape measure should be anchored at the opposite end so that it is taut and even with the other flowing edge. Do not measure nonflowing water.

12 — Stream Width (Feet)

Step 1b: Determine stream cross-sectional area. The first step in determining cross-sectional area is to measure and calculate the average stream depth. In the table below, for streams less than 20 feet wide, record depth measurements at every foot. For streams greater than 20 feet wide, record depth measurements every two feet. The depth must be measured in **tenths of a foot** (e.g. 1.7 feet equals one foot and seven tenths). **DO NOT MEASURE DEPTH IN INCHES.**

Record Depth at 1-Foot Intervals

Interval Number	Depth in Feet	Interval Number	Depth in Feet	Interval Number	Depth in Feet
1	0.1	11	0.3	21	
2	0.2	12	0.2	22	
3	0.4	13		23	
4	0.9	14		24	
5	1.1	15		25	
6	0.9	16		26	
7	1.2	17		27	
8	1.1	18		28	
9	0.6	19		29	
10	0.7	20		30	
Sum	7.2	Sum	0.5	Sum	

The average depth is calculated by dividing the sum of the depth measurements by the number of intervals at which measurments were taken.

7.7 (Sum of Depths (feet)) ÷ 12 (Number of Intervals) = 0.64 (Average Depth (feet))

The final step in calculating the cross-sectional area is multiply the average depth (in feet) by the stream width (in feet) at the point where the tape measure is stretched across the stream.

0.64 (Average Depths (feet)) x 12 (Stream Width (feet)) = 7.7 (Cross Sectional Area (feet)²)

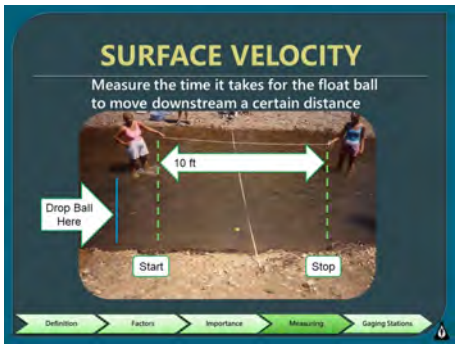
Step 2: Determine the average velocity for the stream. A minimum of four velocity measurements should be taken from equal intervals across the stream's width. For example, if the stream is eight feet wide, then velocity measurements should be taken at approximately every foot and a half across the stream in order to derive four measurements. For a stream width of 16 feet, velocity measurements should be taken at approximately three feet increments across the stream to derive four measurements. This method of measuring the stream velocity will ensure that velocity measurements are recorded for the slow and fast portions of the stream. For greater accuracy, more than four measurements are recommended for wider streams.

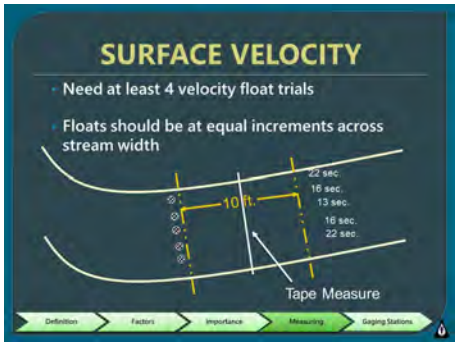
To measure the water's surface velocity, the first step is to select two points located equal distance upstream and downstream from the tape measure you have stretched across the stream. Determine the distance between these two points and record this value (in feet) in the **Distance Box** on the back of this page. A 10-foot total float distance is a recommended starting point. This distance can be lenghtened or shortened depending on stream swiftness. Count the number of seconds it takes a neutrally buoyant object (such as a wiffle practice golf ball) to float this distance. Record this time (in seconds) in the table on the back of this page for each float trial you complete.

Water Quality Volunteer

Volunteer Monitoring - 01/19 Page 1

Surface Velocity



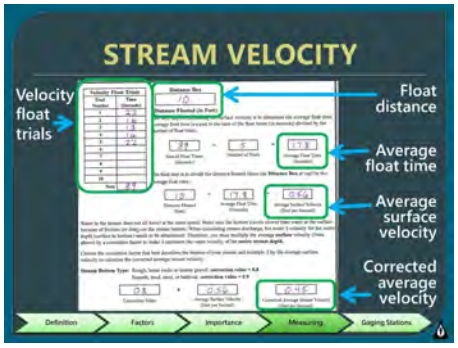


The third step of measuring stream discharge is to determine surface velocity. ***Velocity is expressed as a rate: distance per unit of time.*** To measure this, you will conduct a series of velocity float trials; measuring the time it takes for the wiffle ball to float downstream a certain distance.

A minimum of four velocity float trials are required. Since we will also be taking an average of the velocity float trials, the greater number of measurements, the more accurate the average float time velocity will be.

Use the following process to measure surface velocity:

1. Select two points located equal distance upstream and downstream from the tape measure you have stretched across the stream. The distance will depend on the swiftness of the stream, usually 10 feet. In faster water, you may want this distance to be greater, while shorter in slow water.
2. Record this distance in feet in the ***Distance Floated*** box on page 2 of the Stream Discharge Data Sheet.
3. Place stakes, large rocks, or distinct sticks on each side of the stream to mark the start and finish lines of the float distance.
4. Drop the wiffle golf ball upstream from the start point and record the time it takes to float from the start point to the finish point using a stop watch.
5. Record each float time in seconds in the "Velocity Float Trials" column on your data sheet. Float trials should be spaced at equal increments across the stream width if possible, so that your floats represent the different velocities across the entire stream.
6. Add all the float trials together and record the ***Sum of Float Trials***.
7. Divide this sum by the number of float trials to get an ***Average Float Time***.
8. Divide the ***Distance Floated*** (in feet), by the ***Average Float Time*** (in seconds), to get your ***Average Surface Velocity*** (in feet/seconds).
9. Multiply the ***Average Surface Velocity*** by a correction value to make it represent the water velocity of the entire stream depth. If the stream bottom has rough loose rocks or coarse gravel, the correction value you use is 0.8. If the stream bottom is smooth, muddy, or is bedrock, the correction value you use is 0.9. This will give you the ***Corrected Average Stream Velocity*** (in feet/second).



Surface Velocity

The following example shows how the surface velocity is determined on the Stream Discharge Data Sheet (page 2).

Velocity Float Trials	
Trial Number	Time (seconds)
1	22
2	16
3	13
4	16
5	22
6	
7	
8	
9	
10	
Sum	89

Distance Box

10

Distance Floated (in feet)

The next step in calculating the surface velocity is to determine the average float time. Average float time is equal to the sum of the float times (in seconds) divided by the number of float trials.

89 (Sum of Float Times (seconds)) ÷ 5 (Number of Trials) = 17.8 (Average Float Time (seconds))

The final step is to divide the distance floated (from the **Distance Box** at top) by the average float time.

10 (Distance Floated (feet)) ÷ 17.8 (Average Float Time (seconds)) = 0.56 (Average Surface Velocity (feet per second))

Water in the stream does not all travel at the same speed. Water near the bottom travels slower than water at the surface because of friction (or drag) on the stream bottom. When calculating stream discharge, the water's velocity for the entire depth (surface to bottom) needs to be determined. Therefore, you must multiply the average **surface** velocity (from above) by a correction factor to make it represent the water velocity of the **entire stream depth.**

Choose the correction factor that best describes the bottom of your stream and multiply it by the average surface velocity to calculate the corrected average stream velocity.

Stream Bottom Type: Rough, loose rocks or coarse gravel: **correction value = 0.8**
Smooth, mud, sand, or bedrock: **correction value = 0.9**

0.8 (Correction Value) x 0.56 (Average Surface Velocity (feet per second)) = 0.45 (Corrected Average Stream Velocity (feet per second))

Step 3: Calculate the stream discharge. Multiply the cross-sectional area (Feet)^2 from **Step 1** by the corrected average stream velocity (Feet/Second) from **Step 2.**

7.7 (Cross-Sectional Area (feet)^2) x 0.45 (Corrected Average Stream Velocity (feet per second)) = 3.47 (Stream Discharge (feet)^3 per second or cubic feet per second (cfs))

Fish Present (Please Mark) **Yes** ☑ or **No** ☐

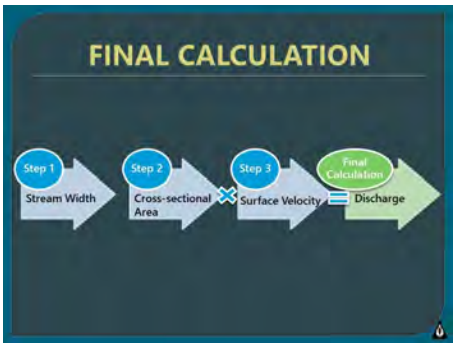
PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO: VWQM Coordinator
Water Protection Program
Department of Natural Resources
PO Box 176
Jefferson City, MO 65102-0176

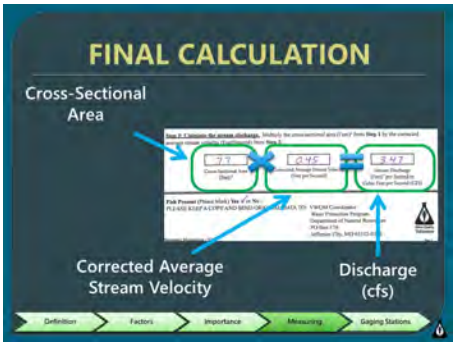
Water Quality Volunteer

Volunteer Monitoring - 01/19

Page 2

Calculate Stream Discharge





The final step is the easiest! Simply multiply the ***Cross-Sectional Area*** from the front of your Stream Discharge Data Sheet, by the ***Corrected Average Stream Velocity*** from the back of your data sheet, to arrive at the ***Stream Discharge*** in cubic feet per second (cfs). Below is an example of the final calculation on a data sheet:

Velocity Float Trials	
Trial Number	Time (seconds)
1	22
2	16
3	13
4	16
5	22
6	
7	
8	
9	
10	
Sum	89

Distance Box

10

Distance Floated (in feet)

The next step in calculating the surface velocity is to determine the average float time. Average float time is equal to the sum of the float times (in seconds) divided by the number of float trials.

89 (Sum of Float Times (seconds)) ÷ 5 (Number of Trials) = 17.8 (Average Float Time (seconds))

The final step is to divide the distance floated (from the **Distance Box** at top) by the average float time.

10 (Distance Floated (feet)) ÷ 17.8 (Average Float Time (seconds)) = 0.56 (Average Surface Velocity (feet per second))

Water in the stream does not all travel at the same speed. Water near the bottom travels slower than water at the surface because of friction (or drag) on the stream bottom. When calculating stream discharge, the water's velocity for the entire depth (surface to bottom) needs to be determined. Therefore, you must multiply the average **surface** velocity (from above) by a correction factor to make it represent the water velocity of the **entire stream depth.**

Choose the correction factor that best describes the bottom of your stream and multiply it by the average surface velocity to calculate the corrected average stream velocity.

Stream Bottom Type: Rough, loose rocks or coarse gravel: **correction value = 0.8**
Smooth, mud, sand, or bedrock: **correction value = 0.9**

0.8 (Correction Value) x 0.56 (Average Surface Velocity (feet per second)) = 0.45 (Corrected Average Stream Velocity (feet per second))

Step 3: Calculate the stream discharge. Multiply the cross-sectional area (Feet)² from **Step 1** by the corrected average stream velocity (Feet/Second) from **Step 2.**

7.7 (Cross-Sectional Area (feet)²) x 0.45 (Corrected Average Stream Velocity (feet per second)) = 3.47 (Stream Discharge (feet)³ per second or cubic feet per second (cfs))

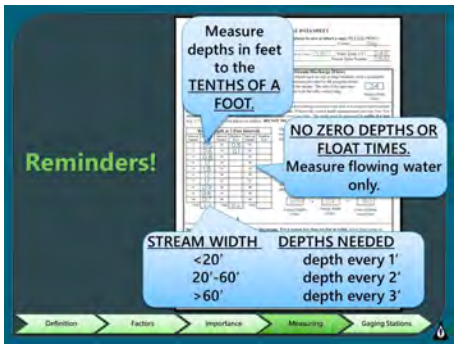
Fish Present (Please Mark) **Yes** ✓ or **No** ☐

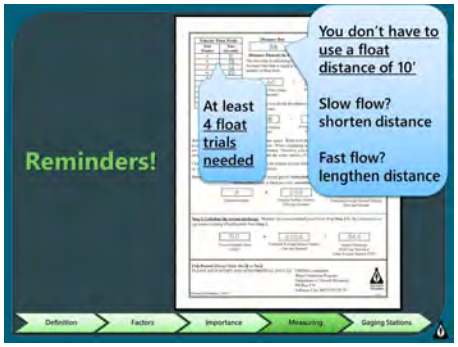
PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO: VWQM Coordinator
Water Protection Program
Department of Natural Resources
PO Box 176
Jefferson City, MO 65102-0176

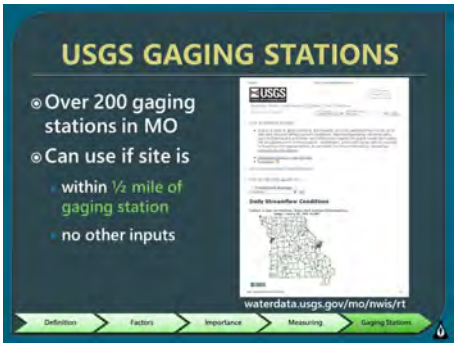
Water Quality Volunteer

Volunteer Monitoring - 01/19

Page 2







A Few Reminders

- Measure depths of your stream in feet to the tenths of a foot.
- No zero depths or float times are permitted. Only measure flowing water.
- Double check to make sure you have recorded enough depths for your stream's width:

Stream Width	Depths Measurements
< 20 feet	Depth every 1 foot
20 feet to 60 feet	Depth every 2 feet
60 feet to 90 feet	Depth every 3 feet
> 90 feet	Depth every 4 feet

- Double check to make sure you have recorded enough float trials for your stream:

Minimum Number of Float Trials
4 Trials

- Your distance floated does not have to be 10 feet. However, remember to record whatever distance you decide to use. We recommend at least 5 feet for a minimum float distance.
- Submit data sheet, including header information, even if flow is too low or too high to measure.
- Read the directions on the data sheet to prevent errors in your calculations. You may want others to review your data sheet for accuracy.

USGS Gaging Stations

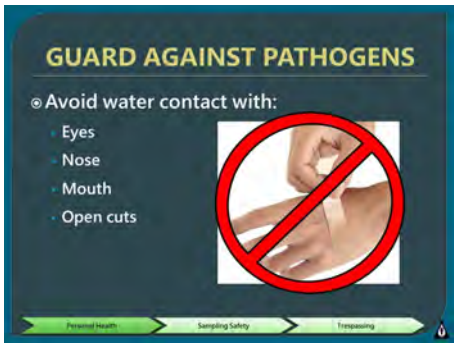
The United States Geological Survey maintains over 200 gaging stations on streams throughout Missouri. Many of these stations record stream discharge every day. Data is in real-time format and updated hourly. The site also includes an interactive map. You can use a gaging station for your stream discharge data if there is a station within a half mile of your site location AND there are no inputs or outputs between your site and the gaging station. Fill in the data sheet header and record the gage number and stream discharge at the time of sampling.

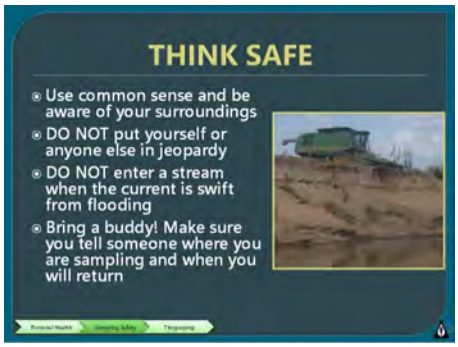
USGS website:
waterdata.usgs.gov/mo/nwis/rt

Chapter 4
Safety and Trespass

Your safety is important. In this chapter, you will learn how to keep yourself healthy and safe when monitoring a stream site. Specifically, you will explore safety responsibilities in three main areas:

- Precautions for your personal health
- Sampling safety protocol
- Trespassing





Personal Health

Keeping you healthy and safe as you monitor a stream begins by taking the right precautions:

- ***Immunizations:*** Before monitoring your stream, check with your doctor or county health department to ensure you are up to date with the appropriate immunizations.
- ***Foot Protection:*** Always wear some type of foot protection. Never go bare foot or wear sandals in a stream. Water boots or old tennis shoes provide good protection from sharp objects in a stream bed.
- ***Life Jacket:*** Always wear a life jacket when the depth of the stream is unknown.
- ***Bug Repellent:*** Use a bug repellent to avoid bites that may lead to serious illness.
- ***Guard Against Pathogens:*** Avoid water contact with your eyes, nose, mouth, or open wounds. Be sure to wash your hands thoroughly with soap and warm water before rubbing your eyes or bringing your hands to your mouth.

Sampling Safety

Think safety when monitoring your stream site:

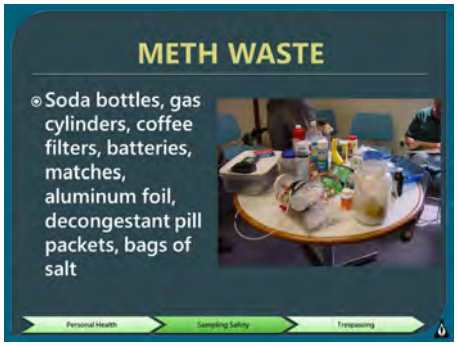
- Use common sense and maintain awareness of your surroundings and potential dangers.
- Never put yourself or anyone else in jeopardy with a potential safety threat.
- Never enter a stream when the current is swift and the depth of water is above your knees. The force from a strong current can easily cause you to lose your balance.
- Use the buddy system. Tell someone where you are sampling and when you are expected to return.

Sampling Safety

Pay close attention to your surroundings as you monitor your streams.

Hazardous Waste Drums: Volunteers may encounter chemical storage drums while in the field. ***Do not open, move, or relocate a drum until it is verified by authorities not to contain hazardous waste.*** If a volunteer removes a drum from a site, they now assume all responsibility for the drum and its contents, including fees for disposal and environmental risks. This may also interfere with any investigation to hold the appropriate parties accountable. Instead follow the procedures outlined below:

1. Visually check to see if the drum is leaking, seeping gaseous fumes, or bulging.
2. Look for a label. Labels should list the manufacturer, contents, hazards and other important information about the drum's contents. If a label is not present, assume it is hazardous.
3. Take photographs of the drum and label.
4. Mark the area with a bright flag and a "Do Not Disturb" sign.
5. ***Contact the 24 hour Environmental Emergency Response hotline at 573-634-2436.***



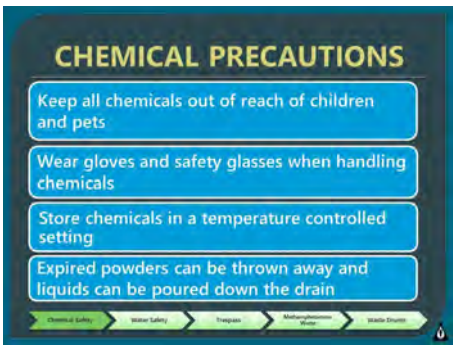
Sampling Safety

Pay close attention to your surroundings as you monitor your streams.

Methamphetamine Waste: Volunteers may encounter common household objects in the woods that are actually methamphetamine waste. If you find soda bottles, gas cylinders, coffee filters, batteries, matches, aluminum foil, decongestant pill packets, or bags of salt, ***do not touch or remove.*** Instead, document the location and report the waste to your local sheriff, police, or conservation agent.

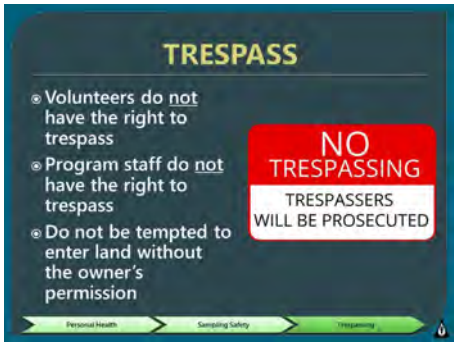
Chemical Safety

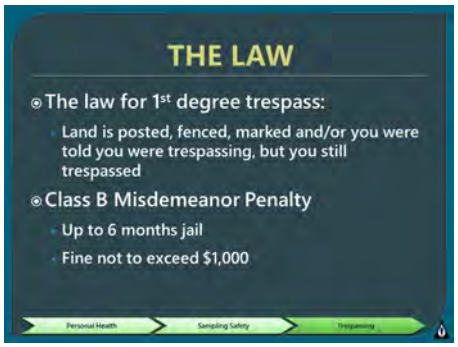
Safety Data Sheet: Information on chemical composition, hazards, disposal, and ecological information of water quality monitoring chemical reagents can be found on Safety Data Sheets (SDS). Every chemical should come with an SDS. These can also be found on the Missouri Stream Team website. Always keep the SDS for all chemicals in an easily accessible location.

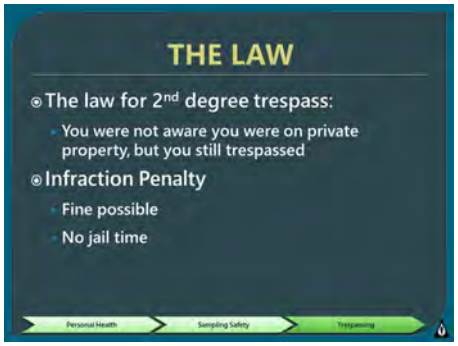


Chemical Precautions:

- Keep all chemicals out of reach of children and pets
- Wear gloves and safety glasses when handling chemicals
- Store chemicals in a temperature controlled setting
- Expired powders can be thrown away and liquids can be poured down the drain







Trespassing

Trespassing is against the law and can be dangerous. Stream Team volunteers and program staff do not have the right to trespass on private land. Although it can be tempting, never enter onto land without the owner's permission.

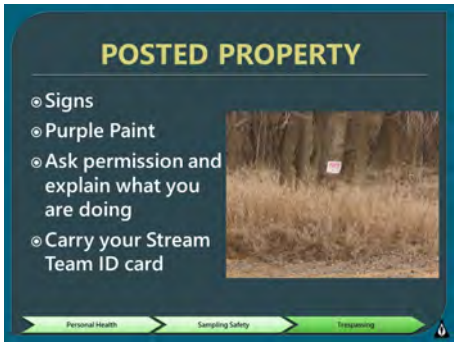
- ***First–degree trespass (RSMo569.140)*** states that a person commits the crime of trespass in the first degree if he or she knowingly enters and remains unlawfully in a building or upon real property. The property must be fenced or enclosed in a manner designed to exclude intruders and notice of trespass is given either by actual communication or by post. The penalty for first-degree trespass is jail or $500.00 maximum.
- ***Second-degree trespass (RSMo 569.150)*** occurs when a person unknowingly enters unlawfully upon real property of another. In this instance, land does not need to be fenced, nor does the property owner need to post a *No Trespassing* sign. The penalty for second-degree trespass is a $200.00 maximum fine, but no jail.

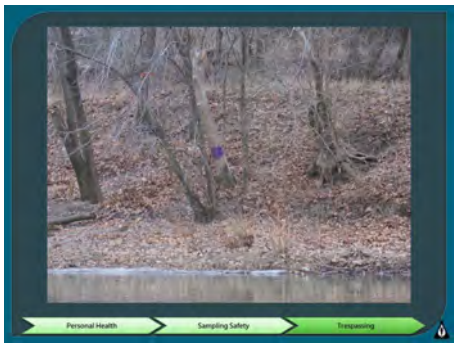
Posted Property

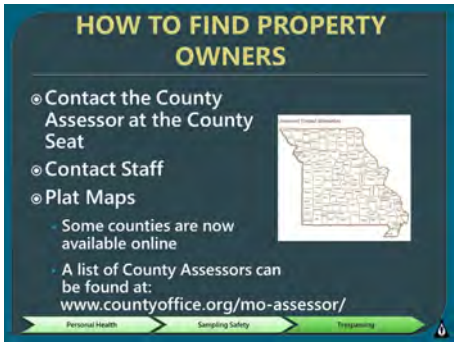
Property owners can protect their land from trespassers in a number of different ways. The most common method is with posted signs. Volunteers should heed any signs such as *No Trespassing, No Hunting, Posted, or Keep Out.*

Additionally, the Purple Paint Statue (RSMo 569.145) specifies how purple paint can be used by landowners to protect their property from trespassers. Even though the law specifies the use of purple paint on a post cap or a vertical line on a tree, volunteers should look for any purple postings such as bandanas, flags, etc. Assume when you see purple, it means keep out!

Acquire landowner permission before you monitor. Explain your objectives and ask them for permission to be on their property. You should do the same when monitoring a stream in a public park or any state land by seeking permission from the appropriate authorities. When seeking permission, you may find it helpful to show your Stream Team Identification Card to landowners.







How to Find Property Owners

If you are unsure who owns the land, you can easily contact your local County Assessor. They will have a collection of plat maps showing ownership of parcels of land.

Landowner Permission

Stream Team volunteers can use the ***Hello Streamside Landowner brochure*** when visiting with property owners. The brochure explains the purpose of the Stream Team and includes a permission slip for landowners to complete. The brochure can be found on the Stream Team website at **www.mostreamteam.org** under the Publications section**.**

Citizens caring for Missouri streams

Landowner: please keep this portion for your records.

Dear Streamside Property Owner,

As a volunteer member of the Missouri Stream Team Program, I am seeking permission to enter the stream on your property to perform stewardship activities in hopes of improving the health of the stream. The Missouri Stream Team Program is a grass-roots citizen effort to protect Missouri streams by conducting activities such as litter pickups, tree planting, water quality monitoring, storm drain stenciling, and many others.

With your permission, I plan to perform (check all that apply):

- ❒ Litter Pickup
- ❒ Water Quality Monitoring
- ❒ Tree Planting
- ❒ Storm Drain Stenciling
- ❒ Invasive Species Monitoring/Removal
- ❒ Photo Point Monitoring
- ❒ Other _____

I respectfully ask for your permission to access the creek through your property. My access will be during daylight hours only. If necessary, access may be limited to times of your choosing. I fully understand that trash disposal is my responsibility, and I promise to be respectful of your property rights. I also understand that as the property owner, you may revoke permission at any time for any reason.

I will share with you the results of our activities (water quality data, trash collected, etc.) after our work is completed. This information is also shared with the Missouri Departments of Conservation and Natural Resources as part of the reporting requirements of the Program.

If this is acceptable, please provide your contact information on the Landowner Permission Slip at right. Thank you for your support of the Missouri Stream Team Program.

Sincerely,

Volunteer Name _____ Stream Team Number _____

Address _____ Phone (_____) _____-_____

City, State, Zip _____ Email _____

Stream Team 3117 "The Litter Gitter Ridders"

Stream Team 4502 "Newburg Children's Museum"

Landowner Permission Slip

Stream Team member: please keep this portion.

I, as property owner, permit Missouri Stream Team (Number/Name)_____

_____

to access the stream adjoining my property for the purpose of:

- ❒ Litter Pickup
- ❒ Water Quality Monitoring
- ❒ Tree Planting
- ❒ Storm Drain Stenciling
- ❒ Invasive Species Monitoring/Removal
- ❒ Photo Point Monitoring
- ❒ Other _____

and with the following conditions as applicable.

I also reserve the right to revoke permission at any time for any reason.

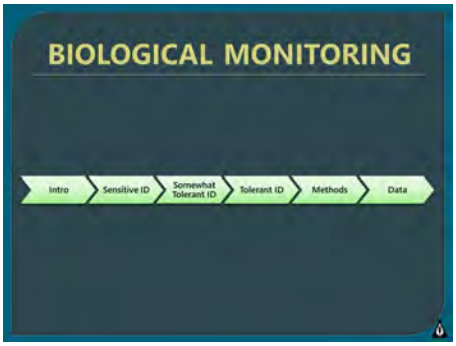
Landowner Name _____

Date _____

Phone _____

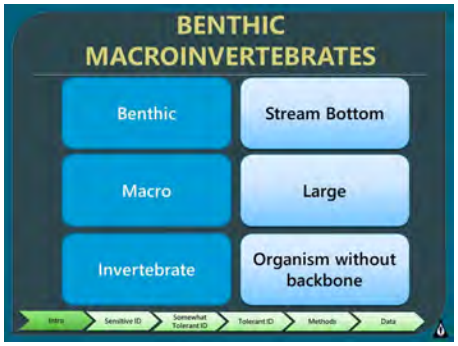
Email _____

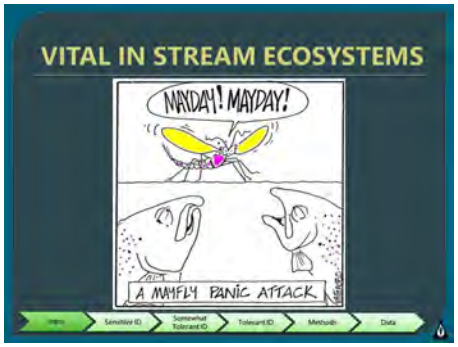
Chapter 5
Biological Monitoring

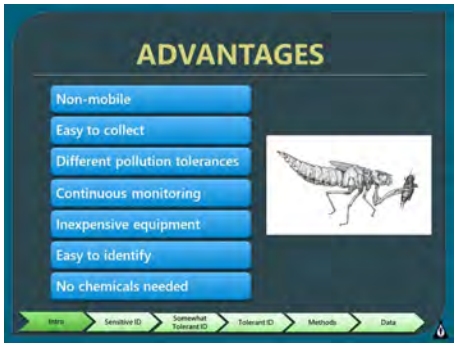


A good way to monitor the water quality of a stream is to closely examine the biological diversity of its habitat. This chapter will introduce you to benthic macroinvertebrates and the important role they play in helping us understand the water quality of Missouri's rivers and streams. Specifically, you will:

- Understand the importance of biological monitoring
- Identify pollution sensitive, somewhat tolerant, and tolerant macroinvertebrates
- Identify the methods and processes to monitor the biological diversity of your stream
- Analyze the data of benthic macroinvertebrates in your stream







Benthic Macroinvertebrates

What are benthic macroinvertebrates? By definition, macroinvertebrates are organisms without backbones which are visible to the human eye without the aid of a microscope. Aquatic macroinvertebrates are often regarded as benthic, which means they live on, under, and around rocks and sediment at the bottoms of lakes, rivers, and streams. Freshwater benthic communities may consist of fly and beetle larvae, mayflies, caddisflies, stoneflies, dragonflies, aquatic worms, snails, leeches, and numerous other organisms.

Since these macroinvertebrates are important to the food chain in our rivers and streams, they play a vital role in a stream's ecosystem. Their presence in a stream, or lack there of, is a good indicator of water quality and health of these ecosystems. There are many advantages to using macroinvertebrates as an indicator of water quality:

- ***Non-Mobile:*** While fish will move if their habitats start to deteriorate, invertebrates are much more limited in their mobility.
- ***Taxa with Different Pollution Tolerances:*** Invertebrates have different levels of sensitivity to pollution. They can be assigned to three categories: pollution sensitive, somewhat tolerant, and tolerant. This allows us to determine the condition of a stream based on their presence or absence.
- ***Continuous Monitoring:*** Invertebrates are permanent residents of a stream. This makes them susceptible to pollutants present in the water and can reveal the impact pollutants have on the health of a stream over time.
- ***Easy to Collect:*** Invertebrates are easy to collect.
- ***Inexpensive Equipment:*** Chemical monitoring requires expensive and sometimes highly sophisticated equipment to analyze water samples. Biological monitoring only requires a kick net, forceps, and a small tray.
- ***Easy to Identify:*** Although it seems difficult at first, with a little practice, people become very adept at identifying these organisms.
- ***No Chemicals Needed:*** No chemicals are needed to conduct this type of monitoring.

Taxonomic Classification

Taxonomic classification is a hierarchical system for classifying organisms. The broadest classifications are by kingdom; the most specific classification is by genus and species.

Taxonomic Classification	How to Remember the Taxonomy
Kingdom	King
Phylum	Phillip
Class	Came
Order	Over
Family	For
Genus	Great
Species	Salmon

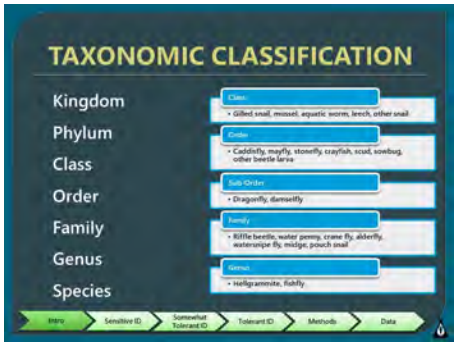
With the exception of a few taxa, volunteers will generally identify organisms to the level of Order when conducting their biological monitoring. This is the typical taxa level that can be identified easily in the field without magnification.

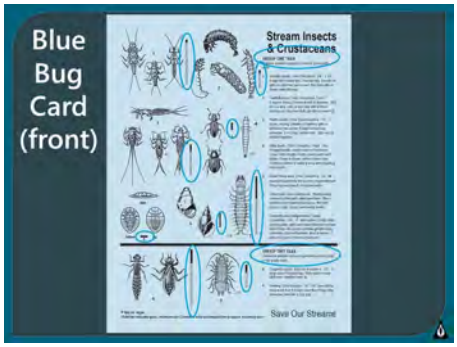
Pollution Tolerance

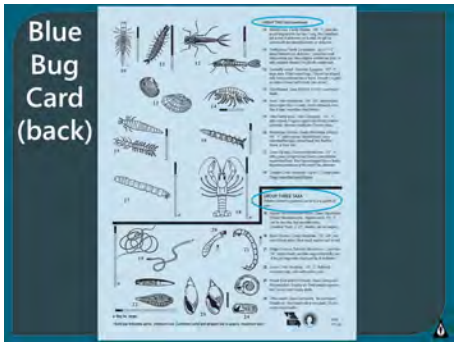
The invertebrates you will be looking for can be categorized into three main groups:

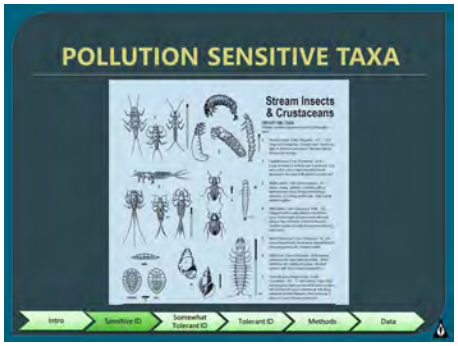
- ***Pollution Sensitive:*** These organisms are very sensitive to pollutants and will only be present in streams that have excellent water quality.
- ***Somewhat Pollution Tolerant:*** These invertebrates can survive in streams with moderate impairment.
- ***Pollution Tolerant:*** Organisms in this category are very tolerant of pollution and are the only organisms you will find in streams with severe impairment. Pollution tolerant organisms can be present in all streams, including those with excellent water quality.

A useful resource for aiding in macroinvertebrate identification is *Stream Insects & Crustaceans*, or Blue Bug Card, adapted from the Izaak Walton League. Taxa are placed in three groups: Group One is pollution sensitive, Group Two is somewhat pollution tolerant, and Group Three is pollution tolerant. The Blue Bug card is located at the end of this chapter.





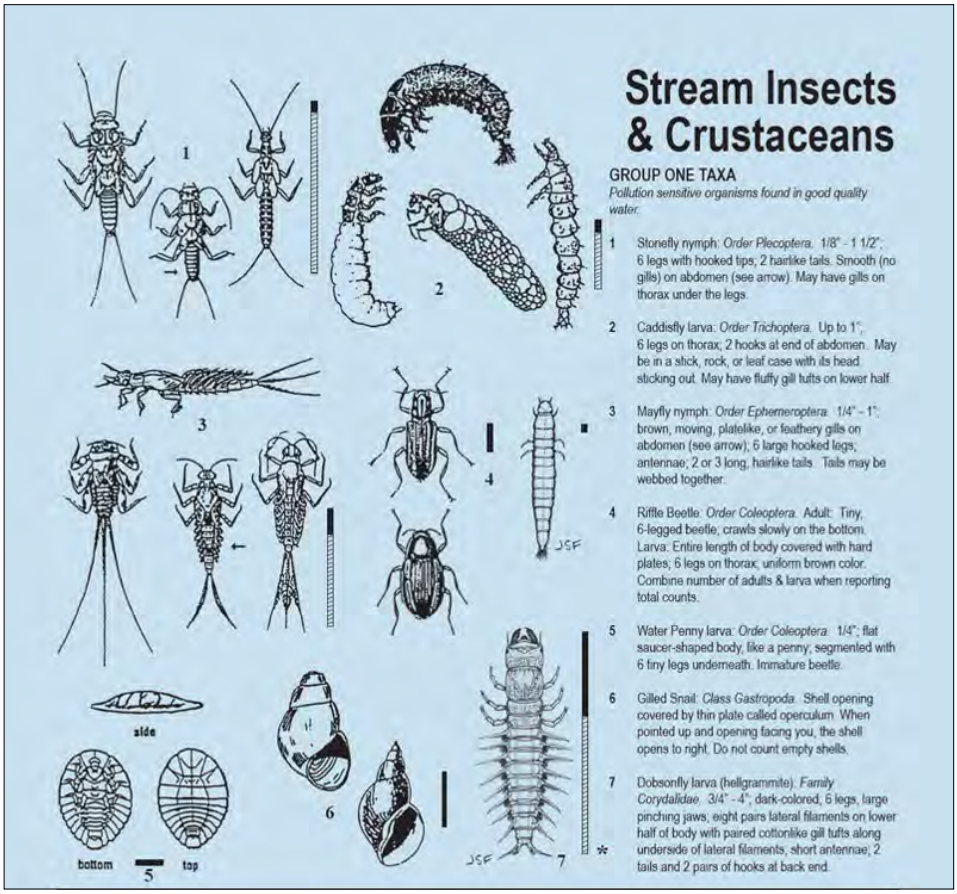




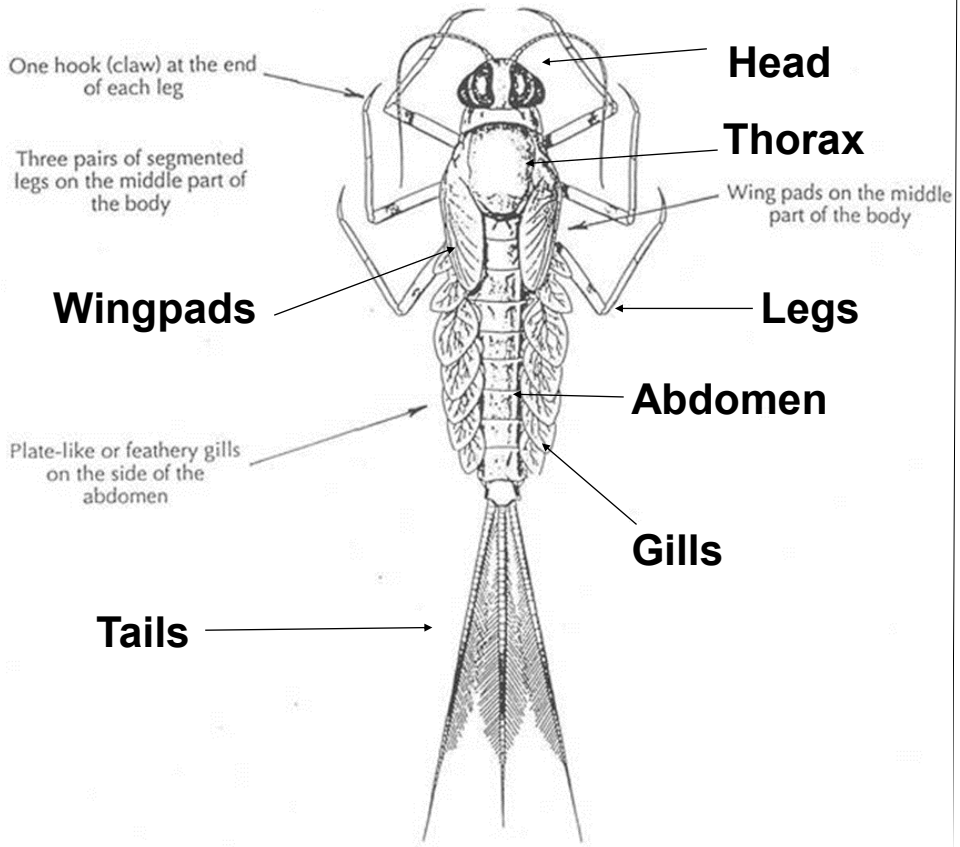
Pollution Sensitive Taxa

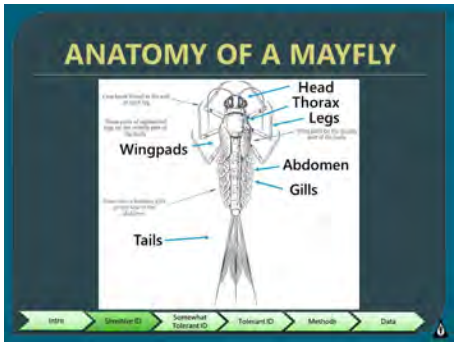
Pollution sensitive invertebrates are organisms that are very sensitive to pollutants and will only be present in streams with excellent water quality. Invertebrates that belong to this group include:

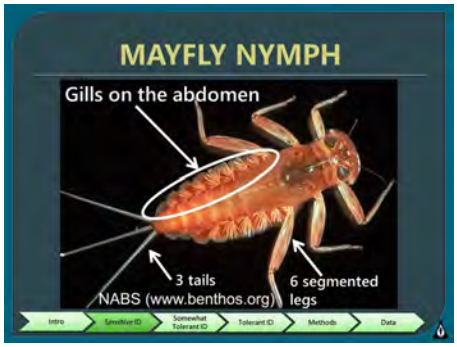
- Mayfly Nymph
- Stonefly Nymph
- Caddisfly Larva
- Riffle Beetle Larva and Adult
- Water Penny Larva
- Gilled Snail
- Dobsonfly Larva (Hellgrammite)

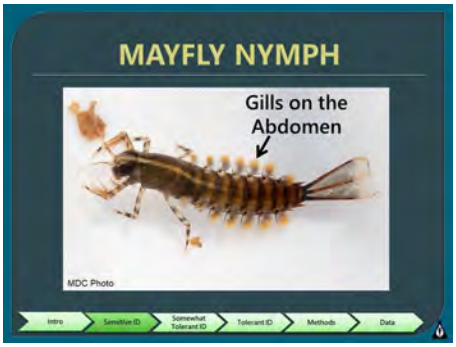


Pollution Sensitive: Mayfly Nymph



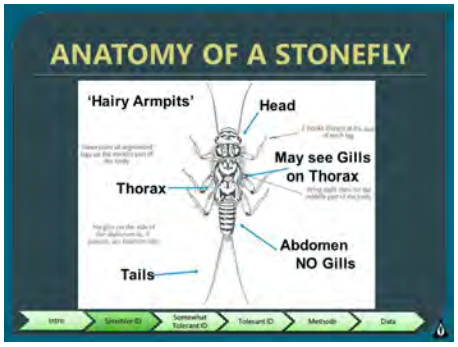


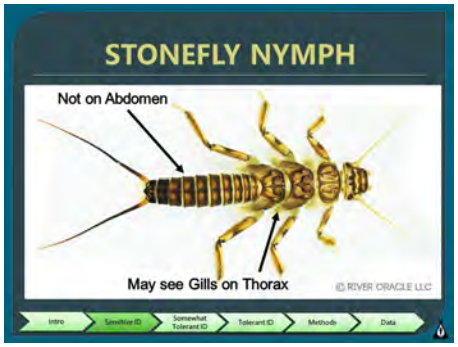


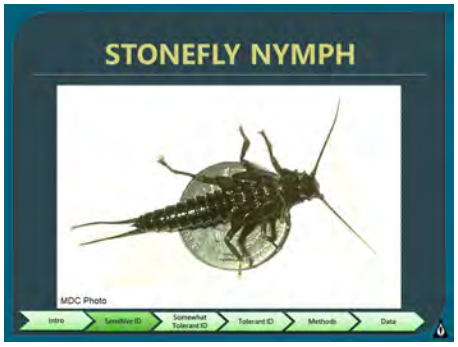


Distinguishing Features:

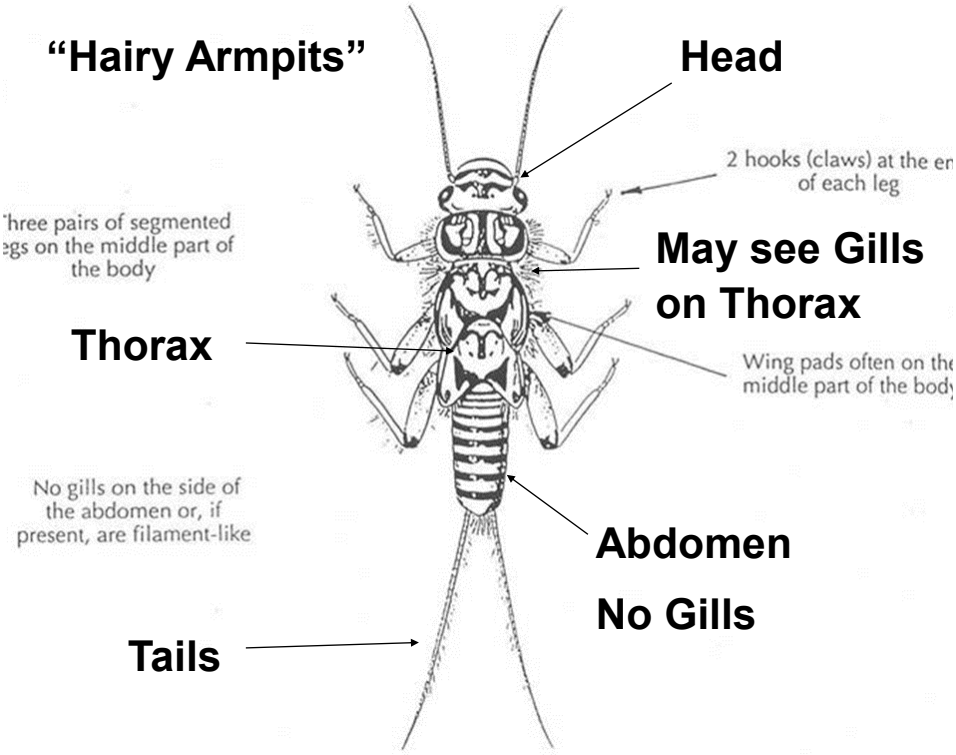
- Plate-like, elongate, or feather-shaped gills located on the sides of the abdomen.
- One hook (claw) at the end of each leg.
- Most mayflies have three filament-like tails; some may have only two.







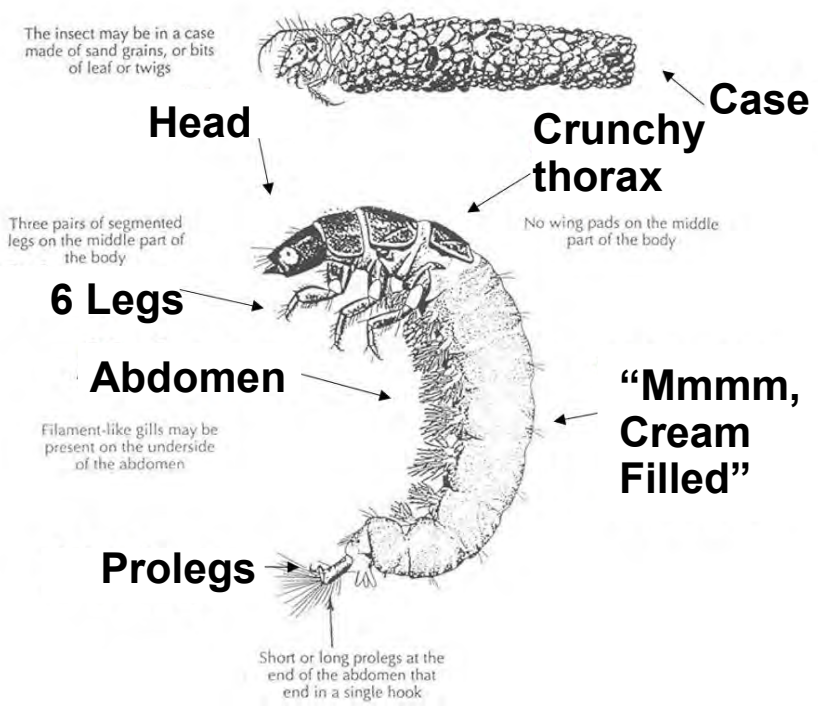
Pollution Sensitive: Stonefly Nymph

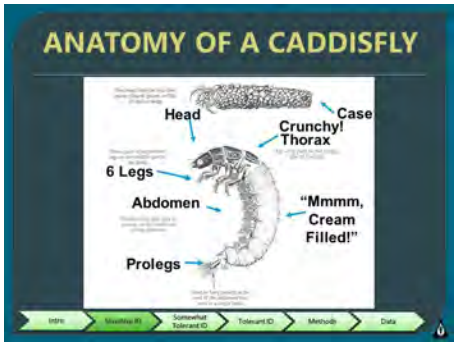


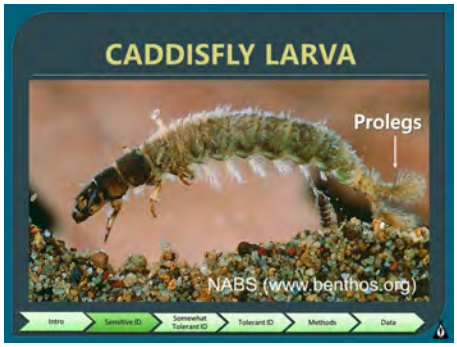
Distinguishing Features:

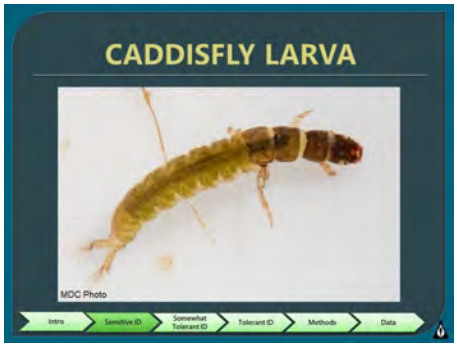
- Usually no gills on the abdomen.
- "Hairy armpits." Stonefly gills may look like hairs and are located under the legs on the thorax.
- Two hooks (claws) at the end of each leg.
- Stonefly nymphs have 2 tails.

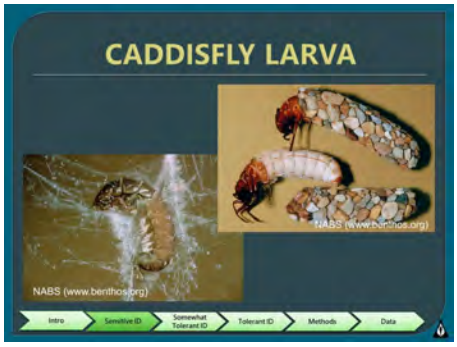
Pollution Sensitive: Caddisfly Larva

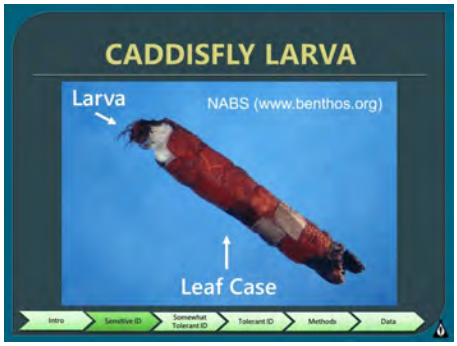






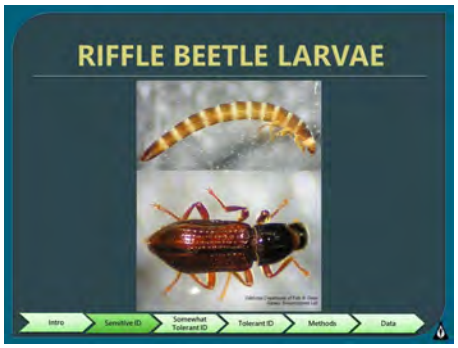






Distinguishing Features:

- No tails; instead they have hook-like features called prolegs.
- No wing pads.
- Crunchy thorax; soft abdomen.
- May build their own case made of sand grains or bits of leaves or twigs.
- Filament-like gills may be present on the underside of the abdomen.

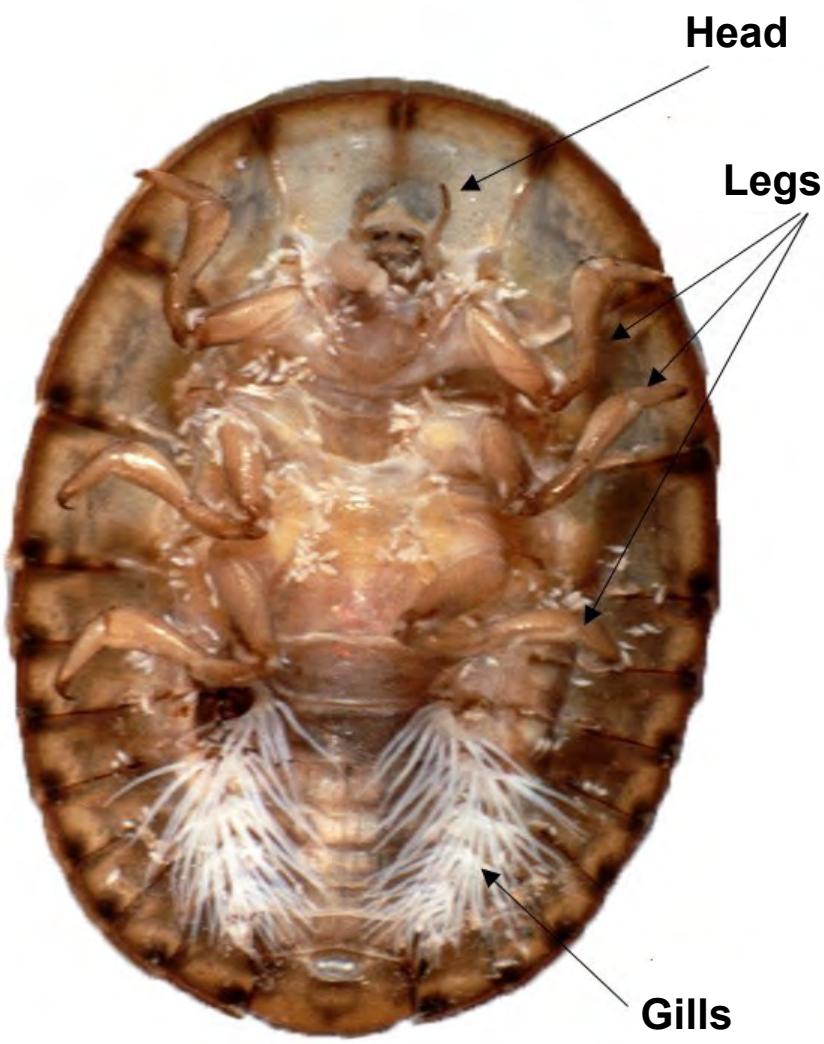


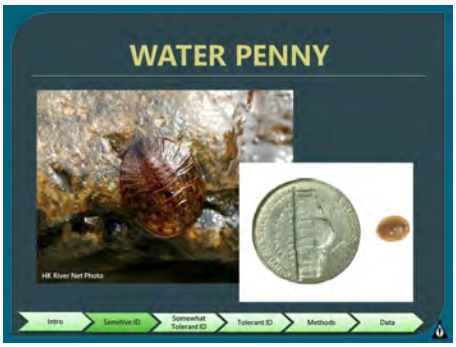
Pollution Sensitive: Riffle Beetle

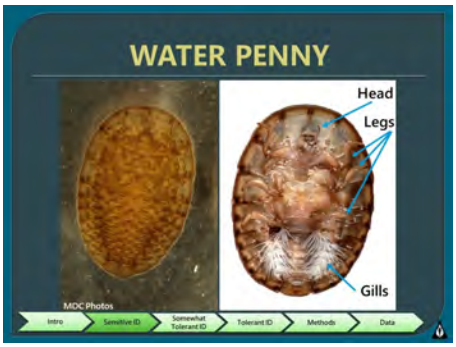
Distinguishing Features:

- Riffle beetles spend both their larval and adult life cycle in water. It is not uncommon to collect adults and larvae in net sets. Count the total of larvae and adults when recording these on the data sheet.
- Riffle beetle larvae are tiny and elongate. The head and 3 pairs of legs are visible; filamentous gills may emerge from the tip of the abdomen. The entire body is covered in hard plates.
- Adult riffle beetles are very small, dark, and hard-bodied. They have relatively long legs and tarsal claws. Adults will crawl slowly on the bottom of your ice cube tray.

Pollution Sensitive: Water Penny







Distinguishing Features:

- Described as looking like a fish scale.
- Body is covered with a hard, oval carapace
- The head, legs, and gills are clearly visible on the underside of a water penny.
- Water pennies are immature aquatic larvae; the adults are terrestrial beetles.

Pollution Sensitive: Gilled Snail

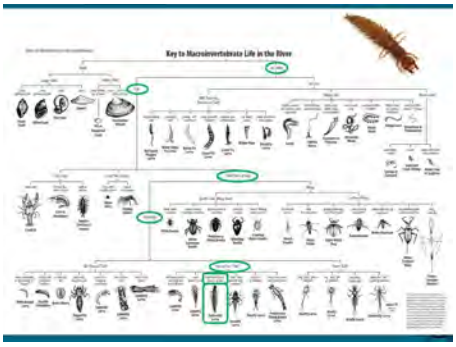
Opening on right side

Distinguishing Features:

- When the snail is held point up, the opening is on the right side.
- The opening is often covered by a hard, plate-like operculum.
- Do not count empty shells on the data sheet

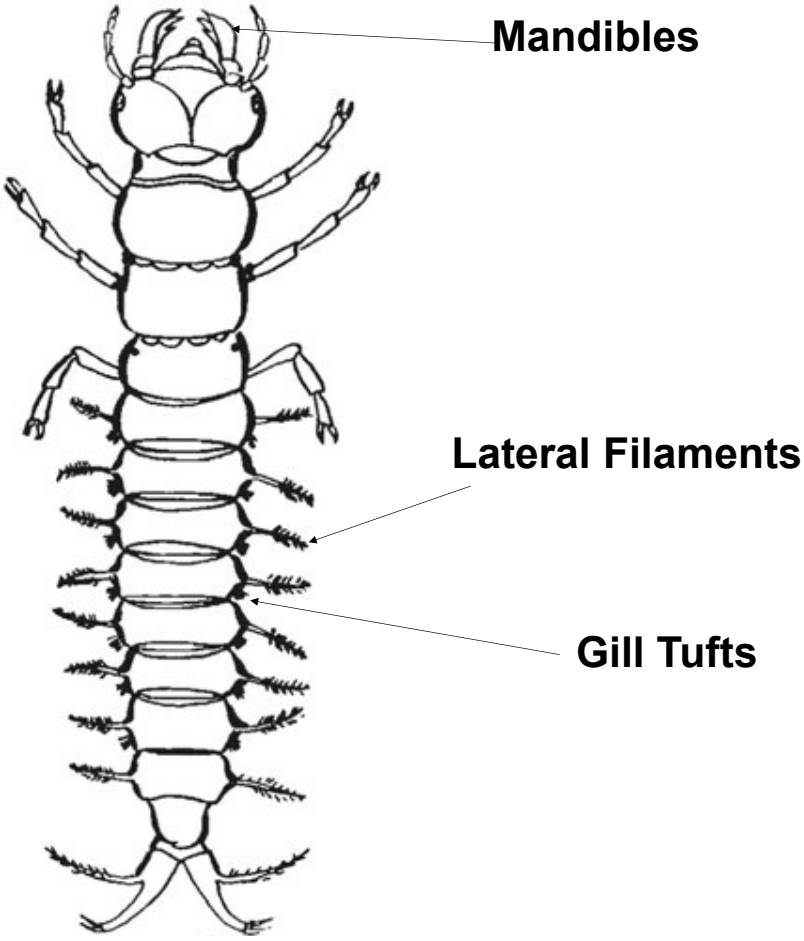
Dichotomous Key

Many resources are available to aid in identifying macroinvertebrates. The Key to Macroinvertebrate Life in the River is a simple dichotomous key with photos. A dichotomous key is a tool that biologists use to help identify organisms by asking questions about distinguishing characteristics. Use the Key to identify the invertebrate



1. Is there a shell?
2. Does this organism have legs?
3. How many pairs of legs does this organism have?
4. Are wings present?
5. Does this organism have an obvious tail?
6. Use description and photo to identify this organism.

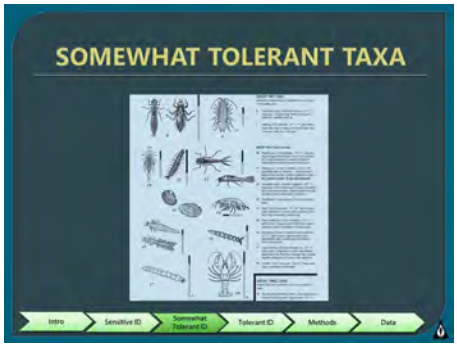
Pollution Sensitive: Dobsonfly larva (Hellgrammite)



Distinguishing Features:

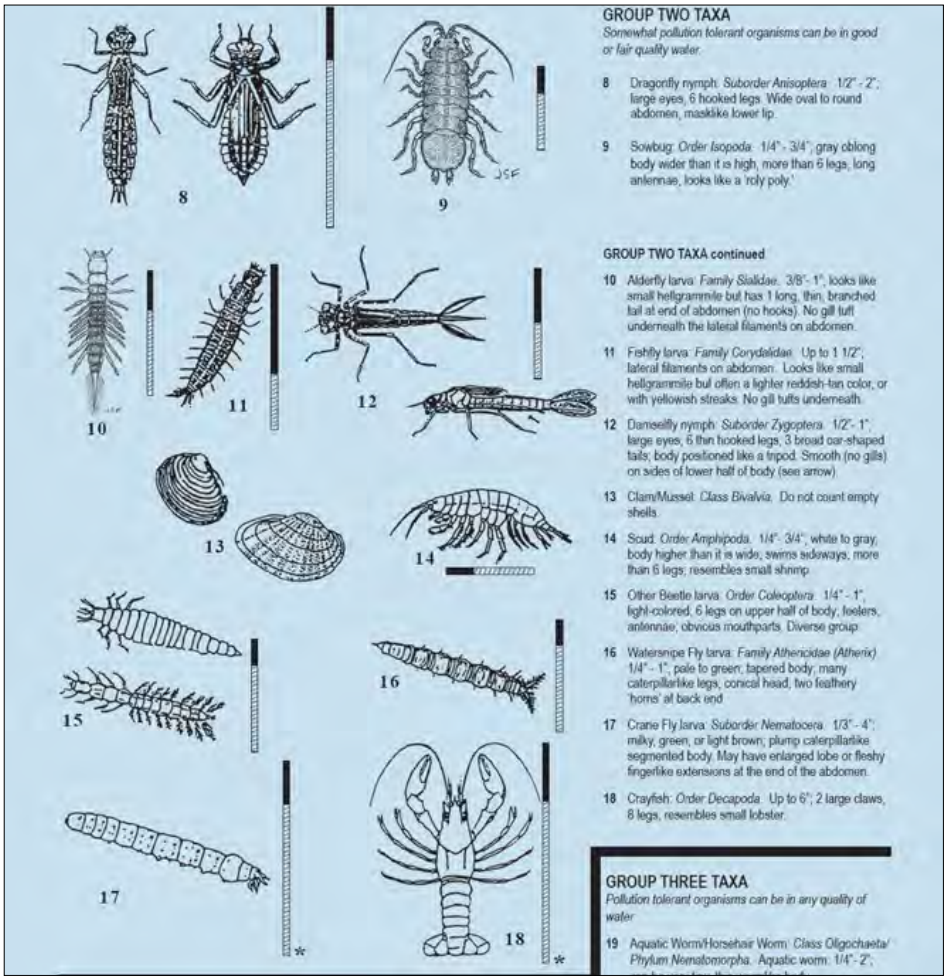
- Hellgrammites, the larval stage of the dobsonfly, are one of the largest invertebrates.
- Large mandibles or pinchers used for feeding and mating.
- Lateral filaments (slender appendages) along sides of abdomen.
- Gill tufts located under the lateral filaments on abdomen.
- 3 pairs of segmented legs

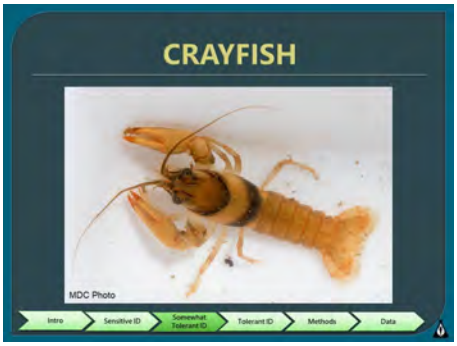
Somewhat Pollution Tolerant Taxa



Somewhat pollution tolerant invertebrates can survive in streams with moderate pollution impairment. Invertebrates that belong to this group include:

- Crayfish
- Sowbug
- Scud
- Alderfly Larva
- Fishfly Larva
- Damselfly Nymph
- Dragonfly Nymph
- Watersnipe Fly Larva
- Crane Fly Larva
- Other Beetle Larva
- Freshwater Clam or Mussel



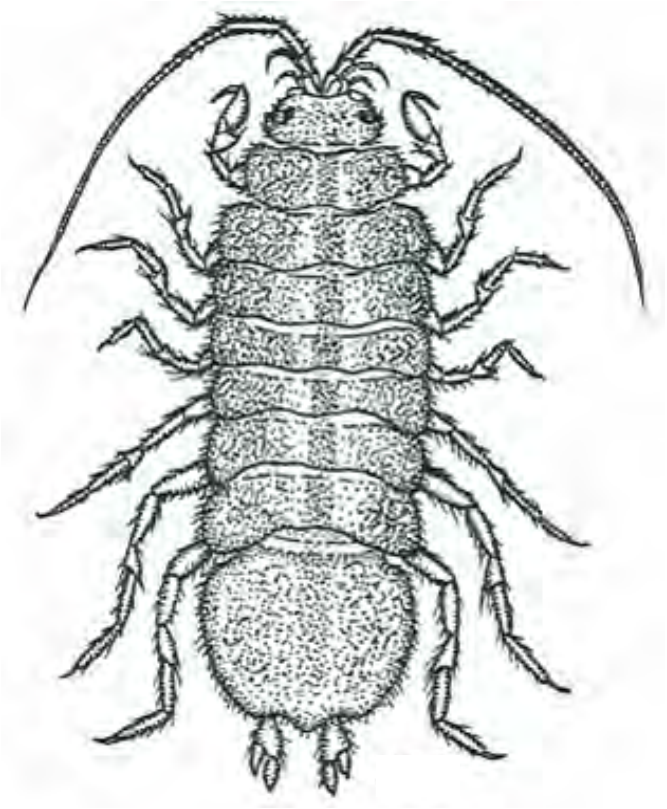


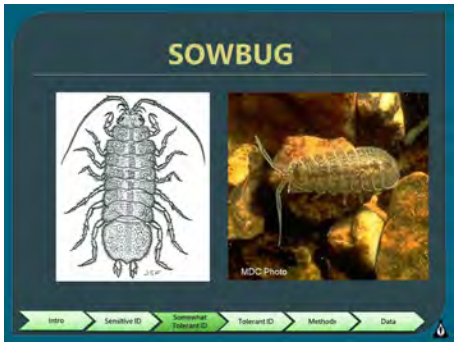
Somewhat Pollution Tolerant: Crayfish

Distinguishing Features:

- One of the most recognizable macroinvertebrates.
- There are 36 species of crayfish in Missouri.
- If you find crayfish in your net, immediately record the number on your data sheet and return them to the water as this predator will consume other organisms on the net or in the sorting tray.
- Crayfish are a keystone species in aquatic ecosystems; they eat everything and are in turn eaten by a great diversity of larger aquatic and terrestrial animals.

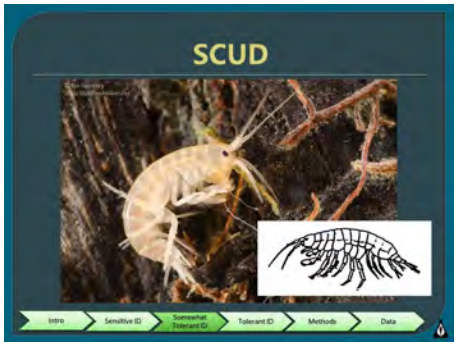
Somewhat Pollution Tolerant: Sowbug

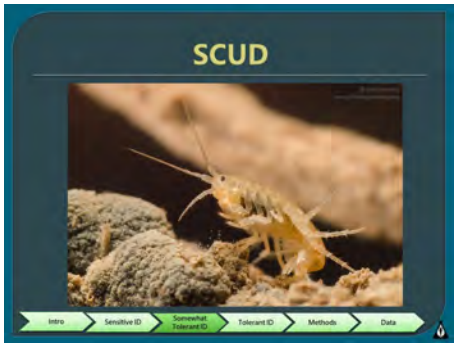




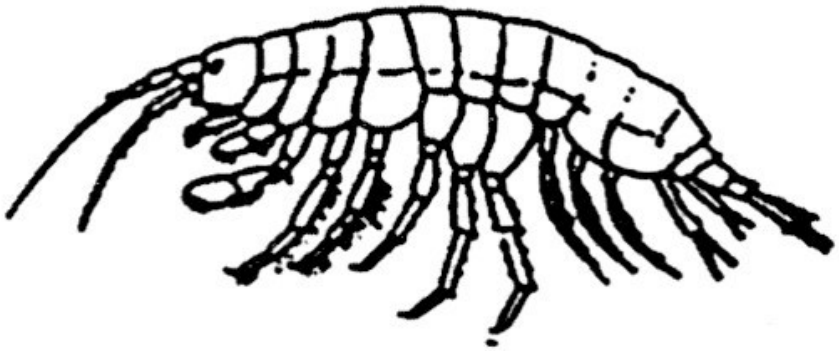
Distinguishing Features:

- A crustacean, similar to the crayfish.
- Resembles its terrestrial cousin, the roly-poly or pill bug.
- Flattened dorsoventrally from top to bottom.
- Seven pairs of legs





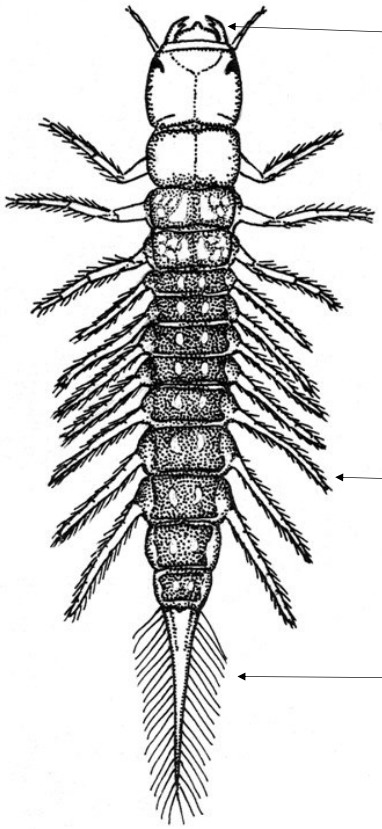
Somewhat Pollution Tolerant: Scud

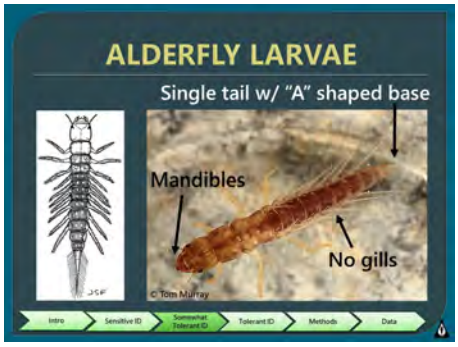


Distinguishing Features:

- Many appendages on their abdomen.
- Seven pairs of legs.
- Several pairs of pinchers.
- Segmented body.
- Flattened laterally from side to side.
- Also referred to as side swimmers.

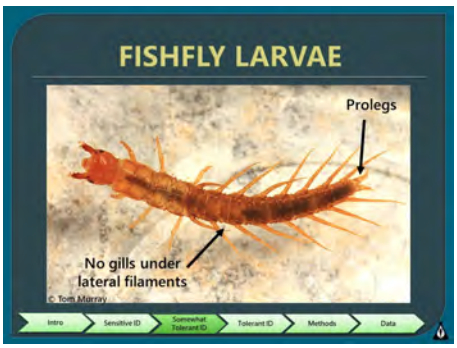
Somewhat Pollution Tolerant: Alderfly Larvae

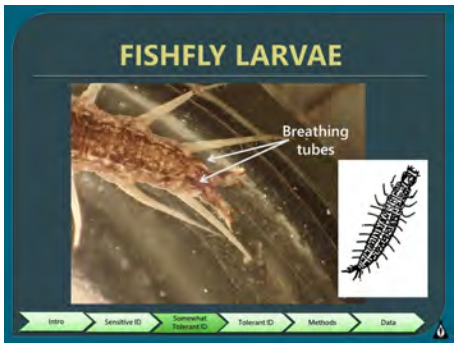




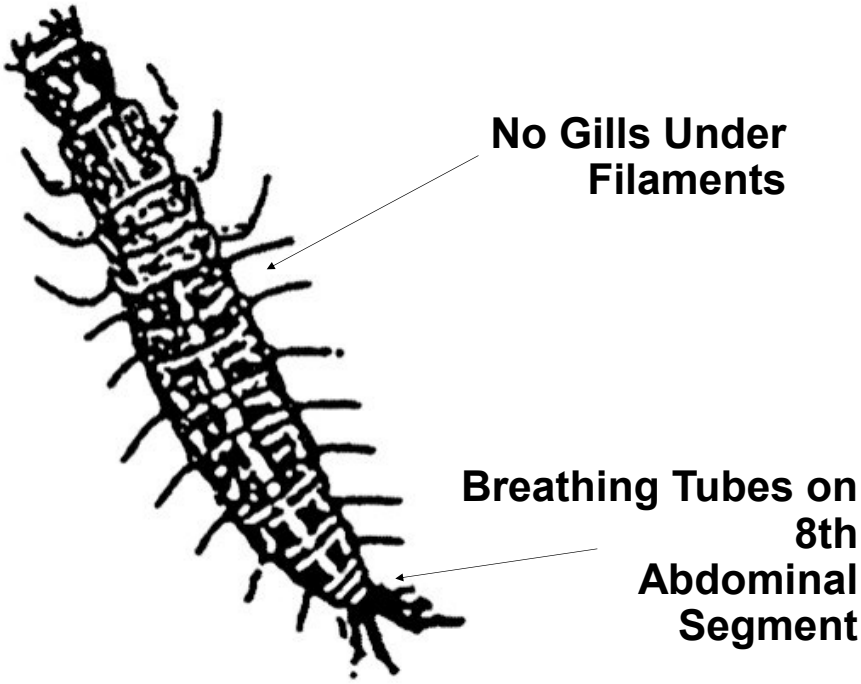
Distinguishing Features:

- Although similar to the hellgrammite, an alderfly is much smaller.
- Mandibles or pinching mouthparts.
- No gills under lateral filaments.
- Abdomen ends in a single filament that looks like a tail in the shape of a capital letter "A."





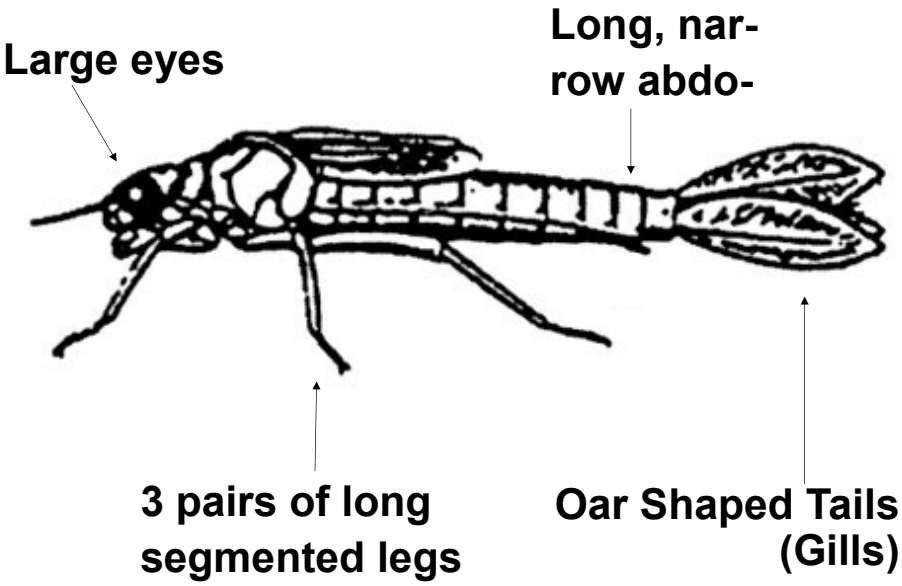
Somewhat Pollution Tolerant: Fishfly Larvae

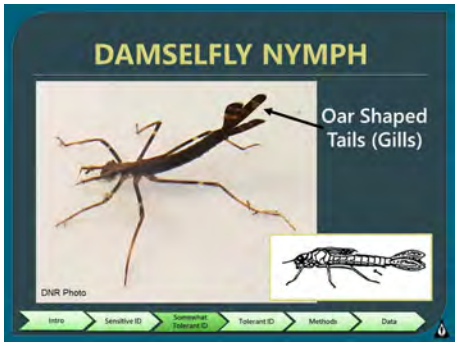


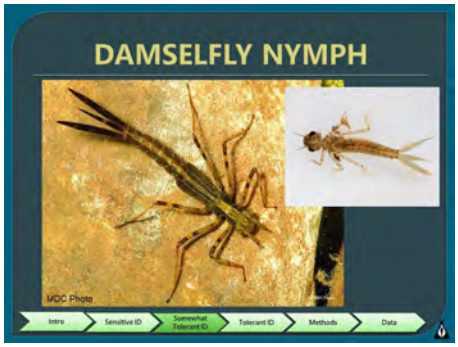
Distinguishing Features:

- Presence of breathing tubes near the end of the abdomen which are used in lower oxygen conditions to get atmospheric oxygen .
- No gills under lateral filaments.
- Fishfly larvae are relatively smaller in size than the hellgrammite.
- Fishfly larvae look similar to the hellgrammite, except gills are not present under the lateral filaments and they are smaller in size than the hellgrammite.

Somewhat Pollution Tolerant: Damselfly nymph

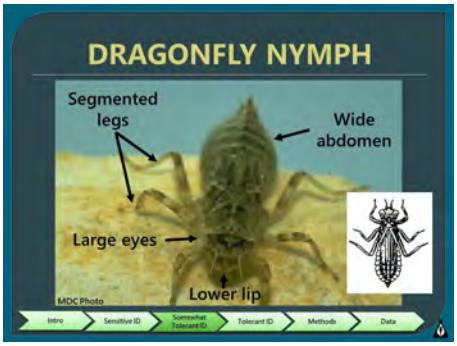


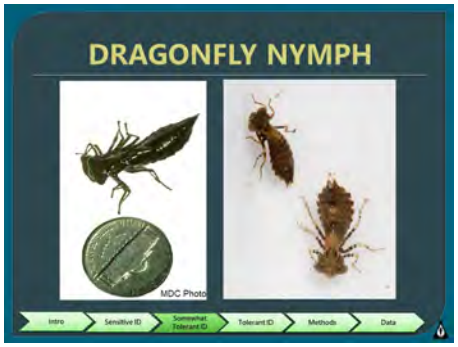


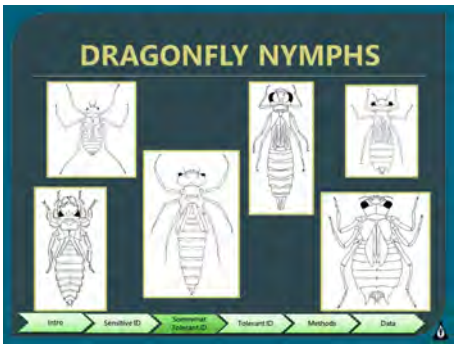


Distinguishing Features:

- Three broad oar or paddle-shaped gills at end of long, narrow abdomen which look like tails.
- Body shape is elongate and 6 legs are long and spindly.
- Extendible lower lip, or labium, for grasping prey.
- Large eyes

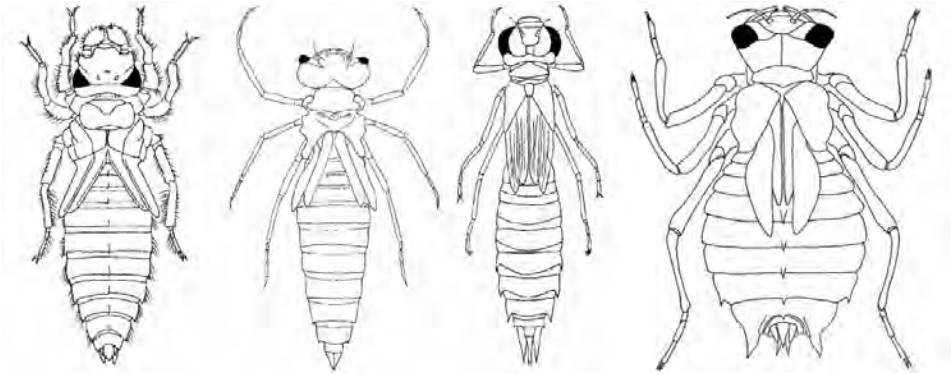






Somewhat Pollution Tolerant: Dragonfly nymph

6 long legs **Large eyes**

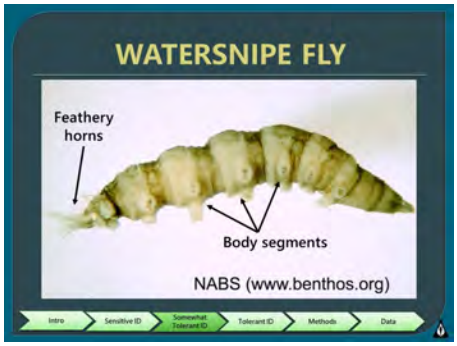


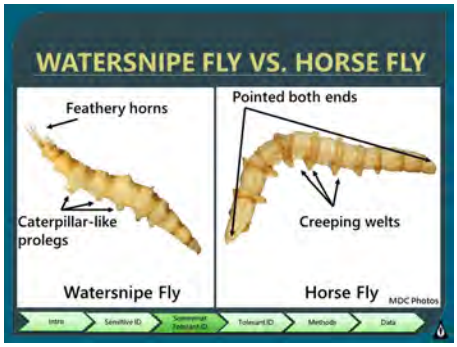
Wide abdomen that is oval, round, and or flat

Distinguishing Features:

- Dragonfly nymphs can have a wide range of body shapes based on species.
- Long, segmented legs.
- Long, folded lower labium or lip used for capturing prey.
- Large eyes located on the front of their head.
- Abdomen is wide and has an oval or round shape.
- Abdomen may have a flat, leaf-like appearance.

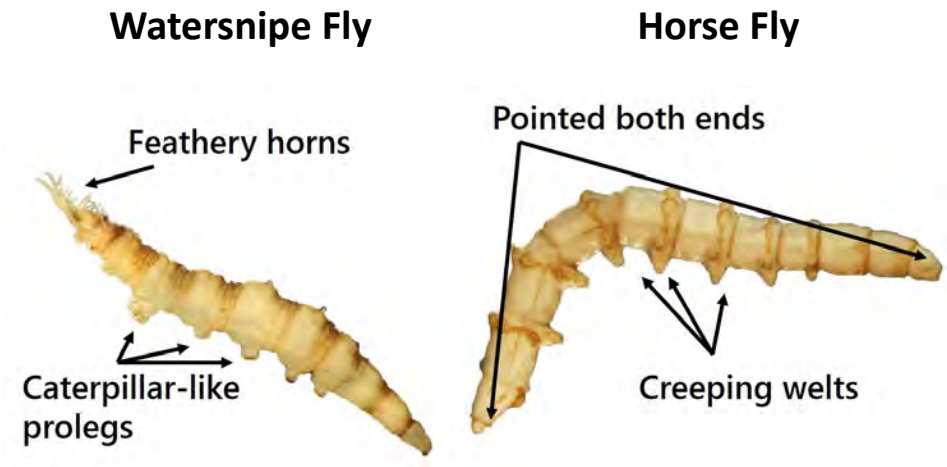
Somewhat Pollution Tolerant: Watersnipe Fly Larvae

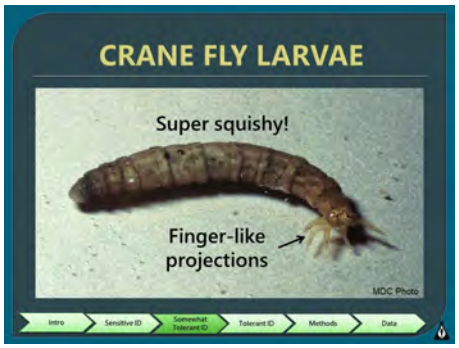




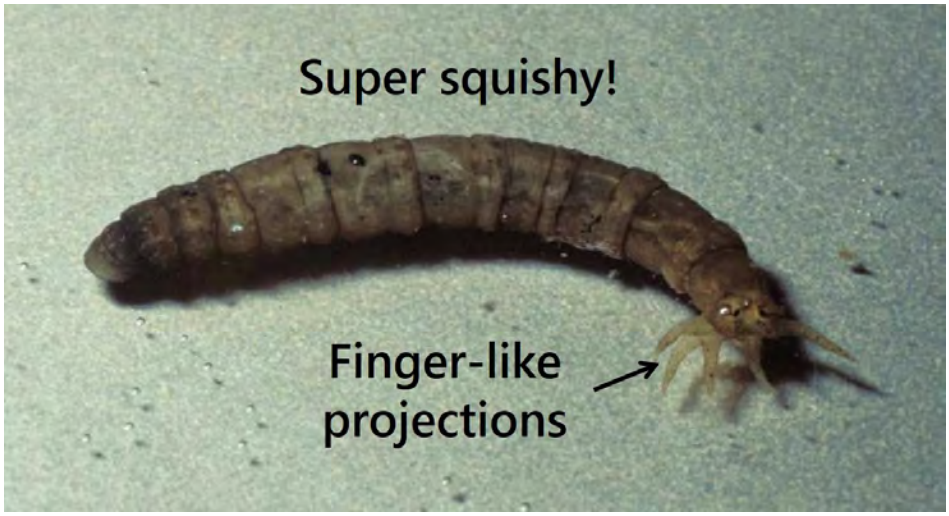
Distinguishing Features:

- Watersnipe fly larvae can be identified by caterpillar-like prolegs on each body segment and two feathery horns at the end of the abdomen.
- Medium size, about half an inch.
- Worm-like appearance with distinct body segments.
- Can be difficult to distinguish from other organisms such as horse flies and crane flies from the order Diptera.





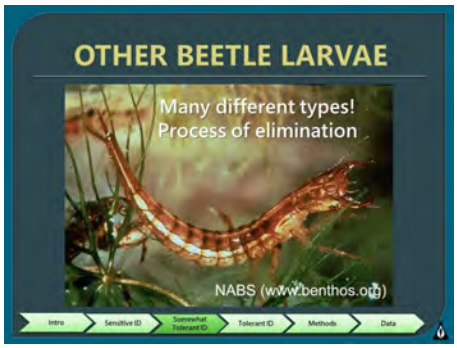
Somewhat Pollution Tolerant: Crane Fly Larvae



Distinguishing Features:

- Very squishy segmented body.
- Often appear transparent.
- Common species found are quite large, up to several inches.
- Abdomen ends in several finger-like lobes. A smaller species of crane fly has an abdomen that ends in an enlarged lobe resembling a turnip shape.

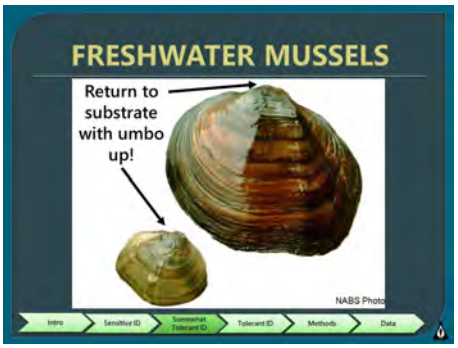
Somewhat Pollution Tolerant: Other Beetle Larvae



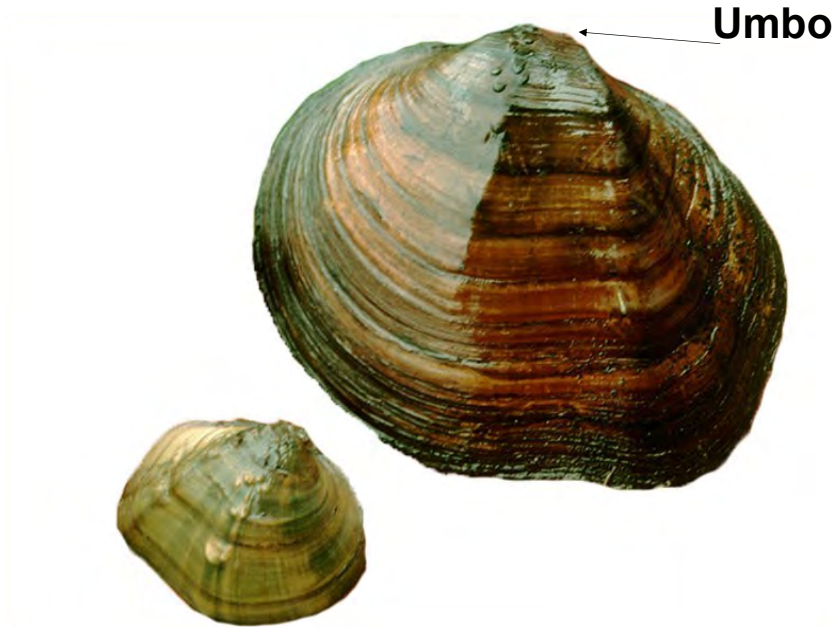
Besides riffle beetles and water pennies, volunteers may find the larvae of other aquatic beetles. If a volunteer finds something they cannot easily identify, use the Blue Bug Card or a dichotomous key. It may be identified as an other beetle larva in a process of elimination. Beetles are a diverse group and have features similar to other taxa counted on the data sheet. When reporting these, simply lump them together under the ***"Other Beetle"*** category on your data sheet.

A few characteristics include:

- 6 segmented legs
- Visible mouth parts



Somewhat Pollution Tolerant: Freshwater Mussels and Clams

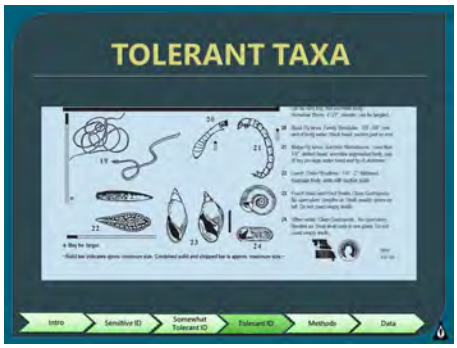


Nationwide, it is estimated that over 70% of native mussels are either threatened or endangered. Likewise, Missouri is facing similar declines in its native mussel populations. Native mussels and clams in Missouri include the maple leaf mussel and fingernail clam, so named because of its small, fingernail-like shape. The Asiatic clam is a foreign species to Missouri, although it has become very abundant in some watersheds. The Asiatic clam can typically be distinguished from native mussels by their symmetrical shape, centered umbo, and strong shell with many ridges. The zebra mussel is another non-native species in Missouri. They have distinctive stripes and unlike our other mussels, they attach themselves to any solid object, often forming extensive colonies that become a nuisance and negatively impact aquatic ecosystems.

Asiatic Clam

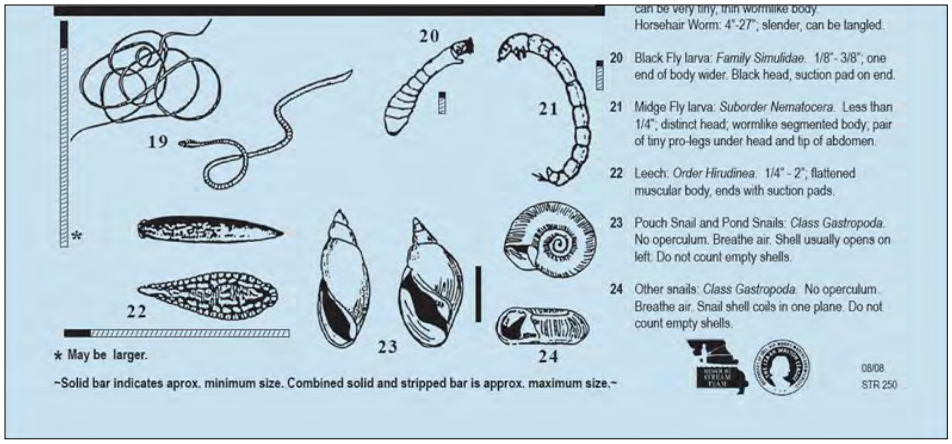
Volunteers are strongly encouraged to return all native clams and mussels to the stream as quickly as possible. Mussels must be placed upright in the substrate with the umbo pointed up. ***If you find an empty shell, do not count it on your Macroinvertebrate Data Sheet.***

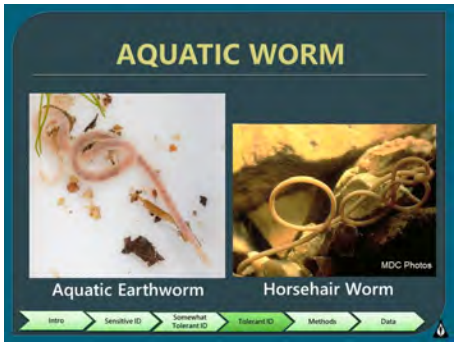
Pollution Tolerant Taxa



The following set of macroinvertebrates are pollution tolerant organisms. These organisms can be found in all river systems, both healthy and impaired. The abundance of tolerant invertebrates compared to the abundance of sensitive invertebrates is an important observation when determining the health of a stream:

- Aquatic Worm
- Midge Fly Larva
- Black Fly Larva
- Leech
- Pouch Snail
- Other Snail



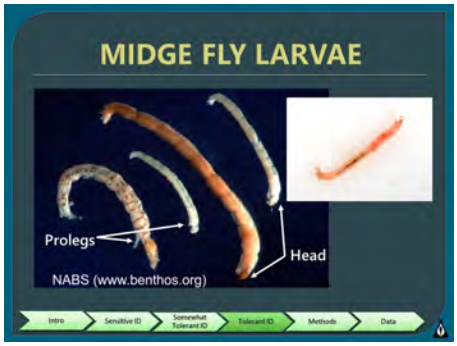


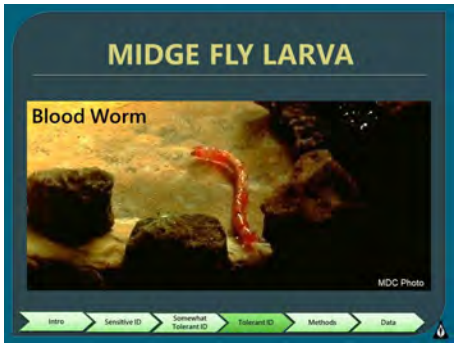
Pollution Tolerant: Aquatic Worm

Distinguishing Features:

- Segmented or unsegmented (horsehair worm).
- Long and thin.
- Often curl back around on themselves.
- Aquatic worms are longer than midge fly larvae.
- Count worms while picking from the net as they will become entangled and difficult to count from the tray.

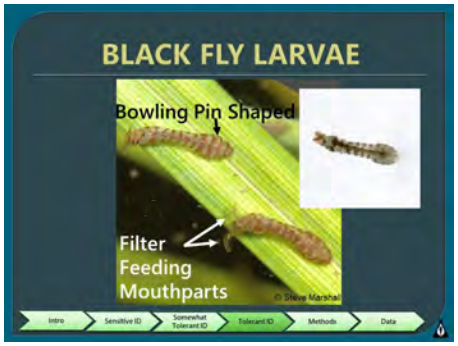
Pollution Tolerant: Midge Fly Larvae





Distinguishing Features:

- Very small larvae, usually less than 1/4 inch in length.
- Head is visible when viewed with magnification.
- Presence of two small prolegs located by the head and at the end of the abdomen. Prolegs are not segmented.
- Slightly curved, segmented body.

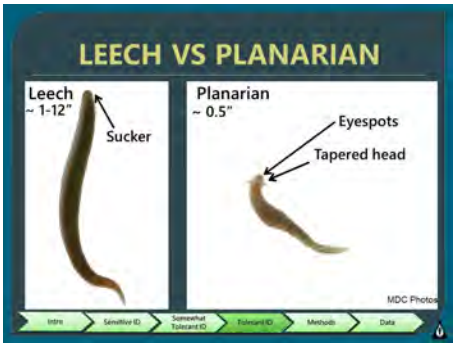


Pollution Tolerant: Black Fly Larvae

Distinguishing Features:

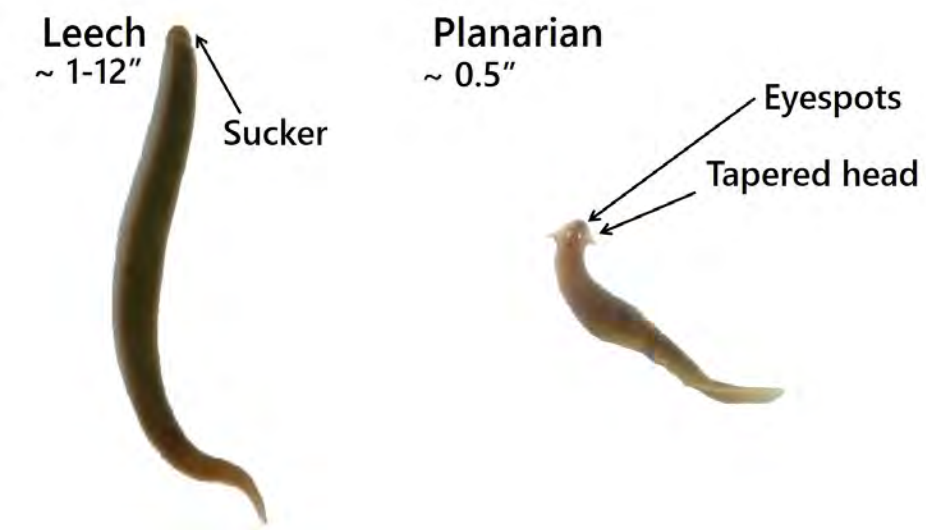
- Very small in size.
- Will readily attach to side of sorting tray or other objects in water.
- Wider on one end than the other(resembles a bowling pin), due to a ring on the posterior end of the animal used to attach itself to debris or rocks.
- Filter feeder with two fan-like structures on the head used to collect food out of the water.

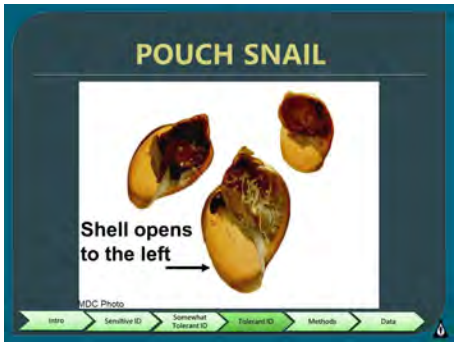
Pollution Tolerant: Leech



Distinguishing Features:

- Suction cup-shaped mouth. Another suction pad is located on the abdomen. These suction pads are used as the leech moves by muscular contraction and expansion.
- Long, flattened, muscular body 1-12 inches in length.
- Often brown, black, or mottled in color.
- Can be misidentified as a planarian. Planarians will have a tapered head, two eyespots, and have a gliding locomotion. The average length of a planarian is 0.5 inches while leeches can grow to several inches.





Pollution Tolerant: Pouch Snail

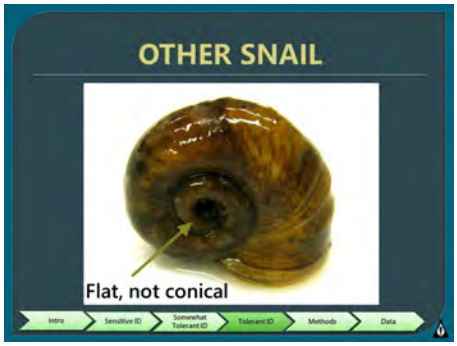
Distinguishing Features:

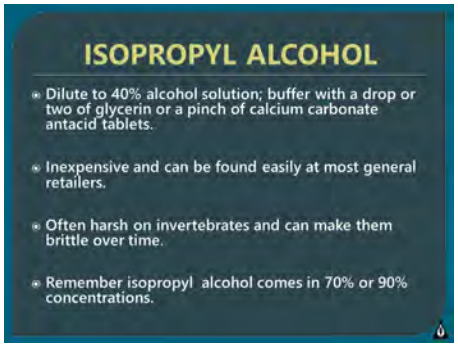
- Pouch snails are sometimes referred to as left-handed snails since the shell opens to the left when the point of the snail is held upwards.
- Also called lunged snails because they have a rudimentary lung to breathe air.
- No operculum.
- Do not count empty shells on data sheet.

Pollution Tolerant: Other Snails

Distinguishing Features:

- Snails that are ***not*** conical-shaped with an opening to the left or right.
- Shell will be coiled or look like a ram's horn.
- Do not count empty shells.

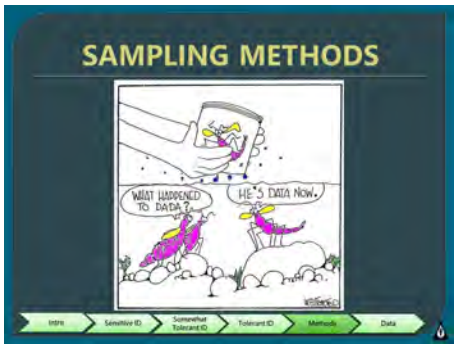


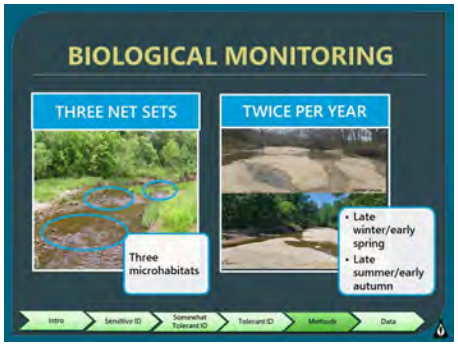


Invertebrate Species Preservation

Monitors may preserve specimens for aid in identification or as a reference collection. The preferred method of preservation is using ethyl alcohol (ethanol). Denatured alcohol with a high ethyl alcohol content may be used. See the Safety Data Sheet to determine alcohol content. If ethyl alcohol is not available, isopropyl alcohol (rubbing alcohol) may be used but is harsher on specimens.

1. Euthanize specimen in jar of 100% ethyl alcohol.
2. Place specimen in vial with 80% ethyl alcohol and 20% water.
3. Specimen may be placed in vial of hand sanitizer for easy viewing. This is best for small specimens. Instructions below:
    1. Euthanize specimen in alcohol.
    2. Fill vial part way with hand sanitizer; insert specimen
    3. Fill completely to top to avoid any air space between gel and cap; screw cap tightly. Use only for small specimens.
    4. Gel will break down and must be replenished occasionally.





Sampling Methods: Equipment Needed

To collect, sort, and analyze the invertebrates in your stream, you will need the following equipment:

- 3' X 3' Net*
- Forceps*
- Magnifying Lens*
- Sorting Pan or Tray
- Squirt Bottle
- Macroinvertebrate Data Sheet*

* *Indicates equipment provided by the Stream Team Program.*

Biological Monitoring

Macroinvertebrates should be sampled twice a year, once in the spring before the leaves appear and once in the fall before leaves drop. Sampling more often may destroy stream habitats.

When conducting your biological sampling, you will collect three net sets for replication within your 300-foot site. It is preferable that each net set is collected from three different microhabitats. For example, if you are sampling from riffles, choose three different microhabitats: the bottom of a riffle, a riffle area with vegetation, and a riffle area with leaf packs.

Habitat Types

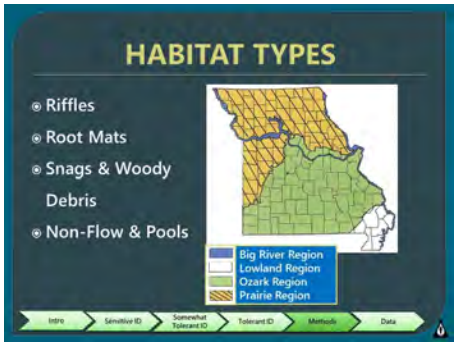
Missouri can be divided into four principle aquatic faunal regions: Big River, Lowland, Ozark, and Prairie. Each region is characterized by different habitats and fauna. Streams in the Ozark Region have many riffles, but they are less common in the Prairie Region due to the gradient of the land.

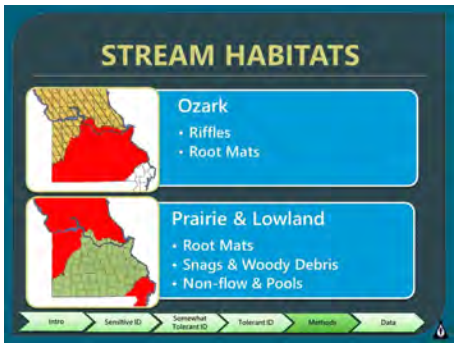
When sampling for macroinvertebrates, you will find different habitat types in different regions. You will commonly find riffles and root mats in the Ozark region. In the Prairie and lowland regions, you will characteristically have root mats, snags, and pools, but very few, if any, riffles.

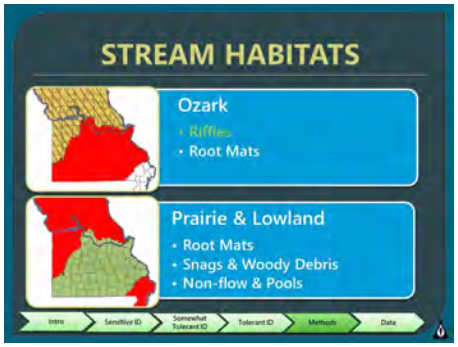
Stream Team protocol prefers you to sample the habitats in the following order. If you do not have a riffle, then look for a root mat next. If you fail to find one, then you can sample a snag or woody debris. Sample a non-flow or pool only as a last resort.

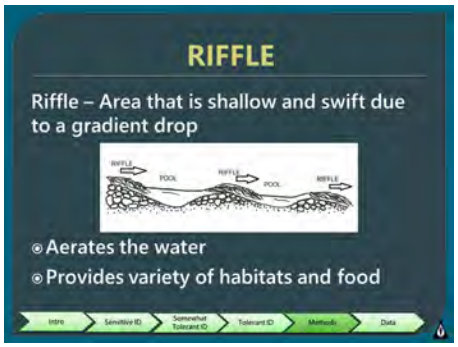
Priority Order for Sample Habitats

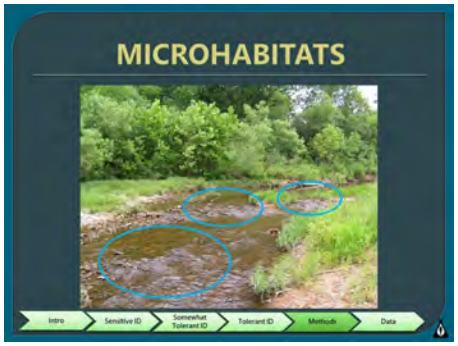
1. Riffles
2. Root Mats
3. Snags and Woody Debris
4. Non-Flow and Pools











Sampling Riffles

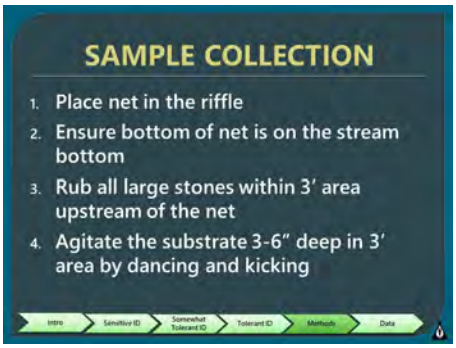
A riffle is an area in your stream where water breaks over the rocks due to a gradient drop in the stream bed. This action incorporates atmospheric oxygen into the water which results in higher dissolved oxygen levels needed for invertebrates to thrive. A riffle provides a variety of microhabitats for a diverse community of organisms.

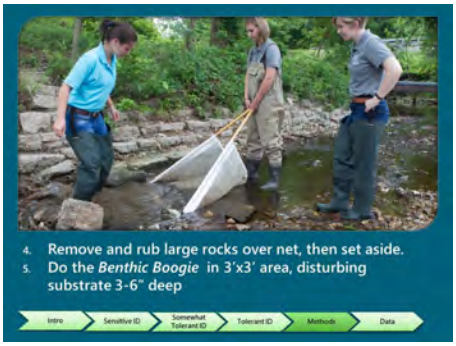
Since Stream Team protocol requires samples from three microhabitats, start with the most downstream microhabitat and work your way upstream. This prevents disturbing the other locations you will be sampling.

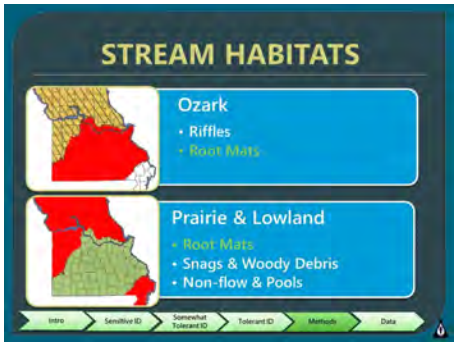
Sampling Riffles

Follow the process to collect samples of invertebrates in a riffle:

1. Place net in riffle.
2. Ensure bottom of net is on stream bottom and stretched taut side to side.
3. Weigh down the bottom of the net with large rocks.
4. Rub any large rocks in the sample area over the net, then set aside.
5. Agitate the stream bottom directly in front of the net in a 3' X 3' area, disturbing the substrate 3 to 6 inches deep. (Benthic Boogie!)
6. Remove and rub rocks weighing down the net.
7. Slowly lift the net from the stream, ensuring water does not pour over the sides.
8. Move the net to land to pick, sort, and identify invertebrates.







Sampling Root Mats

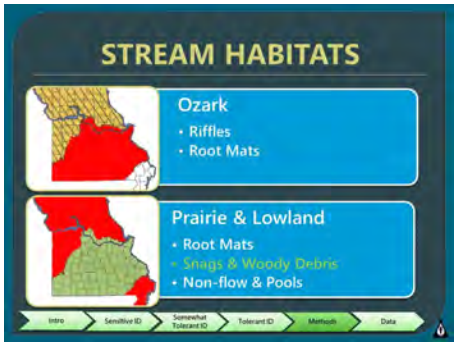
Root mats are the fibrous roots from vegetation that hang over a stream bank and into the water. Damselflies, dragonflies, mayflies, caddisflies, and midges are common in root mats. Use the following process to sample macroinvertebrates from root mats:

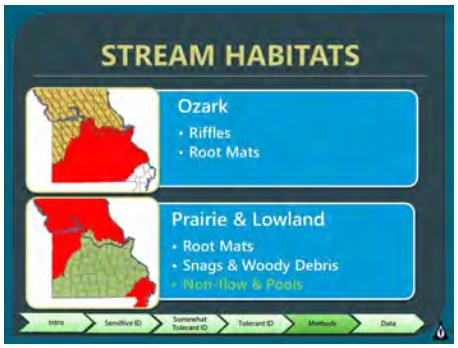
1. Place net downstream of root mat.
2. Kick and swirl water through roots into the net.
3. Slowly lift the net from the stream, ensuring water does not pour over sides.
4. Move the net to land to pick, sort, and identify invertebrates.

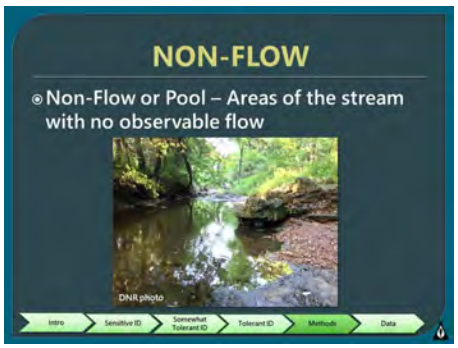
Sampling Snags and Woody Debris

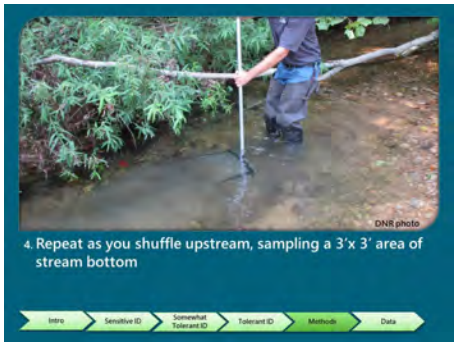
If your site has no riffles or root mats, you can sample snags or woody debris. When tree limbs, logs, and sticks fall into a stream and begin to decompose, the material becomes soft and provides a microhabitat for invertebrates. Follow the process below when sampling snags or woody debris:

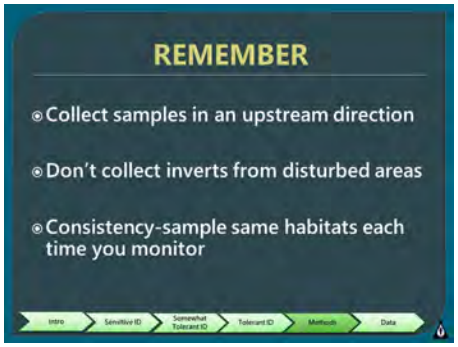
1. Place net below the woody debris.
2. Scrub the debris using a brush.
3. Slowly lift the net from the water.
4. Move the net to land to pick, sort, and identify invertebrates.
5. Repeat steps 1 to 4 to sample three to five snags for one net set.











Sampling Non-Flow

If no other habitats exist at your monitoring site, you can sample in pools or non-flow areas. Use a D-net and the following process to collect your samples from these microhabitats:

1. Hold D-frame net downstream of where you stand in the water.
2. Shuffle feet to disturb substrate 6-12'' deep if possible.
3. Sweep net side to side or in a circular motion just above substrate.
4. Repeat as you shuffle upstream, sampling a 3' by 3' area of stream bottom

Sampling Tips

- Prioritize habitats to monitor according to stream team protocol:

    1. Riffles
    2. Root Mats
    3. Snags and Woody Debris
    4. Non-flow or pools

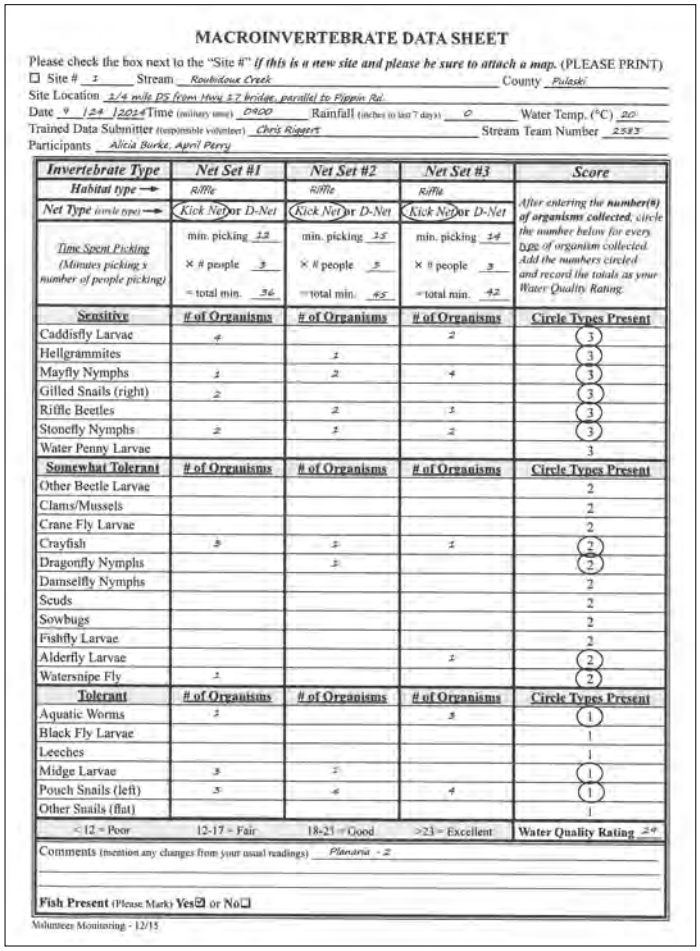
- Collect samples in an upstream direction.
- Do not collect invertebrates from disturbed areas.
- Be consistent in the habitats you sample.
- Sample macroinvertebrates twice a year; once in the spring and once in the fall.

Completing the Macroinvertebrate Data Sheet

After you have collected a sample, begin the process of sorting, identifying, and counting each type of invertebrate. Record your findings on the Macroinvertebrate Data Sheet. This process will be repeated for each of the three net sets:

1. Remove invertebrates from the net and place them into your sorting tray.
2. Record the time spent removing invertebrates.
3. Identify invertebrates.
4. Count invertebrates and record your findings on the data sheet.

As with every data sheet you submit, be sure the header information is filled out entirely. For each of the three net sets, you will record the ***Habitat Type*** and select the ***Net Type*** you used. Record the amount of time it took to pick invertebrates from the net and the number of people that helped. Identify the organisms in the sorting tray and record the quantity of each variety found. After all three net sets have been completed, circle the number in the far right column called ***Score.*** If the taxa was present in any of the three net sets, circle the corresponding number. Once all data has been recorded, add up the scores to get the final water quality rating.



MACROINVERTEBRATE DATA SHEET

Please check the box next to the "Site #" *if this is a new site and please be sure to attach a map.* (PLEASE PRINT)

☐ Site # 1 Stream Roubidoux Creek County Pulaski

Site Location 1/4 mile DS from Hwy 17 bridge, parallel to Flippin Rd.

Date 9 / 24 / 2014 Time (military time) 0900 Rainfall (inches in last 7 days) 0 Water Temp. (°C) 20

Trained Data Submitter (responsible volunteer) Chris Riggert Stream Team Number 2583

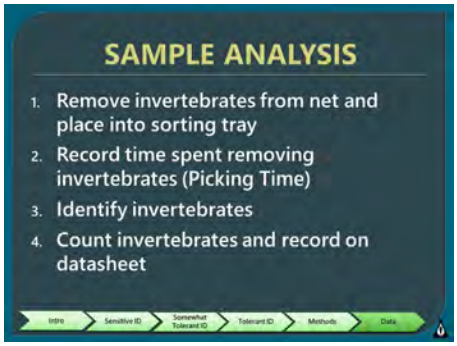
Participants Alicia Burke, April Perry

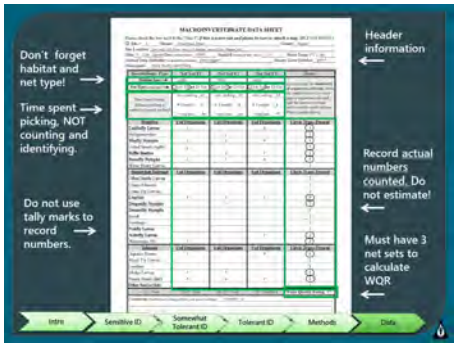
Invertebrate Type	Net Set #1	Net Set #2	Net Set #3	Score
Habitat type →	Riffle	Riffle	Riffle	After entering the number(#) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the totals as your Water Quality Rating.
Net Type (circle type) →	Kick Net or D-Net	Kick Net or D-Net	Kick Net or D-Net	
Time Spent Picking (Minutes picking x number of people picking)	min. picking 12 × # people 3 = total min. 36	min. picking 15 × # people 3 = total min. 45	min. picking 14 × # people 3 = total min. 42	
Sensitive	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Caddisfly Larvae	4		2	(3)
Hellgrammites		1		(3)
Mayfly Nymphs	1	2	4	(3)
Gilled Snails (right)	2			(3)
Riffle Beetles		2	1	(3)
Stonefly Nymphs	2	1	2	(3)
Water Penny Larvae				3
Somewhat Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Other Beetle Larvae				2
Clams/Mussels				2
Crane Fly Larvae				2
Crayfish	3	1	1	(2)
Dragonfly Nymphs		1		(2)
Damselfly Nymphs				2
Scuds				2
Sowbugs				2
Fishfly Larvae				2
Alderfly Larvae			1	(2)
Watersnipe Fly	1			(2)
Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Aquatic Worms	1		3	(1)
Black Fly Larvae				1
Leeches				1
Midge Larvae	3	1		(1)
Pouch Snails (left)	3	4	4	(1)
Other Snails (flat)				1
<12 = Poor	12-17 = Fair	18-23 = Good	>23 = Excellent	**Water Quality Rating** 24

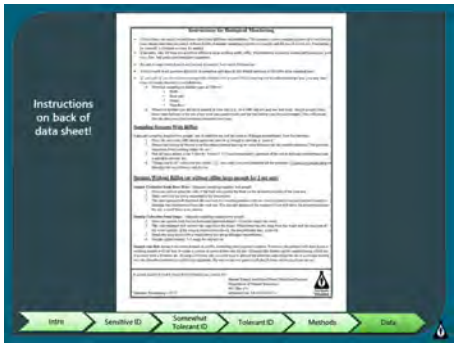
Comments (mention any changes from your usual readings) Planaria - 2

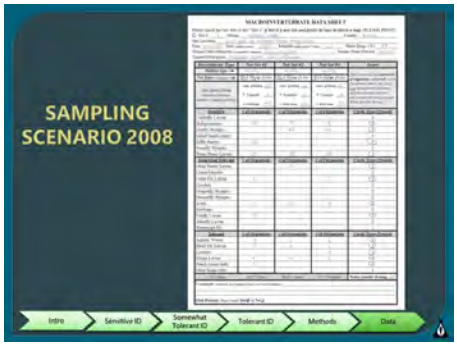
Fish Present (Please Mark) **Yes**☑ or **No**☐

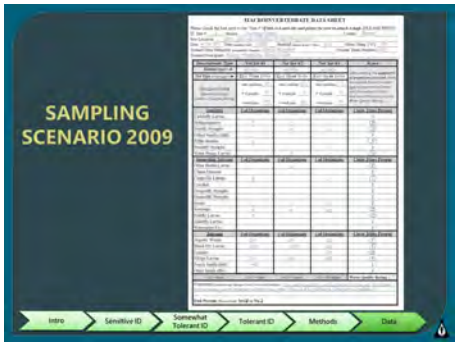
Volunteer Monitoring - 12/15

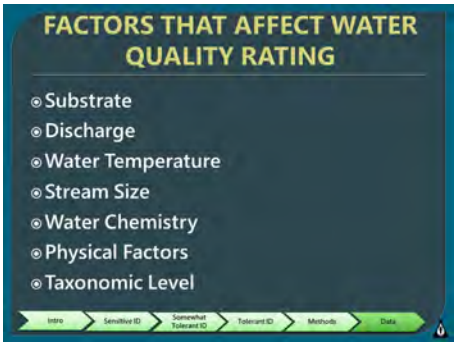












Factors Affecting Biological Water Quality Rating

There are many factors that affect the biological water quality rating. Some of these include:

- ***Substrate:*** The type of habitat the stream provides will affect the rating. Silt and sand-bottomed streams will generally have lower ratings than cobble-bottomed Ozark streams due to poor habitat availability.
- ***Discharge, Depth and Velocity:*** Sensitive organisms prefer water with some velocity because it helps to keep oxygen levels high. Too much velocity though, can result in a lower water quality rating. An example of this would be when rain events generate deep, fast flows in which organisms can be swept away.
- ***Season:*** Many invertebrates are insect larvae and emerge at varying times of the year. If you conduct your biological monitoring when they are in the adult stage, your rating will be lowered.
- ***Water Temperature:*** Very warm streams, like those with no riparian corridor or those in urban areas that are partially paved, will not hold much oxygen and will not support aquatic life.
- ***Stream Size:*** Invertebrate communities are dependent on the characteristics associated with stream size.
- ***Water Chemistry:*** A balance of chemical constituents must be maintained to support aquatic life. Imbalances will result in changes in the stream that will alter what organisms can live there. Certain chemicals are toxic and if present in large enough quantities, will kill all life in a stream.
- ***Physical Factors:*** Habitat, flow, and rates of soil erosion are all physical factors that affect aquatic life. Poor ratings can often be attributed to physical problems in the stream.
- ***Level of Taxonomy:*** Our program identifies many macroinvertebrates to class, order, and family based on ability to identify stream-side. A general pollution sensitivity is assigned to this level. However, a given taxa may have a genus or species more tolerant than others. For example, mayflies are considered pollution sensitive on the data sheet, but there are some species of mayfly that are actually somewhat pollution tolerant.

Biological Monitoring Analysis

How does the collection and identification of macroinvertebrates aid in determining overall water quality of a stream? The four scenarios below illustrate how density and diversity of macroinvertebrates in a stream can aid in determining the health or impairment of a stream.

Scenario 1

Observations of Macroinvertebrates	Water Quality Analysis
• High density • High diversity • Many sensitive taxa (stoneflies, caddisflies, mayflies)	

Scenario 2

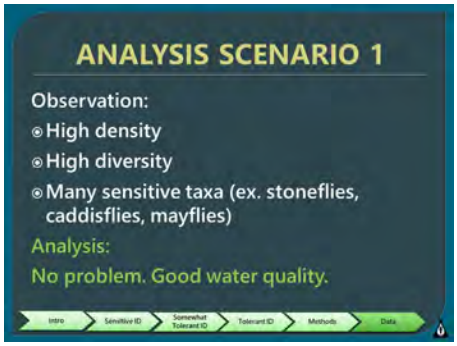
Observations of Macroinvertebrates	Water Quality Analysis
• Low density • High diversity	

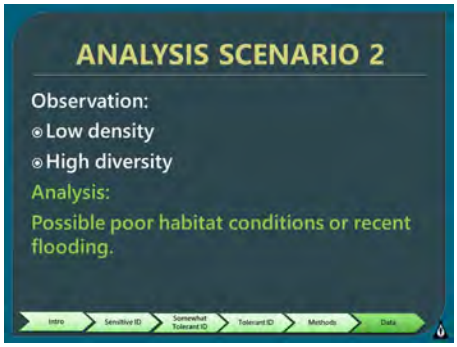
Scenario 3

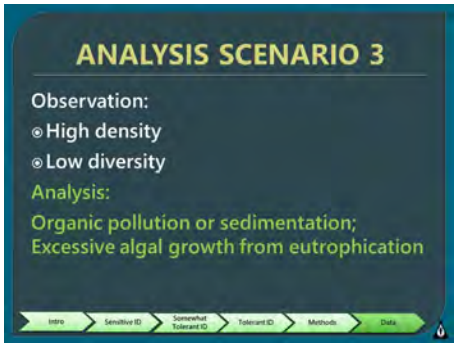
Observations of Macroinvertebrates	Water Quality Analysis
• High density • Low diversity	

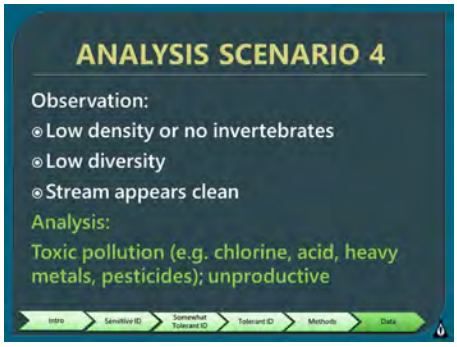
Scenario 4

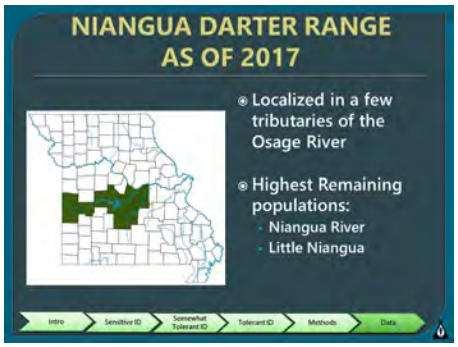
Observations of Macroinvertebrates	Water Quality Analysis
• Low density or no invertebrates • Low diversity • Stream appears clean	











Other Organisms to Consider

As you begin your monitoring efforts, there are a few additional organisms for you to consider. Niangua Darters are small fish that are endangered in Missouri and federally threatened. Located in a few tributaries along the Osage River, their highest remaining populations can be found in the Niangua and Little Niangua rivers. Because the Niangua Darter spawns in riffles, kicking up macroinvertebrates can be detrimental to spawning and future populations. Consequently, do not conduct macroinvertebrate monitoring in the following streams from March 15 through June 15.

<u>Niangua River Watershed</u>

- Niangua River
- Greasy Creek
- Little Niangua River

<u>Little Niangua River Watershed</u>

- Macks Creek
- Starks Creek
- Thomas Creek
- Cahoochie Creek

<u>Sac River Watershed</u>

- Sac River
- Bear Creek
- Brush Creek
- Panther Creek
- North Dry Sac River

<u>Tavern Creek Watershed</u>

- Tavern Creek
- Barren Fork
- Brushy Fork
- Kenser Creek
- Little Tavern Creek

<u>Other Streams</u>

- Pomme de Terre River
- South Fork Pomme de Terre River
- Little Pomme de Terre River
- Maries River
- Little Maries Creek

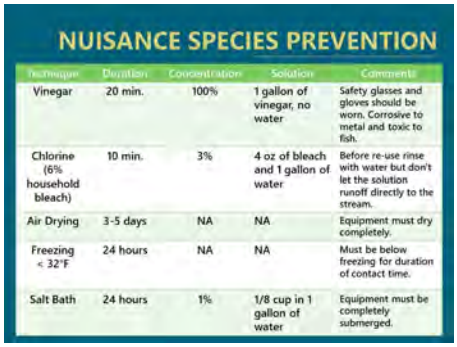
Other Organisms to Consider

Please be mindful of nuisance species, too. Some of the invasive species in Missouri's streams include:

- Zebra mussel
- Chinese mystery snail
- Rusty crayfish
- Hydrilla

To prevent spreading these species to even more streams, be sure to clean and dry your equipment, boots, and boats after being in the water. This is especially true if you monitor more than one stream. The table below provides guidelines on how to prevent the spread of these species from one stream to another.

Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	I gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use, rinse with water but do not let the solution runoff directly to a stream
Air Drying	3-5 days	NA	NA	Equipment must dry completely
Freezing <32° F	24 hours	NA	NA	Must be below freezing for duration of contact time
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged



Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	1 gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish.
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use rinse with water but don't let the solution runoff directly to the stream.
Air Drying	3-5 days	NA	NA	Equipment must dry completely.
Freezing < 32°F	24 hours	NA	NA	Must be below freezing for duration of contact time.
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged.

NOTES

Aquatic Macroinvertebrates Characteristics Chart

This chart was designed to aid in the identification of aquatic macroinvertebrates and is a supplement to the dichotomous key in Chapter 4 of your Introductory Notebook, Stream Insects & Crustaceans "blue bug card" and the Key to Macroinvertebrate Life in the River.

Key:
× = present
✓ = sometimes present

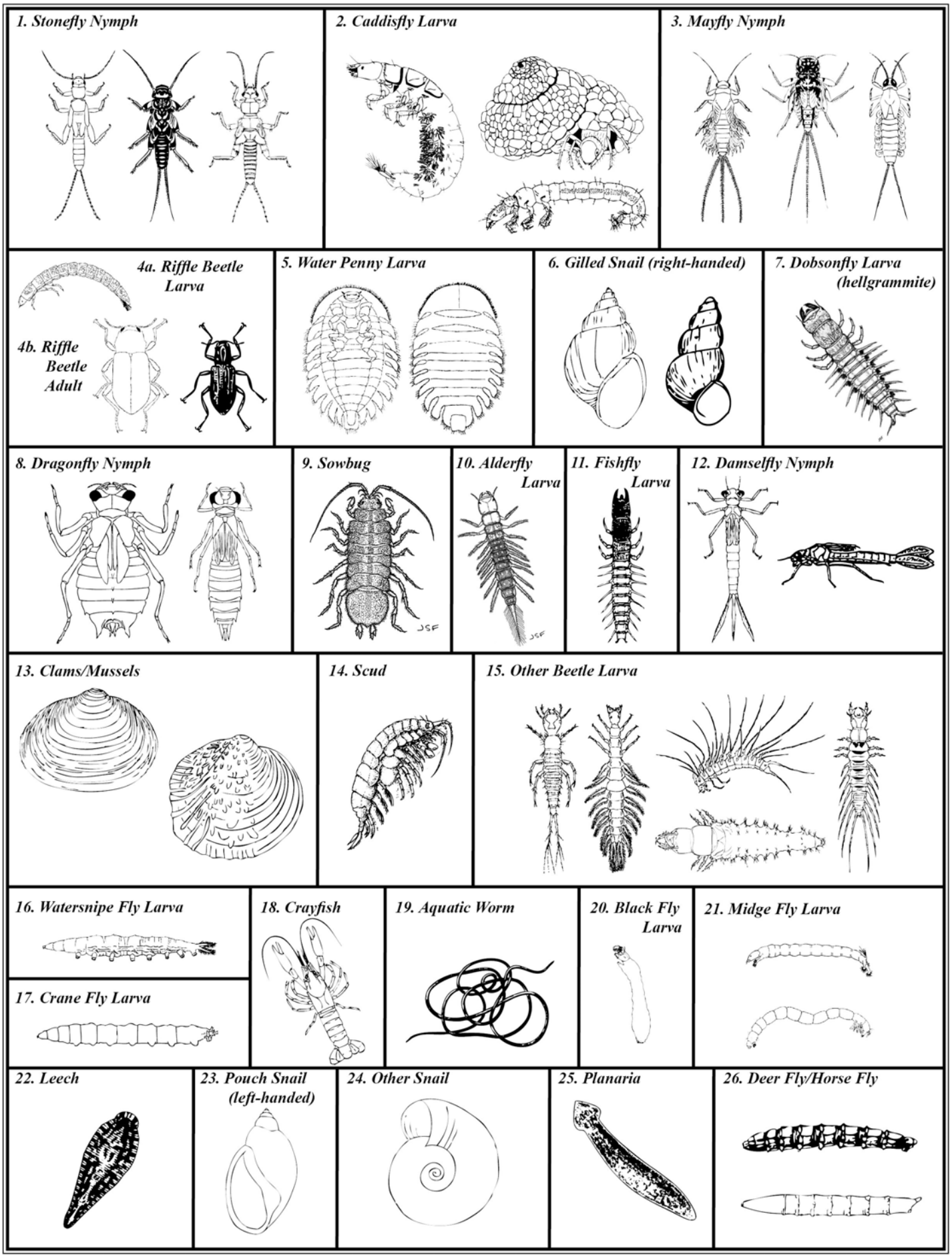
				Head						Thorax							Abdomen					
	Flattened body	Shell	Caterpillar-like	Distinct head	Large eyes	Obvious antennae	Obvious mouth parts	Mask-like lower lip	No legs	Prolegs	Six segmented legs	More than six segmented legs	Gills	Hard plate(s)	Wings/Wing pads	Gills	Hard plate(s)	Lateral filaments	Prolegs	Hooked prolegs	Suction pad(s)	Tail(s)
1. Stonefly Nymph	✓			×		×					×		✓		×							×
2. Caddisfly Larva				×							×			×		✓				×		
3. Mayfly Nymph	✓			×		✓					×				×	×						×
4a. Riffle Beetle Larva				×							×			×			×					
4b. Riffle Beetle Adult				×		×					×			×								
5. Water Penny Larva	×			×							×			×		✓	×					
6. Gilled Snail (right-handed)		×							×													
7. Dobsonfly Larva (hellgrammite)	✓			×			×				×			×		×		×		×		
8. Dragonfly Nymph	✓			×	×	×	×	×			×				×							
9. Sowbug	×					×						×		×			×					
10. Alderfly Larva	✓			×			×				×			×				×				×
11. Fishfly Larva	✓			×			×				×			×				×		×		
12. Damselfly Nymph				×	×	×	×	×			×				×							×
13. Clam/Mussel		×							×													
14. Scud	×			×		×						×		×			×					
15. Other Beetle Larva	✓			×		✓	×				×			✓			✓	✓				✓
16. Watersnipe Fly Larva			×						×										×			
17. Crane Fly Larva			×						×													
18. Crayfish					×	×						×		×			×					×
19. Aquatic Worm									×													
20. Black Fly Larva				×					×	×											×	
21. Midge Fly Larva				×					×	×									×			
22. Leech	×								×												×	
23. Pouch Snail (left-handed)		×							×													
24. Other Snails		×							×													

Other macroinvertebrates you may encounter that are not included in our count/protocol.

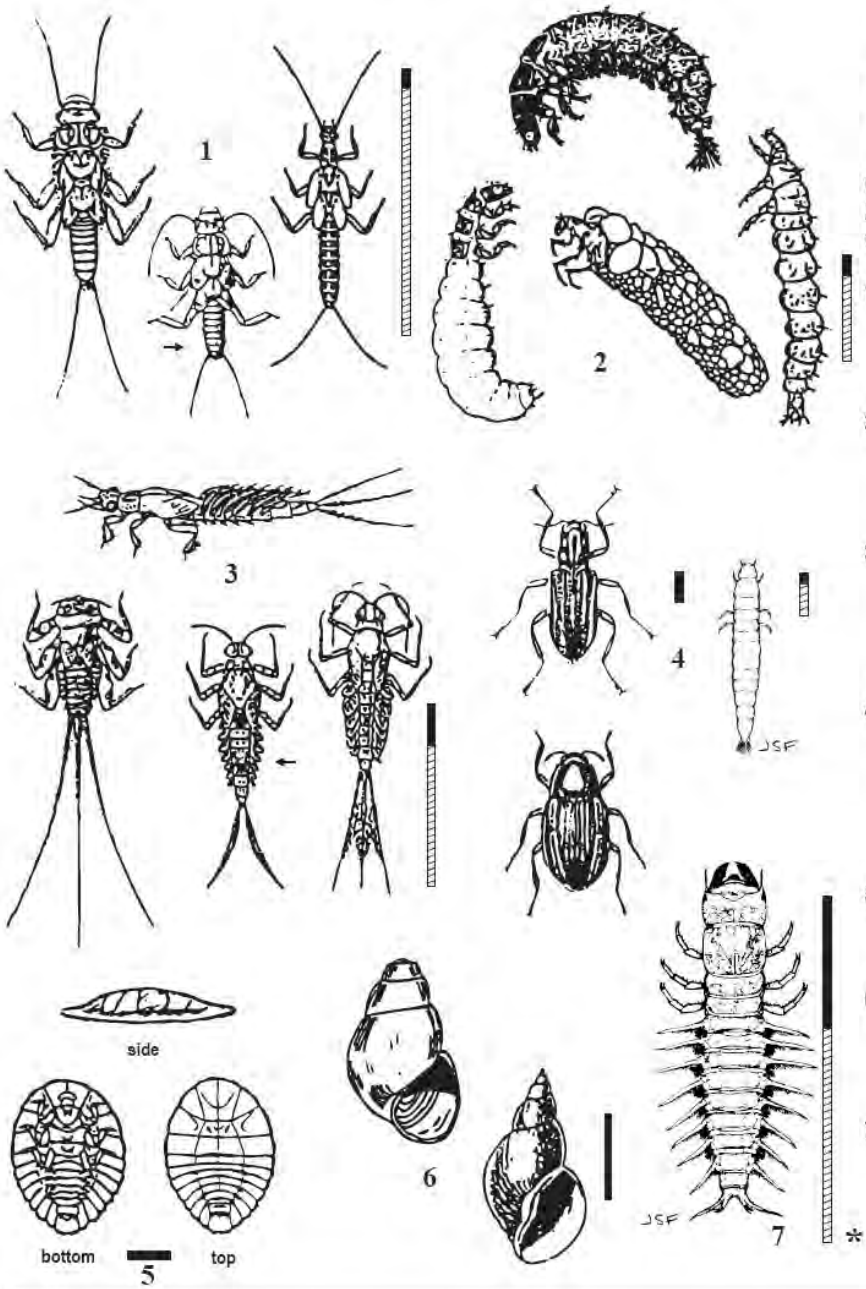
25. Planaria	×			×					×													
26. Deer Fly/Horse Fly			×						×													

Images by Bouchard, R.W., Jr. 2004. Guide to Aquatic Macroinvertebrates of the Upper Midwest, except where otherwise noted.

02/10
STR 423


1. Stonefly Nymph
2. Caddisfly Larva
3. Mayfly Nymph
4a. Riffle Beetle Larva
4b. Riffle Beetle Adult
5. Water Penny Larva
6. Gilled Snail (right-handed)
7. Dobsonfly Larva (hellgrammite)
8. Dragonfly Nymph
9. Sowbug
10. Alderfly Larva
11. Fishfly Larva
12. Damselfly Nymph
13. Clams/Mussels
14. Scud
15. Other Beetle Larva
16. Watersnipe Fly Larva
17. Crane Fly Larva
18. Crayfish
19. Aquatic Worm
20. Black Fly Larva
21. Midge Fly Larva
22. Leech
23. Pouch Snail (left-handed)
24. Other Snail
25. Planaria
26. Deer Fly/Horse Fly

Stream Insects & Crustaceans



GROUP ONE TAXA

Pollution sensitive organisms found in good quality water.

1 Stonefly nymph: *Order Plecoptera*. 1/8" - 1 1/2"; 6 legs with hooked tips; 2 hairlike tails. Smooth (no gills) on abdomen (see arrow). May have gills on thorax under the legs.

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

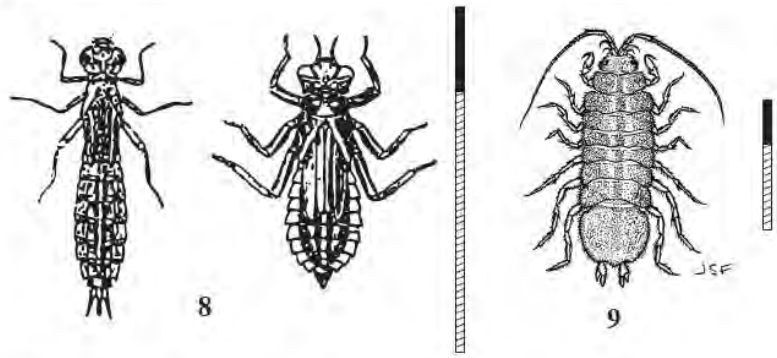
3 Mayfly nymph: *Order Ephemeroptera*. 1/4" - 1"; moving, platelike, or feathery gills on abdomen (see arrow); 6 large hooked legs; antennae; 2 or 3 long, hairlike tails. Tails may be webbed together.

4 Riffle Beetle: *Order Coleoptera*. Adult: Tiny, 6-legged beetle; crawls slowly on the bottom. Larva: Entire length of body covered with hard plates; 6 legs on thorax; uniform brown or black color. Combine number of adults & larvae when reporting total counts.

5 Water Penny larva: *Order Coleoptera*. 1/4"; flat saucer-shaped body, like a penny; segmented with 6 tiny legs underneath. Immature beetle.

6 Gilled Snail: *Class Gastropoda*. Shell opening covered by thin plate called operculum. When pointed up and opening facing you, the shell opens to right. Do not count empty shells.

7 Dobsonfly larva (hellgrammite): *Family Corydalidae*. 3/4" - 4"; dark-colored; 6 legs, large pinching jaws; eight pairs lateral filaments on lower half of body with paired cottonlike gill tufts along underside of lateral filaments; short antennae; 2 pairs of hooks at back end.



GROUP TWO TAXA

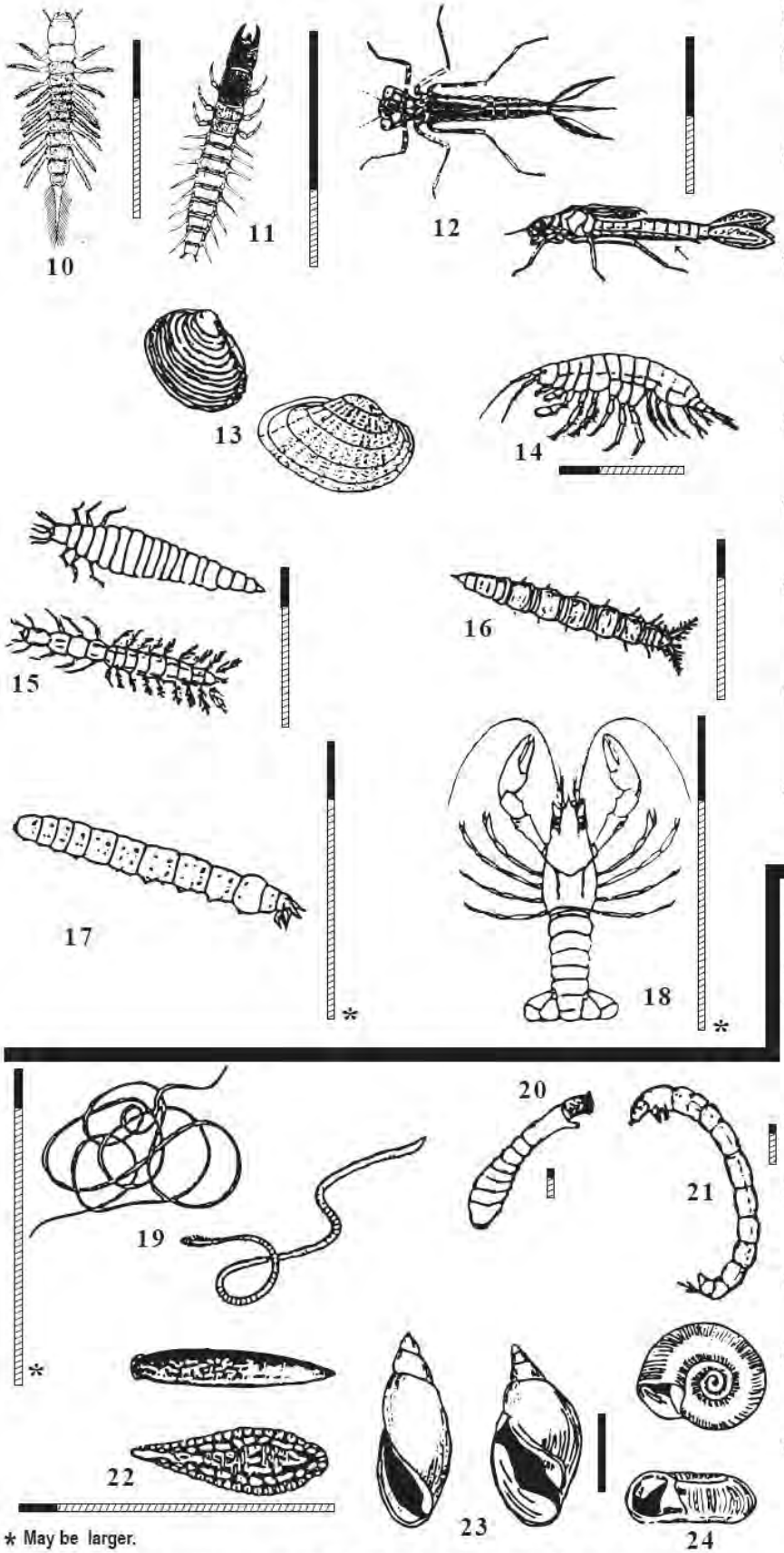
Somewhat pollution tolerant organisms can be in good or fair quality water.

8 Dragonfly nymph: *Suborder Anisoptera*. 1/2" - 2"; large eyes, 6 hooked legs. Wide oval to round abdomen, masklike lower lip.

9 Sowbug: *Order Isopoda*. 1/4" - 3/4"; gray oblong body wider than it is high, more than 6 legs, long antennae, looks like a 'roly poly.'

*** May be larger.**
~Solid bar indicates approx. minimum size. Combined solid and striped bar is approx. maximum size.~

Save Our Streams



GROUP TWO TAXA continued

10 Alderfly larva: *Family Sialidae*. 3/8"- 1"; looks like small hellgrammite but has 1 long, thin, branched tail at end of abdomen (no hooks). No gill tuft underneath the lateral filaments on abdomen.

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

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

13 Clam/Mussel: *Class Bivalvia*. Do not count empty shells.

14 Scud: *Order Amphipoda*. 1/4"- 3/4"; white to gray, body higher than it is wide; swims sideways; more than 6 legs; resembles small shrimp.

15 Other Beetle larva: *Order Coleoptera*. 1/4" - 1"; light-colored; 6 legs on upper half of body; feelers; antennae; obvious mouthparts. Diverse group.

16 Watersnipe Fly larva: *Family Athericidae (Atherix)*. 1/4" - 1"; pale to green; tapered body; many caterpillar-like legs; conical head; two feathery 'horns' at back end.

17 Crane Fly larva: *Suborder Nematocera*. 1/3" - 4"; milky, green, or light brown; plump caterpillar-like segmented body. May have enlarged lobe or fleshy fingerlike extensions at the end of the abdomen.

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

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

19 Aquatic Worm/Horsehair Worm: *Class Oligochaeta/ Phylum Nematomorpha*. Aquatic worm: 1/4"- 2"; can be very tiny, thin wormlike body. Horsehair Worm: 4"-27"; slender, can be tangled.

20 Black Fly larva: *Family Simulidae*. 1/8"- 3/8"; one end of body wider. Black head, suction pad on end.

21 Midge Fly larva: *Suborder Nematocera*. Less than 1/4"; distinct head; wormlike segmented body; pair of tiny prolegs under head and tip of abdomen.

22 Leech: *Order Hirudinea*. 1/4" - 6"; flattened muscular body, ends with suction pads.

23 Pouch Snail and Pond Snails: *Class Gastropoda*. No operculum. Breathe air. Shell usually opens on left. Do not count empty shells.

24 Other snails: *Class Gastropoda*. No operculum. Breathe air. Snail shell coils in one plane. Do not count empty shells.

*** May be larger.**

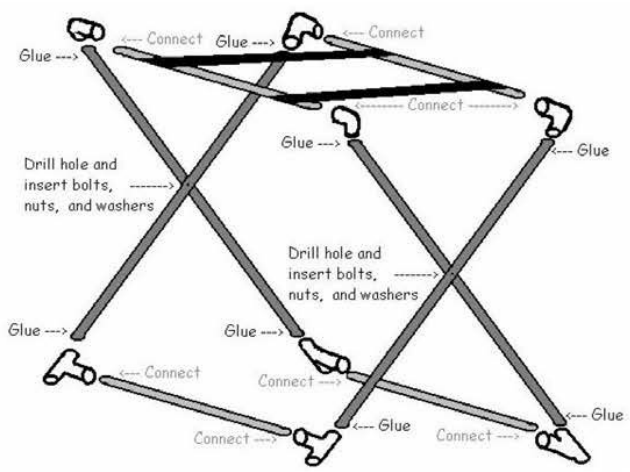
~Solid bar indicates approx. minimum size. Combined solid and striped bar is approx. maximum size.~

01/10
STR 250

PVC Net Rack

Materials

- Three 10 foot sections of 1 inch PVC pipe
- Four PVC elbows (1 inch - 90°)
- Four PVC 'T' connectors (1 inch - 90°)
- Two bolts (3 X 1/4 inch)
- Three lock nuts (1/4 inch)
- Four washers (1/4 inch)
- Canvas
- Heavy duty thread / twine
- Needle
- PVC cleaner and glue
- Tape measure
- Hacksaw and scissors
- Pliers
- Drill and 3/8 inch bit



Procedure

1. Cut two 10ft. PVC pipes into one 4ft. section and two 3 ft. sections.

2. Cut the third 10ft. PVC pipe into two 4 ft. sections.

3. Steps 1-3 will give you the legs (4ft. sections) and the cross supports (3 ft. sections).

4. Drill a hole in the 4ft pieces (2 ft. from the end).

5. Connect the legs (4 ft. sections) with a bolt, washer and lock nut.

6. Clean the ends of the legs and inside the 'T' connector with pipe cleaner and wipe off.

7. Put the 'T' sections (bottom of the 'T') onto either end of two cross pieces and make sure the 'T's" are lined up the same way. **Note: Do not glue these together. This allows you to dissemble the rack for transport.**

8. Apply PVC glue to both ends of the legs and inside the 'T' sections.

9. Attach the 90° elbows to the other end of the legs.

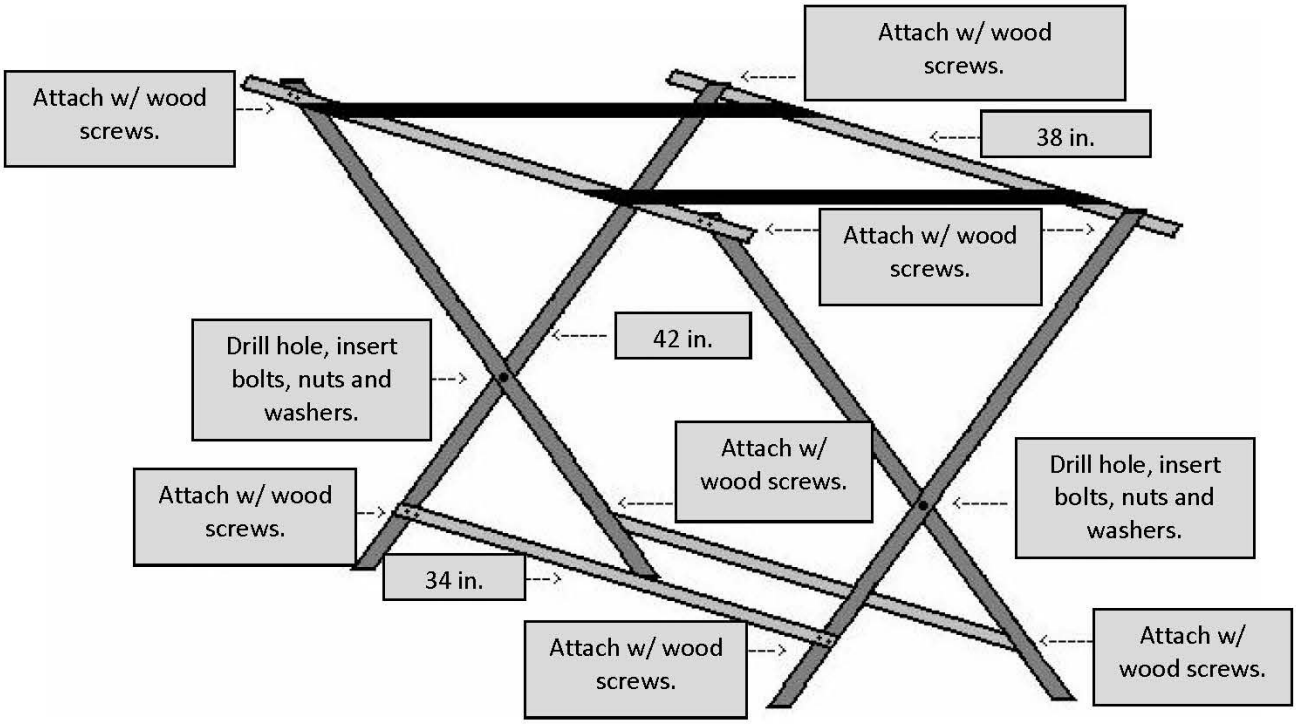
10. Cut the canvas to a length that will allow you to work off your bug rack at a comfortable height. **Note: The shorter the canvas the taller the rack.**

11. Loop the ends of the canvas around the top cross bar to the desired length and sew canvas loop closed.

12. Let the glue cure before use.

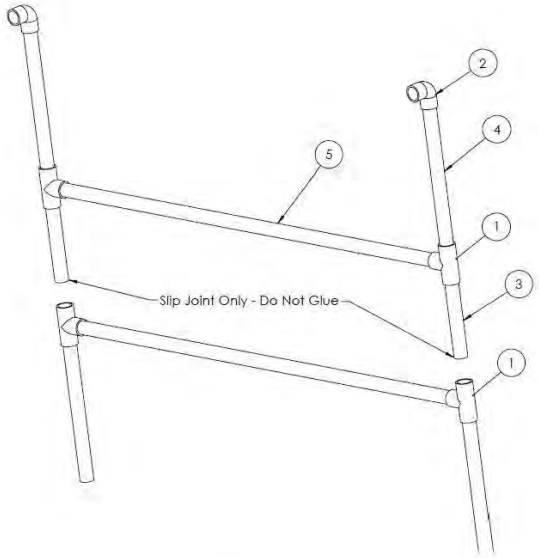
Wooden Net Rack

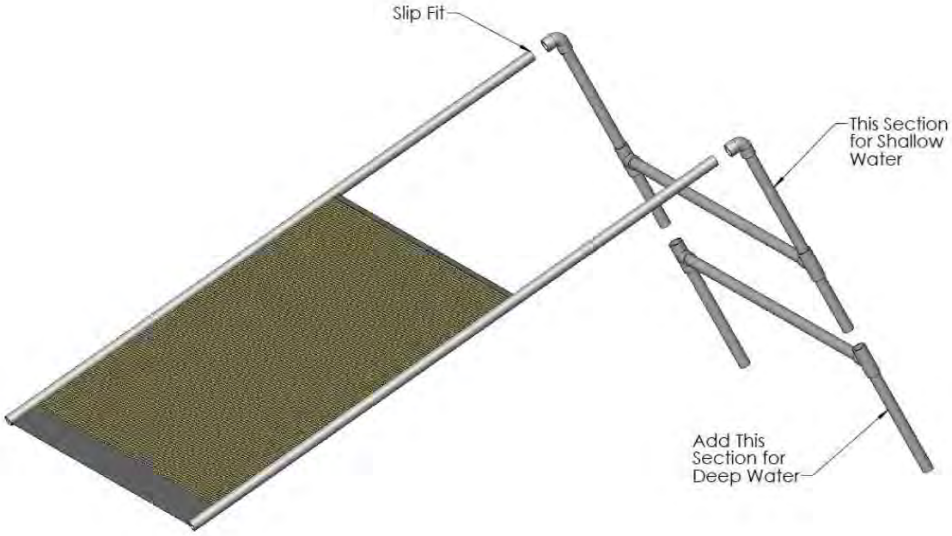
Part	Length
Lumber 1x2	42"
Lumber 1x2	1-34", 1-36" and 2-38"
Drywall Screws	1 3/4"
Bolts wit lock nuts	3"
Canvas strips	6" wide x 40" long



Free Standing Net

Item Number	Part	Length	Quantity
1	PVC 3/4" Tee		4
2	PVC 3/4" Elbow		2
3	PVC 3/4" Upright	8"	2
4	PVC 3/4" Upright	13"	4
5	Cross Bar	43" using 1 inch PVC	2





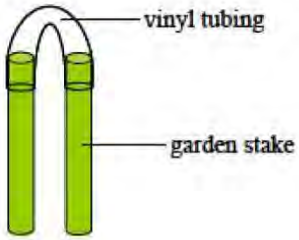
Plans for Freestanding Kicknet Support

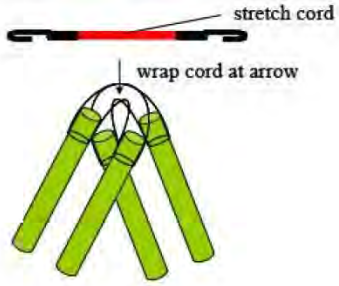
Materials

Quantity	Part	Length	Diameter
4	Steel core, plastic-coated garden stakes	4ft	3/8"
1	Clear vinyl tubing soft	6"	7/16" outside, 5/16" inside
1	Long stretch bungee cord with hooked ends or rope	10"	

Procedure

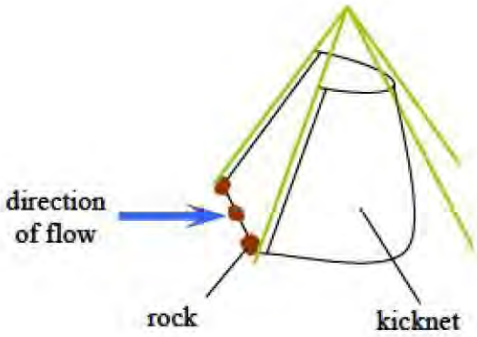
- Place a 3-inch piece of vinyl tubing onto the end of the garden stakes.
- Wrap the stretch cord around both pieces of vinyl tubing and interlock the hooks to create a flexible joint.





Practical Use

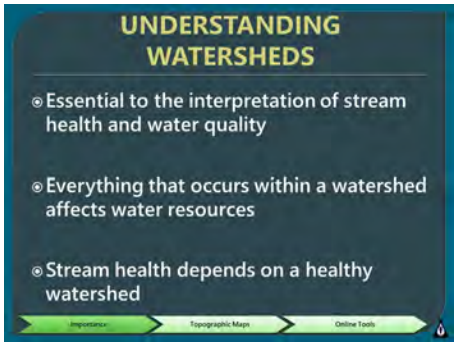
- Guide the looped edges on opposite sides of the kicknet onto tow supports.
- Lower the kicknet into the stream and step on the bottom edge to hold it in place in the flowing water.
- Place large rocks on the submerged edge of the kicknet to hold it firmly on the stream bottom.
- Position downstream supports to make a stable structure.
- When removing the kicknet from the stream, grab the bottom edge as you remove the rocks to prevent the loss of the sample.

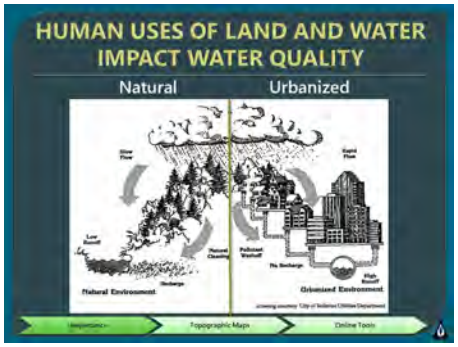


Chapter 6
Mapping and Online Tools

The stream site you monitor is just part of a much larger system. When analyzing stream health, it is important to take a holistic view by considering the entire watershed. This chapter will introduce you to:

- The importance of watershed mapping
- How to interpret topographic maps
- Utilizing online tools





Importance of Watersheds

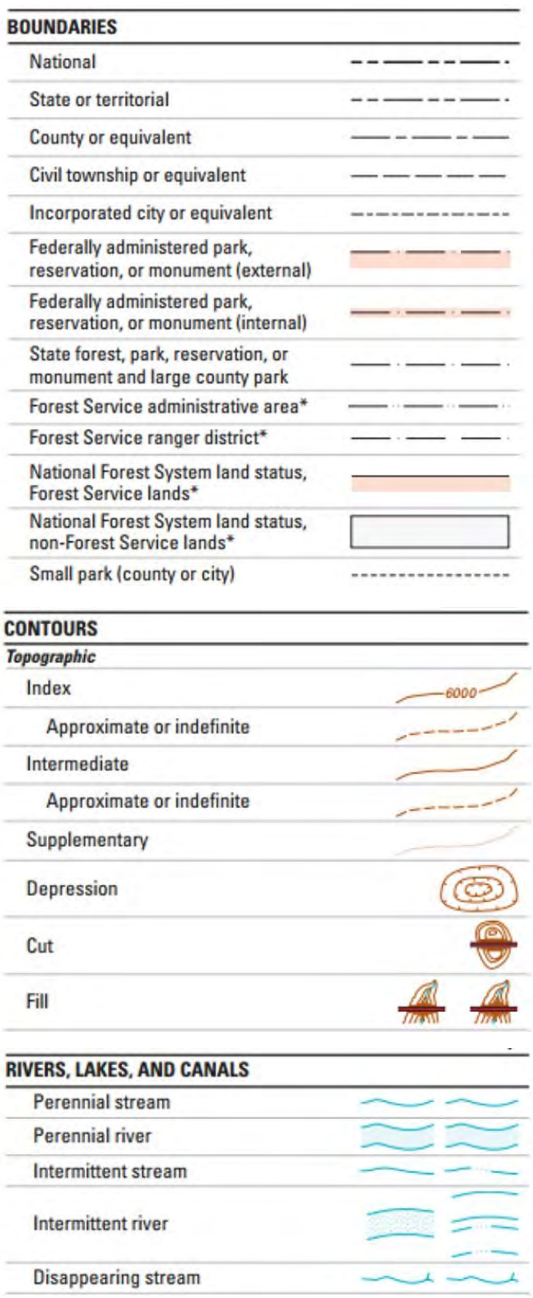
Knowing the boundaries of the watershed in which your stream site is located allows you to see the big picture when analyzing the health or impairment of a stream. Everything that occurs within a watershed affects the water resources in it. A healthy stream is a good indicator of a healthy watershed.

For example, consider the differences between natural and urbanized environments. Natural environments have a slower rate of overland flow due to plants, trees, and vegetation. This allows for the filtering of water before it enters a stream and a greater recharge of groundwater. Urbanized environments with concrete and other infrastructure has rapid overland flow. This results in higher runoff, no filtering and little or no groundwater recharge.

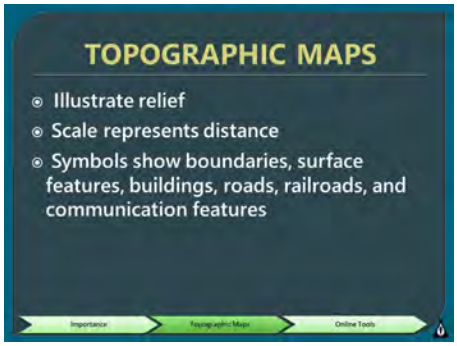
Mapping the watershed of your stream site has many benefits. It can help identify sources of pollution, aid in locating optimal monitoring sites, provide information to educate your local community leaders, and provide a sense of value. If your site is located in a large watershed, you may want to consider mapping a limited portion of it so it is more manageable. Once mapped, you can identify how the land within its boundaries is used and how this will affect your sampling results.

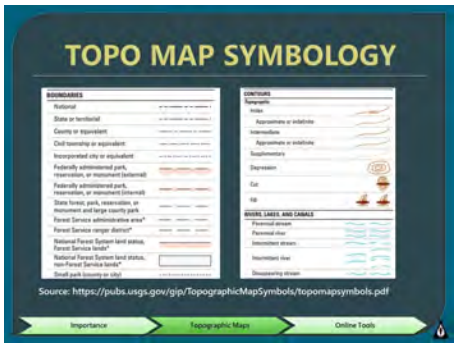
Topographic Maps

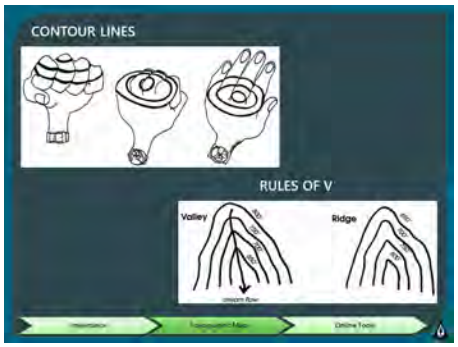
Because a watershed is defined by the topography of the land, a topographic map will be your best resource in defining the watershed for your stream site. Topographic maps represent a specific area of land or quadrangle; a four-sided region bounded by a particular latitude and longitude. These maps use contour lines to show the shape of the earth's surface. The contour lines make it possible to show the elevation and shape of mountains, hills, and the steepness of slopes. Maps are drawn to a scale that represent distance. This is a ratio comparing a measurement on the map to the distance you would find in real life between two points. Topographical maps will also use symbols to show boundaries, surface features, building, roads, railroads, and communication features. The following symbols are often used on a topographical map:

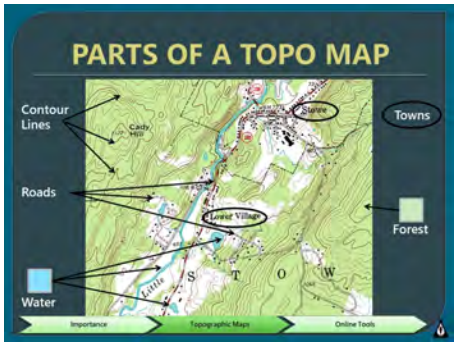


BOUNDARIES	
National	
State or territorial	
County or equivalent	
Civil township or equivalent	
Incorporated city or equivalent	
Federally administered park, reservation, or monument (external)	
Federally administered park, reservation, or monument (internal)	
State forest, park, reservation, or monument and large county park	
Forest Service administrative area*	
Forest Service ranger district*	
National Forest System land status, Forest Service lands*	
National Forest System land status, non-Forest Service lands*	
Small park (county or city)	
CONTOURS	
Topographic	
Index	6000
Approximate or indefinite	
Intermediate	
Approximate or indefinite	
Supplementary	
Depression	
Cut	
Fill	
RIVERS, LAKES, AND CANALS	
Perennial stream	
Perennial river	
Intermittent stream	
Intermittent river	
Disappearing stream	



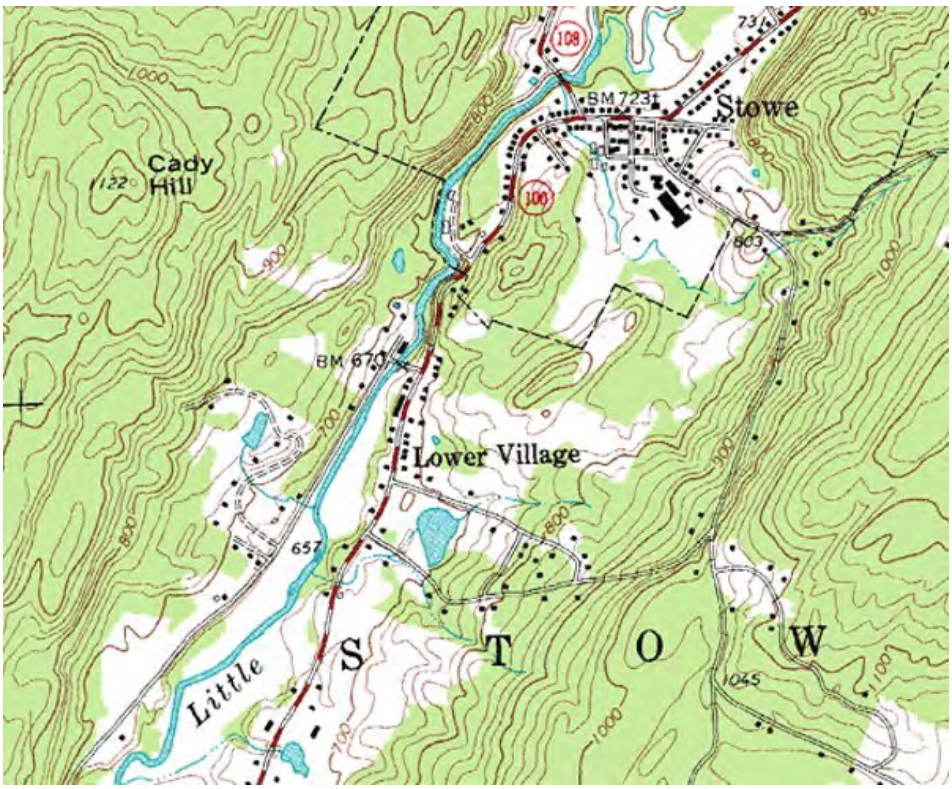




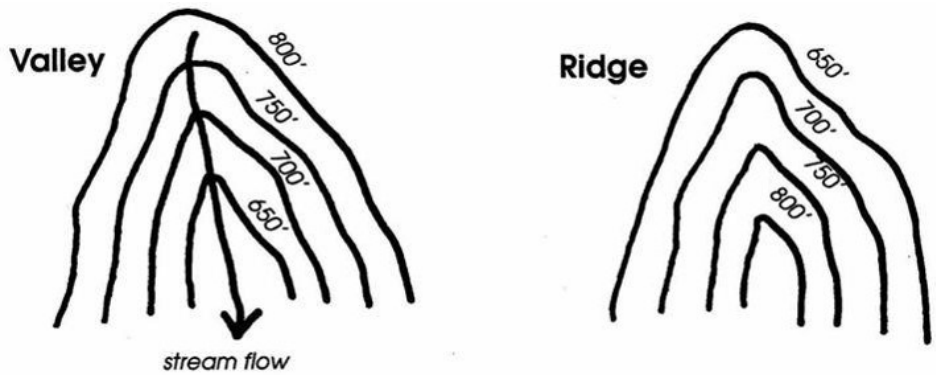


Parts of Topographic Maps

The most striking feature of a topographic map is the contour lines. These lines show the elevation of the earth's surface. Notice that these lines will never cross on a map. Some contour lines are marked with a specific elevation. You can determine the elevation of the unmarked intermediate contour lines by using the contour interval printed in the margin of a map. When contour lines are close together, it indicates steep terrain. When these lines are drawn further apart, there is a more gentle slope to the terrain.

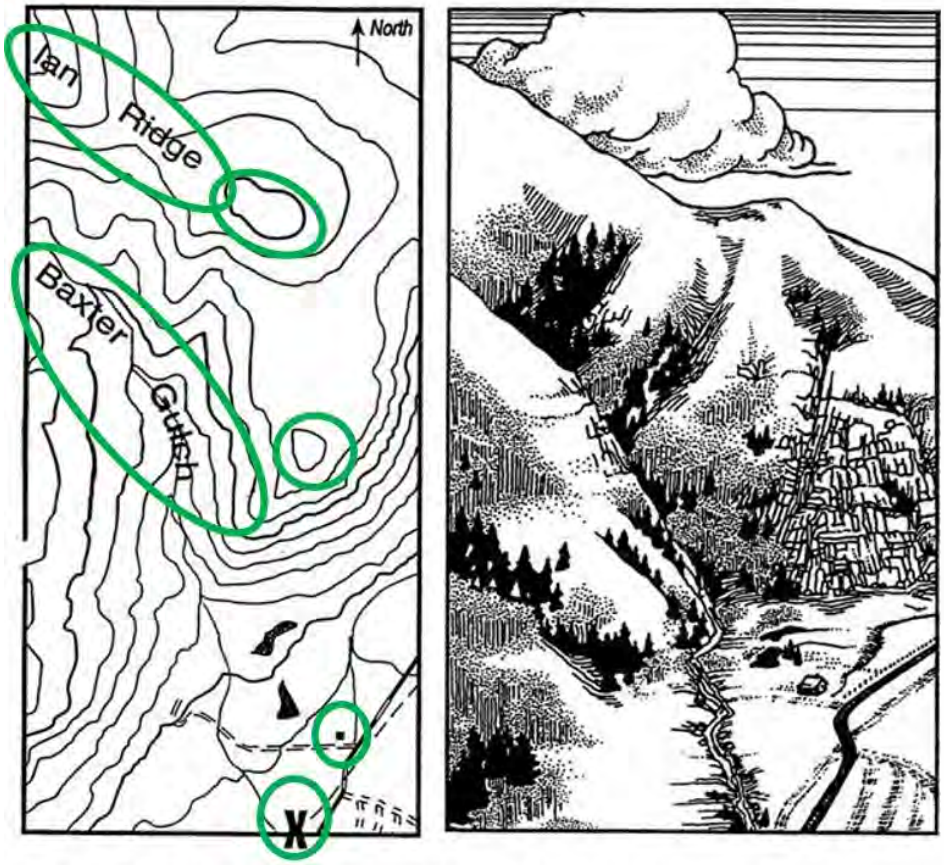


The Rule of the V: When contour lines cross a river or stream, they form a "V" shape that always points upstream. This helps you determine the direction of flow in a stream. The Rule of the V's also applies to ridges. The top of a ridge is shown as an enclosed shape, like an irregular oval. As contour lines extend out from the ridge, they often form rows of parallel "V's" that point downhill towards lower elevations. Other features like forests, water features, town, and roads are depicted on topographic maps.

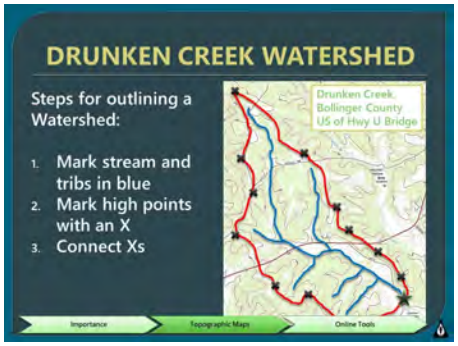


Translating Topographic Maps

It is sometimes difficult to translate the contour lines on a two dimensional map to what a specific landscape might look like in three dimensions. The illustration below might help. Imagine you are standing where the X is marked on the topographical map on the left and looking north. The picture on the right demonstrates the landscape you would see.



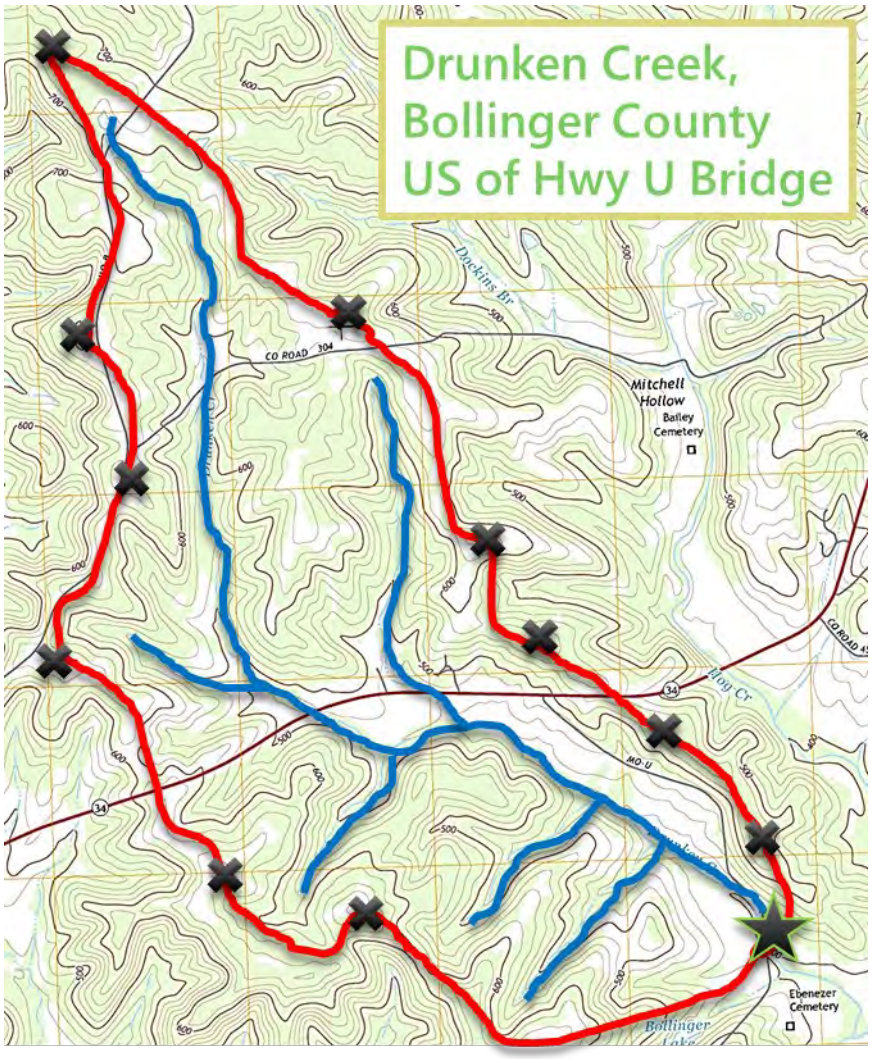
Standing at the "X" on the topo map (above left), someone looking north would see the scene depicted above, right, including the secondary highway, streams, house, unfinished roads, ponds, and mountain ridges.



Watershed Mapping

Steps for delineating a watershed:

1. Mark monitoring site with a star.
2. Trace the stream and tributaries in blue upstream from the monitoring.
3. Mark ridge tops around the stream and tributaries with an X.
4. Connect the Xs following the contour lines.

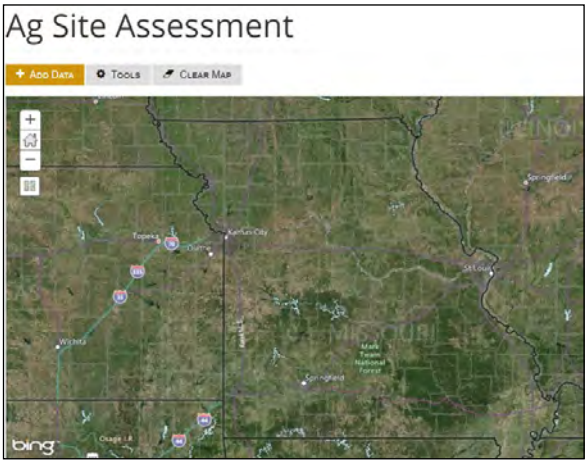


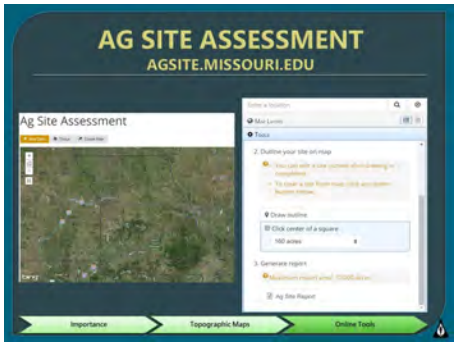
Online Watershed Mapping Tools

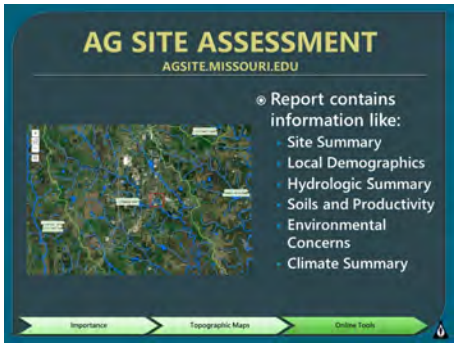
MU Ag Site Assessment:
agsite.missouri.edu

The University of Missouri's Ag Site Assessment tool generates a report for a selected site that includes the following helpful information:

- Soils
- Streams
- Wetlands
- Ponds
- Watersheds
- Floodplains
- Karst geology
- Legal description
- Threatened and endangered species

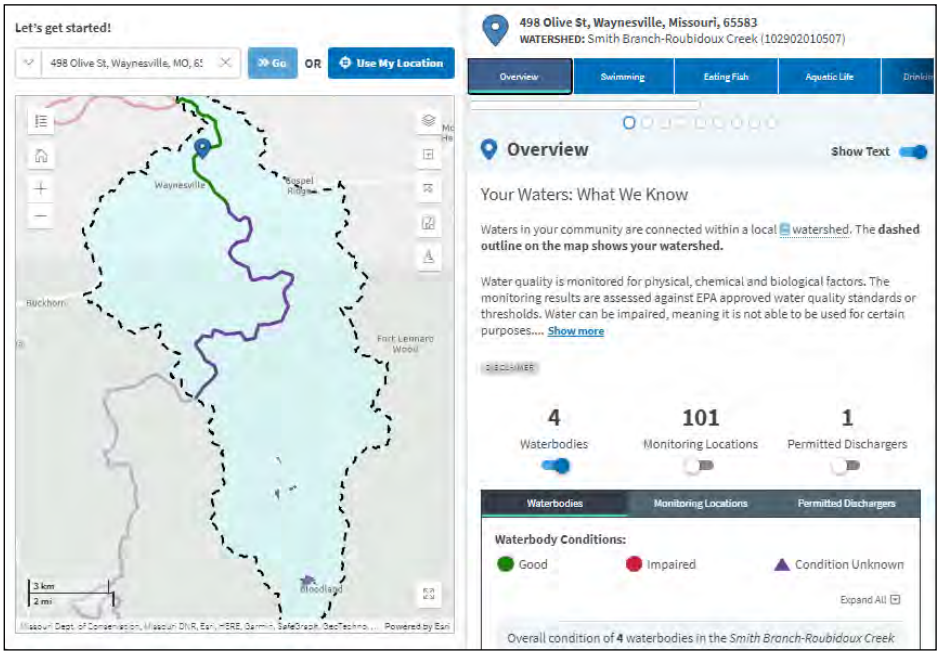


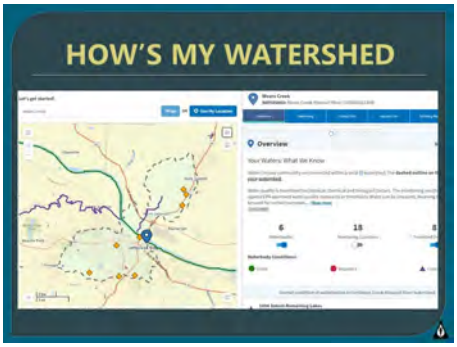


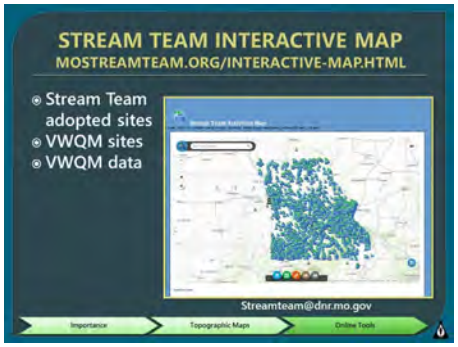


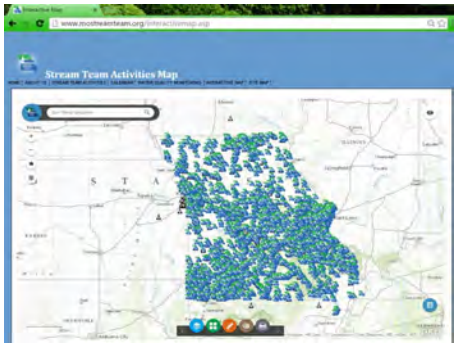
EPA How's My Waterway:
mywaterway.epa.gov

EPA's How's My Waterway is another online tool for mapping watersheds and a good resource to learn about the conditions and uses of water in your area.









Online Tools

There are many resources and tools online to aid you in your monitoring efforts:

Stream Team Website
mostreamteam.org

The Missouri Stream Team website has many resources available for you. Under the ***Reporting Forms*** tab, you can submit activity reports, request equipment, and add new members to your Stream Team. The ***Water Quality Monitoring*** tab has many of the documents and resources you have covered in this workshop, helpful tips for monitoring, and information on future workshops. The ***Calendar of Events*** keeps you informed of the many events taking place around the state. You can even post your own events to this calendar.

Stream Team Interactive Map
mostreamteam.org/interactive-map.html

This map can be used to find Stream Team adopted sites and corresponding VWQM data. As you use the map to zoom in to your stream, you will see two logos: the Stream Team logo and the black and white VWQM logo. By clicking on any VWQM logo, you can view details about the site. In the Water Quality Data field, you can click on "More Info" to view the data we have for that site. If you use this map to find a site, note that not all locations are currently adopted or monitored. If you see a VWQM icon at the site you want to monitor, contact Stream Team staff to see if it is currently being monitored.

Adding Your Site

Once you completed the field training and are certified as a Level 1 monitor, the next step is selecting a site. Data cannot be submitted online until this site is created under your user in the database.

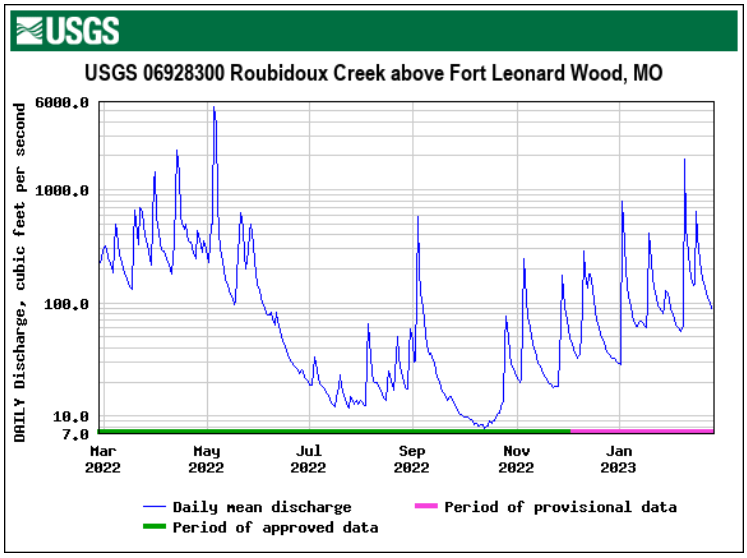
To establish your first monitoring site and subsequential sites, you will email a map of your site to streamteam@dnr.mo.gov. This map should include your name, stream name, county of the stream, and a verbal site description. If you are adopting an existing site from the Stream Team Interactive Map, also provide the Site IDX from the map information.

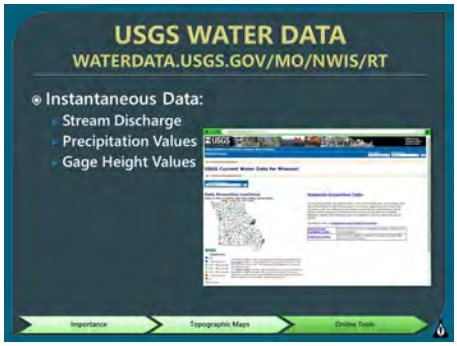
Do not submit a map or any data until field training is completed.

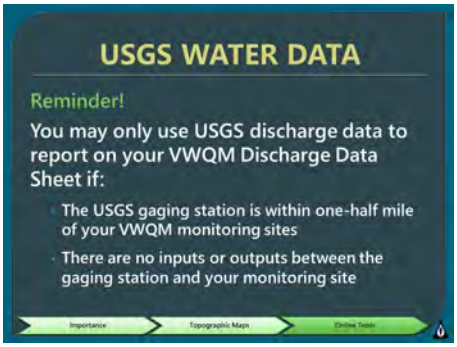
Online Tools

United States Geological Survey Water Data
waterdata.usgs.gov/mo/nwis/rt

This site offers water data online, including stream discharge and precipitation. This is an excellent tool to evaluate general stream conditions before you monitor your site. For instance, you may want to know if recent flood waters have receded or if stream discharge has increased with a recent snow melt. ***Remember, you may only use USGS stream discharge data if the USGS gage station is within one-half mile of your monitoring site and there are no inputs or outputs between the gaging station and your monitoring site.***







Activity Report

mostreamteam.org

Please report all Stream Team activities on the Stream Team website. Not only does this allow us to track volunteer hours and accomplishments, but it also helps keep our program running. Volunteers submitting activities are eligible to request free incentive items and to be entered into a prize drawing. Some Stream Team activities include:

- Litter cleanup
- Water quality monitoring
- Tree planting
- Habitat improvement
- Storm drain stenciling
- Advocacy
- Stream Team recruitment

Scan this QR code to submit your Stream Team activities!

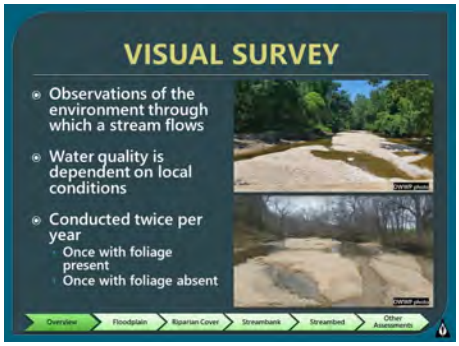
NOTES

Chapter 7
Visual Survey

Visual Survey is the physical assessment of a stream site. This assessment helps to interpret water quality data and determine if there are observable problems in or around the stream.

In this chapter, you'll learn how to characterize the environment through which your stream flows. Specifically, we will cover the characteristics of the following parts of the watershed and stream:

- Floodplain
- Riparian cover
- Streambank
- Streambed
- Other assessments



Visual Survey

The purpose of visual survey is to record observations of the environment in and around the stream. These characteristics have a large affect on the water quality of your stream.

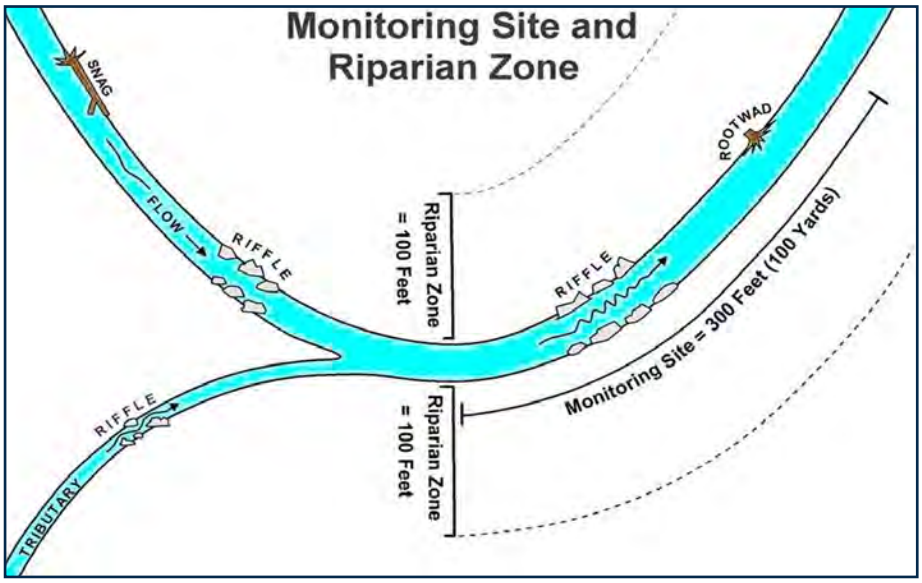
By documenting conditions using Visual Survey, we can look at changes in the watershed and stream over time, which help get a better understanding of how water quality responds to those changes.

Visual survey is conducted two times per year.

- Once with foliage present, around September or early October
- Once with foliage absent, around February or March

These are also the times we recommend doing biological monitoring.

Visual survey should be completed along the same stretch of stream each time that data is collected.



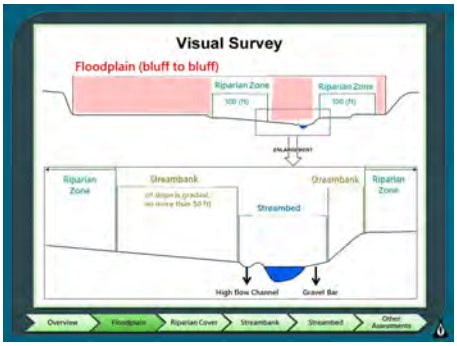
Visual Survey Data Sheet

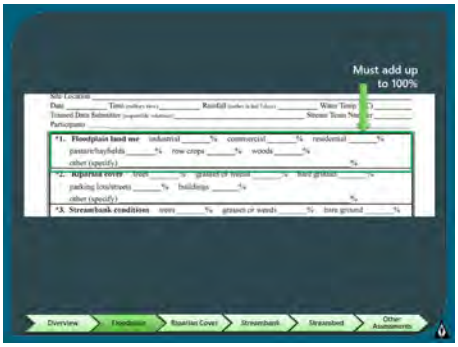
This data sheet is subjective. If you monitor with a team, have the same person make the determination for the values for every monitoring trip.

As with all data sheets, the first section is the header information. This section is covered in the Site Selection chapter.

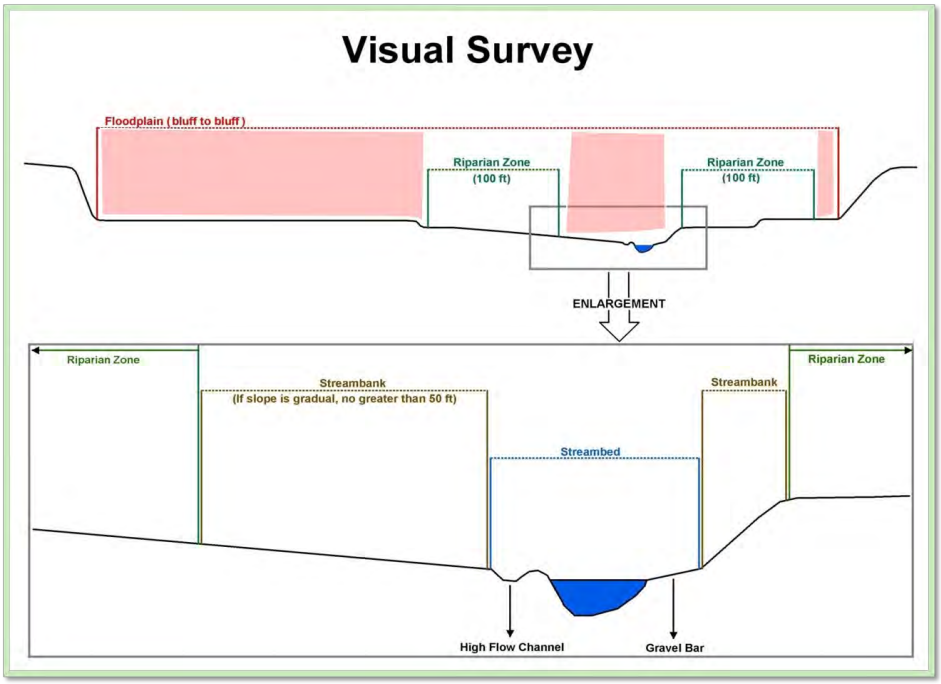
Many of the sections on the Visual Survey data sheet are for entering percentages for what is present in each part of the watershed or stream. These percentages should add up to 100%.

Floodplain



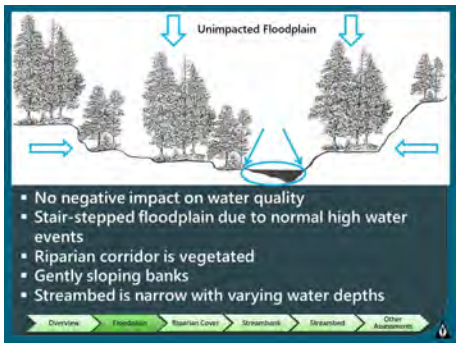


A floodplain is the flattened portion of a stream valley susceptible to flooding. This extends from riparian zone to bluff on both sides of the stream. In many streams you will not see the bluffs from the water.



On the Visual Survey data sheet, you will assess the floodplain for the following land use:

- Industrial
- Commercial
- Residential
- Pasture/Hayfields
- Row crops
- Woods
- Other (please specify)

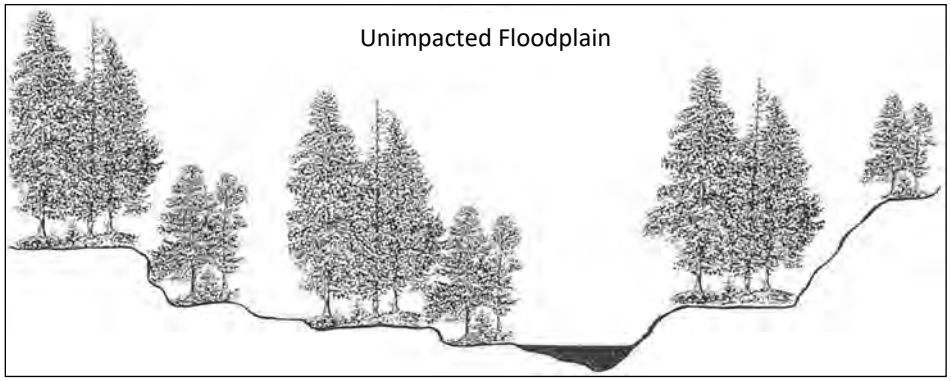


Floodplain

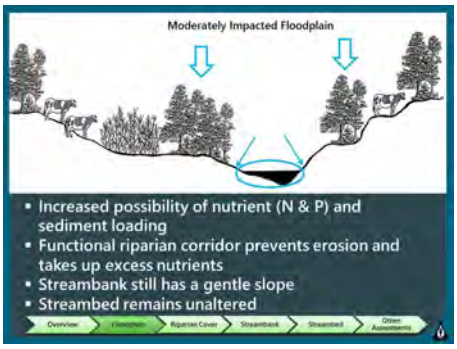
Unimpacted Floodplain

In an "unimpacted" floodplain, land use has not negatively impacted water quality.

- The floodplain has a stair-stepped appearance due to normal intensity high water events.
- The riparian corridor is vegetated.
- Streambanks are gently sloping.
- Streambed is narrow with varying water depths.



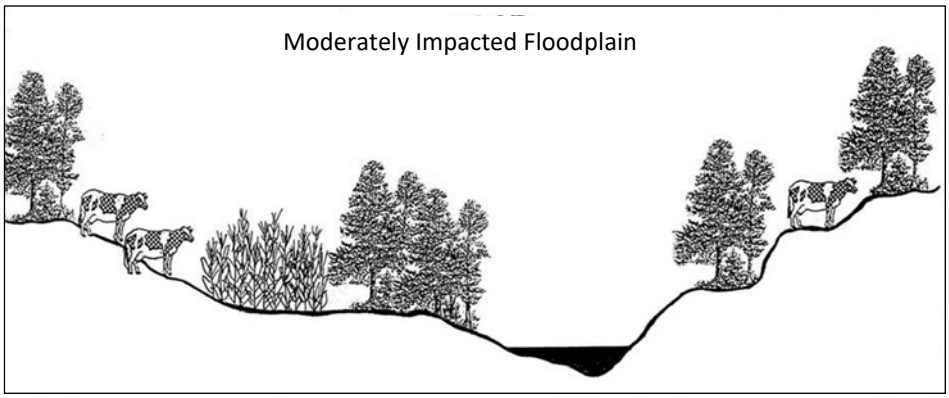
Floodplain

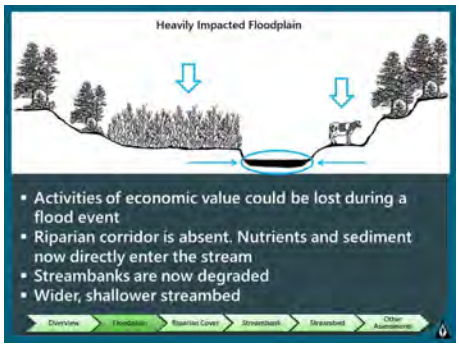


Moderately Impacted Floodplain

In a moderately impacted floodplain, land use may affect the water quality of the stream, but the floodplain is still in good condition.

- The possibility of nutrient and sediment loading is increased by crop management practices and animal production activities.
- A vegetated riparian corridor mediates these threats to some extent by preventing erosion and taking up excess nutrients.
- The streambank is moderately changed but still has a gentle slope.
- The streambed remains unaltered.





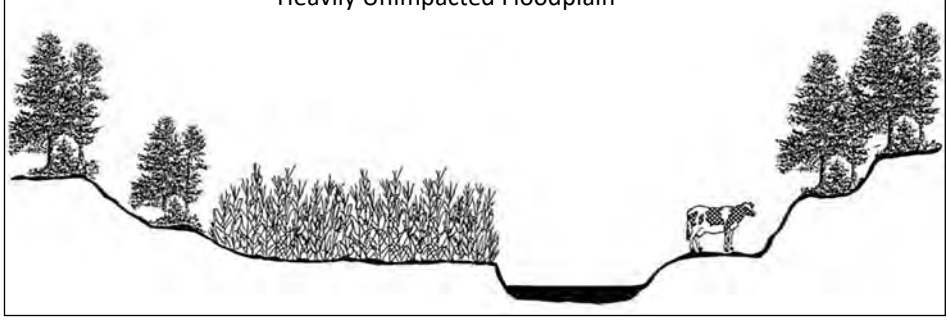
Floodplain

Heavily Unimpacted Floodplain

In a heavily unimpacted floodplain, it contains land uses that have economic value and could be lost during a flood.

- Nutrient and sediment loading are a greater threat.
- Permanent vegetation in riparian corridor is absent along with its benefits. Nutrients and sediment now directly enter stream.
- Streambanks are steeper and more vertical due to erosion or downcutting.
- They are vulnerable to severe erosion because there are no roots to stabilize the banks.
- Streambed is wider, shallower and more uniform due to sediment filling in the stream.

Heavily Unimpacted Floodplain

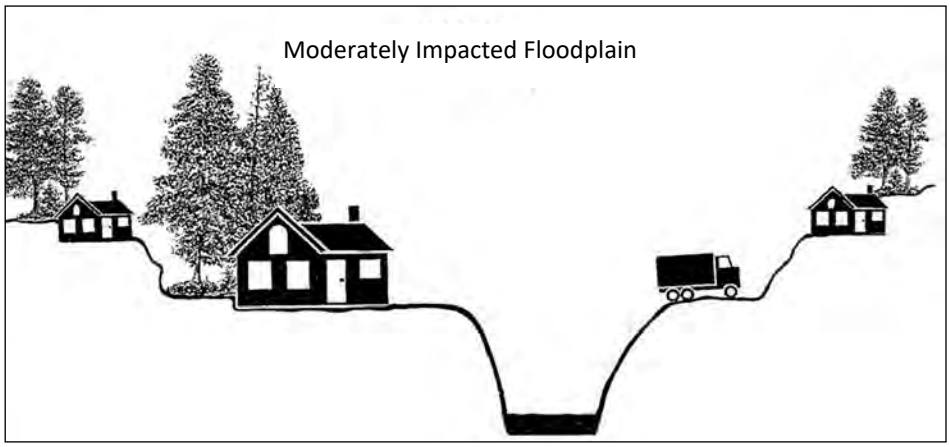


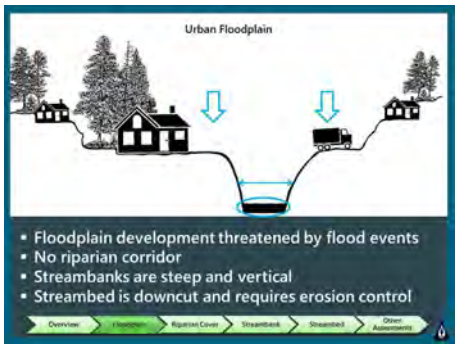
Floodplain

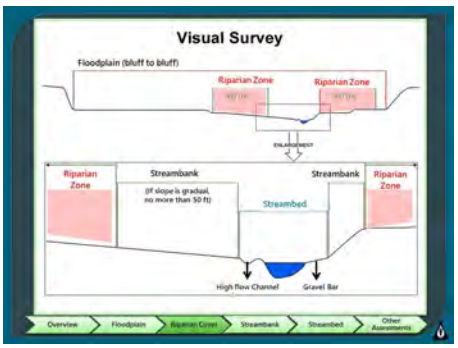
Urban Floodplain

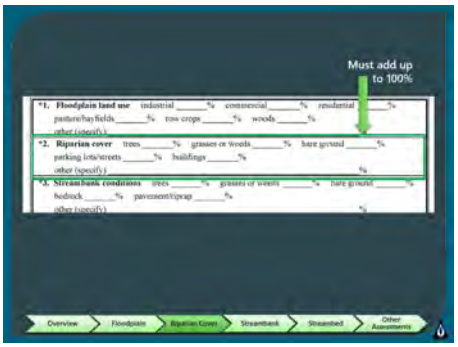
In an urban floodplain, land uses include residential, roads, and other developments that will be threatened by flood events.

- Land uses including residential, roads, and other developments that will be threatened by flood events.
- The riparian corridor lacks vegetation.
- Streambanks are very steep and vertical. These banks will be prone to erosion.
- Streambed is down-cut and uniform. Downcutting is a process of erosion that causes deepening of the stream.
- All developments in this floodplain are at risk if there is a flood event.



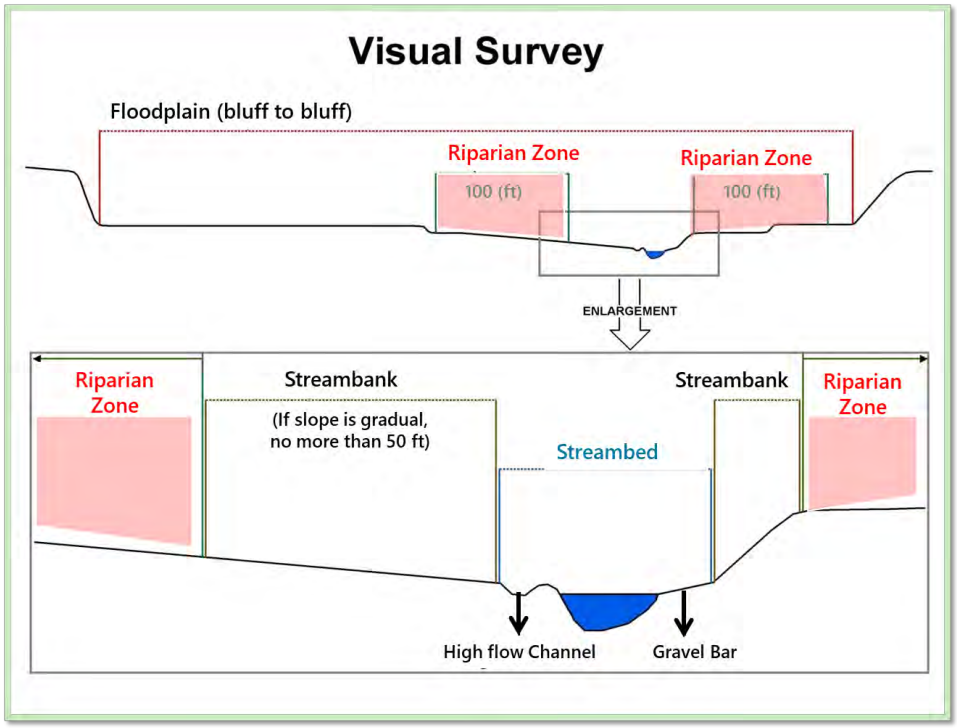






Riparian Cover

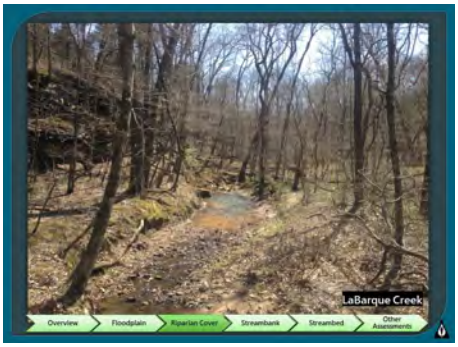
The riparian zone or riparian cover is the strip of land on each side of the stream. This starts at the top of the streambank to 100 feet back on both sides of the stream.

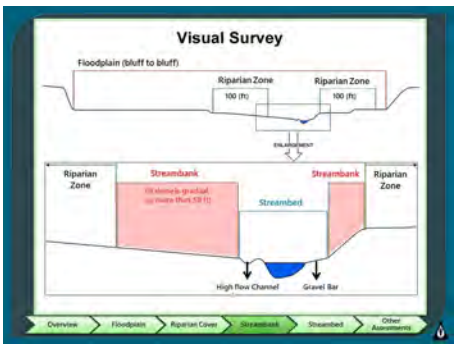


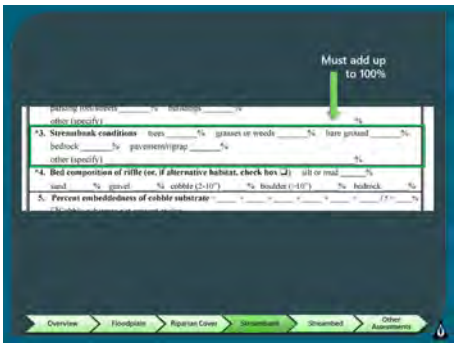
Visual Survey assess the following cover in riparian zones:

- Trees
- Grasses or weeds
- Bare ground
- Parking lot/streets
- Buildings
- Other (specify)

Riparian Cover

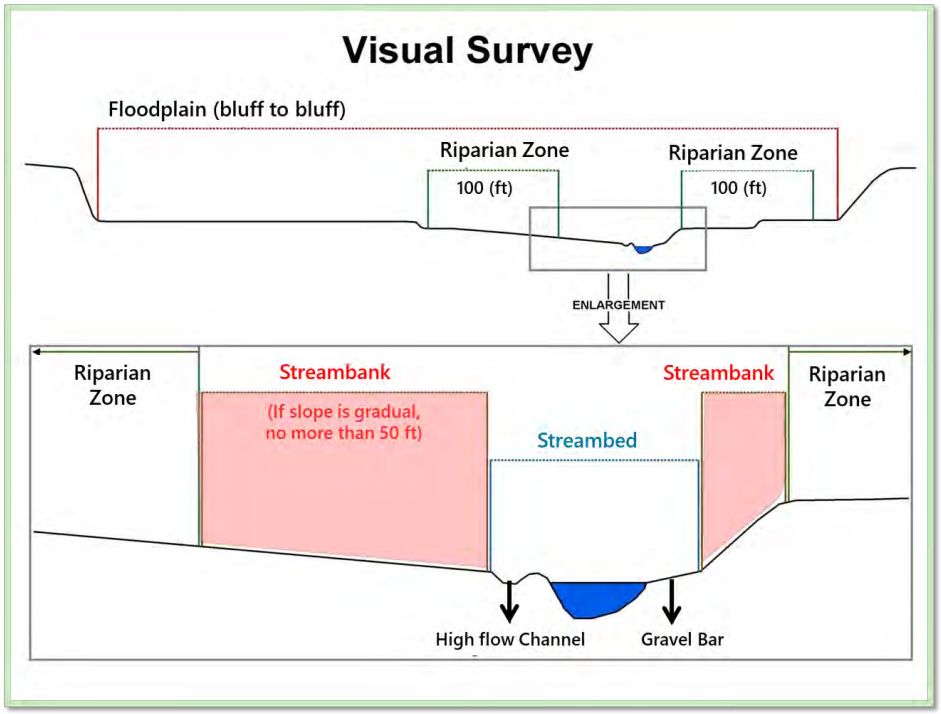






Streambank

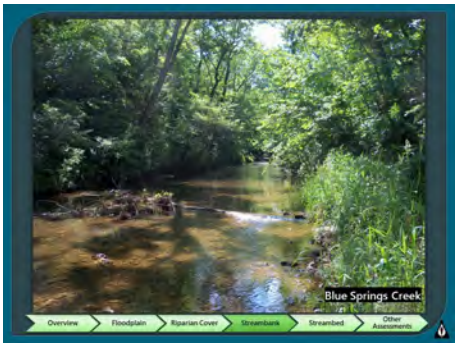
The streambank is the portion of the stream area that rises from the streambed and reaches a crest. If there is no noticeable crest, consider the streambank to extend no more than 50 feet from the edge of the streambed.



Visual Survey assess the following conditions of the streambacnk:

- Trees
- Grasses or weeds
- Bare ground
- Bedrock
- Pavement/riprap
- Other (specify)

Streambank


Blue Springs Creek
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Lost Creek, Seneca MO City Park, Newton Co., photo by D. Miller
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Lost Creek, Seneca MO City Park, Newton Co.
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments

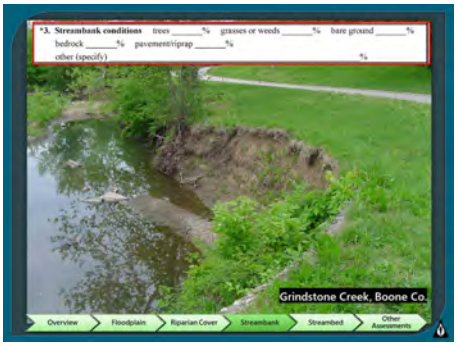

Maline Creek, St. Louis
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments

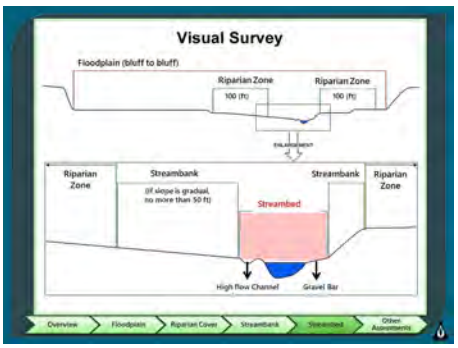
Streambank

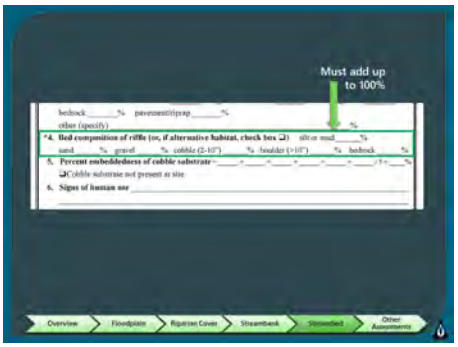
Streambank


Why does this negatively impact habitat?
Wears Creek, Jefferson City
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments

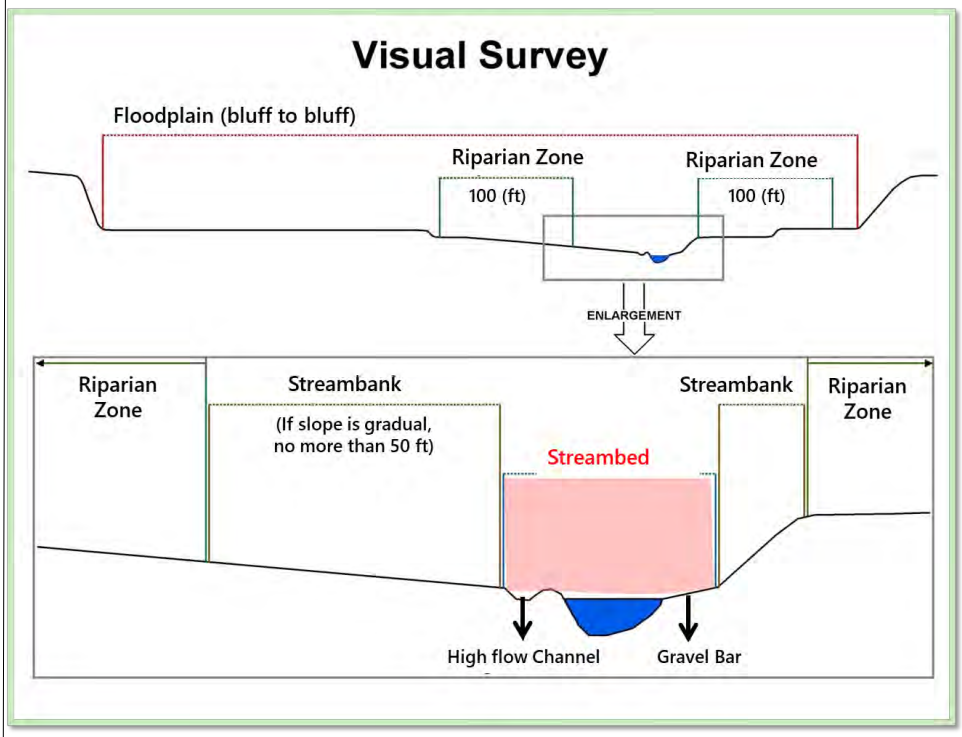

*3. Streambank conditions trees _____% grasses or weeds _____% bare ground _____%
bedrock _____% pavement/riprap _____%
other (specify) _____%
Grindstone Creek, Boone Co.
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments





Streambed

The streambed is the portion of the stream where water flows under normal conditions. You can usually tell a difference in substrate and vegetation between the streambank and the streambed. Gravel bars are considered to be part of the streambed since they are covered by flowing water for at least part of the year

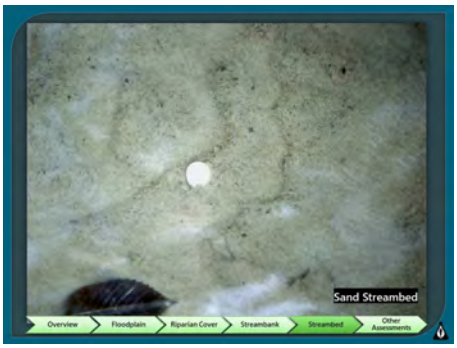


Visual Survey assess the following composition of a riffle in the streambed:

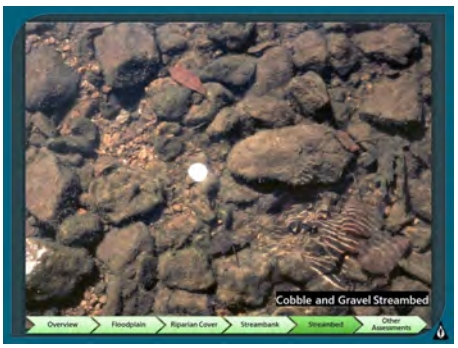
- Silt or mud
- Sand
- Gravel
- Cobble
- Boulder
- Bedrock

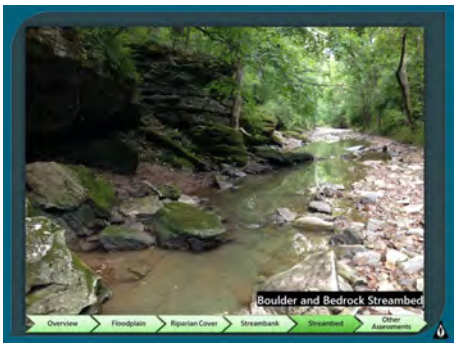
Streambed


Silt or Mud Streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Sand Streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Gravel and Sand Streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Cobble and Gravel Streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Boulder and Bedrock Streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments


Bedrock streambed
Overview
Floodplain
Riparian Cover
Streambank
Streambed
Other Assessments

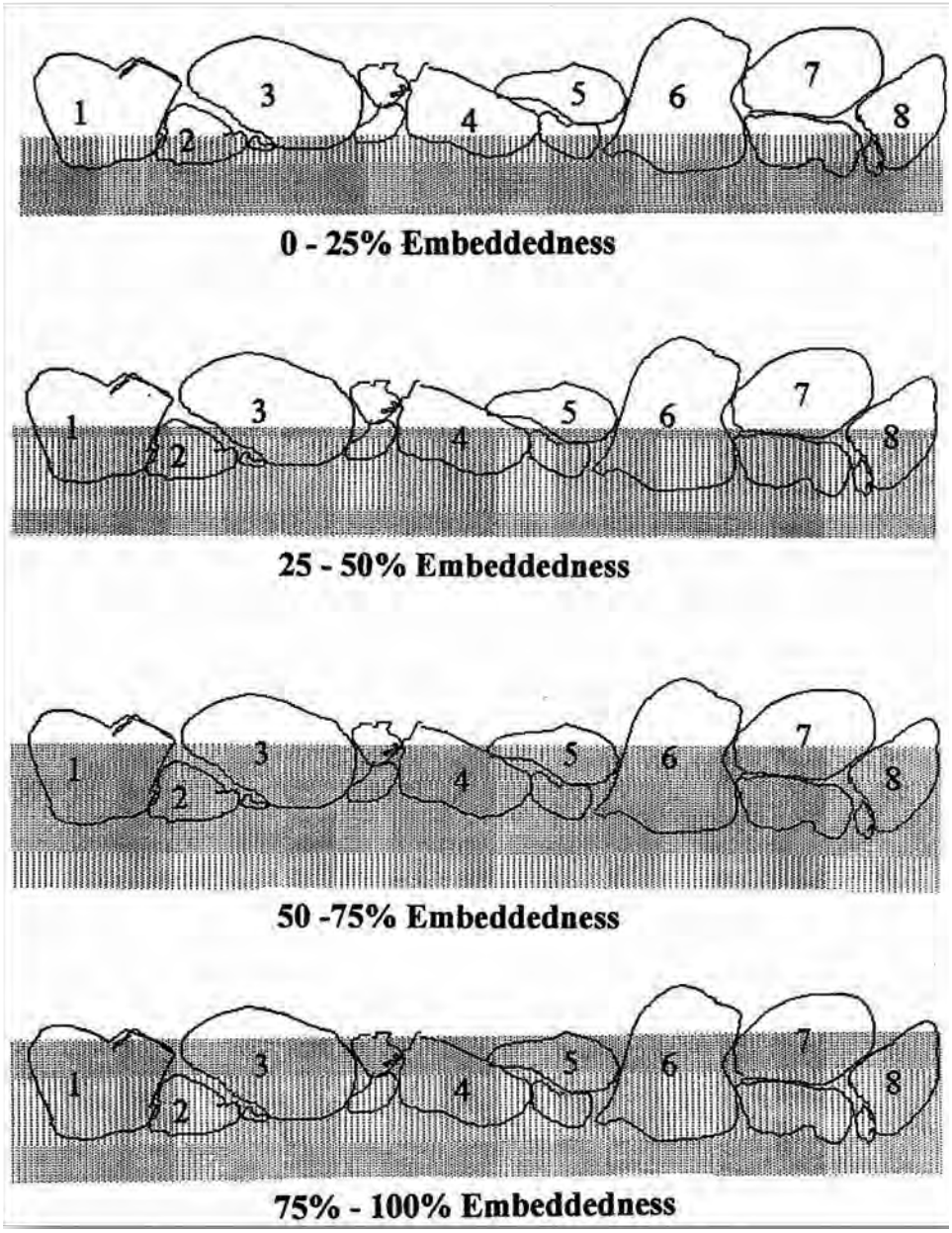
Streambed

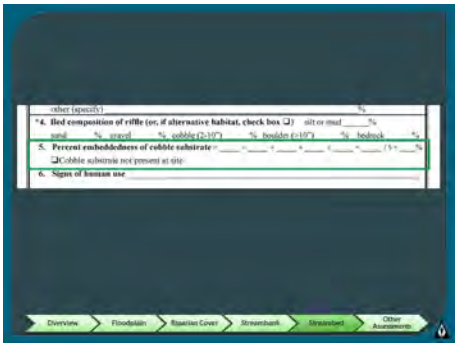
Percent Embeddedness

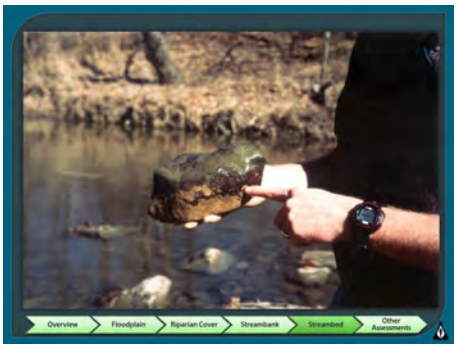
Within the streambed, the percent embeddedness of cobble substrate is also assessed. You will pick up 5 cobble rocks from the streambed and determine the average embeddedness from all five rocks. If there is no cobble at the stream site, just check the box on the data sheet that cobble substrate is not present.

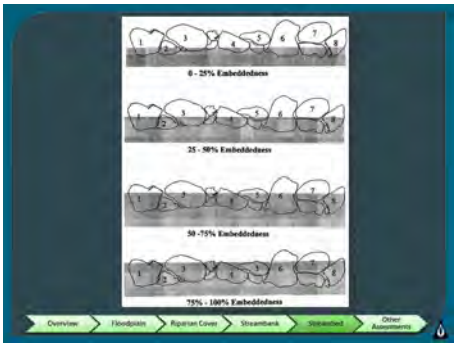
Embeddedness can be determined by looking at algae or oxidation on a rock.

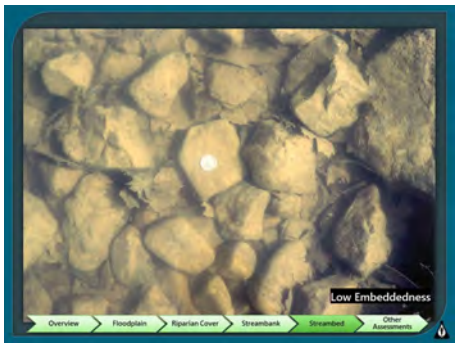
Measuring embeddedness is an indication of soil erosion. The greater the embeddedness, the greater the soil erosion and sedimentation.





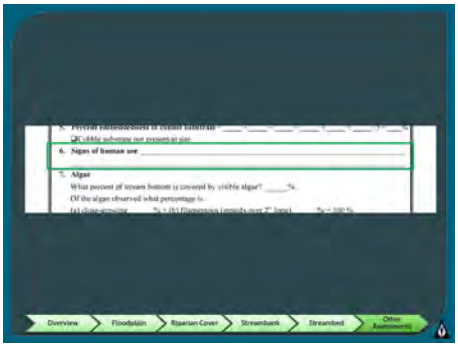






Percent Embeddedness

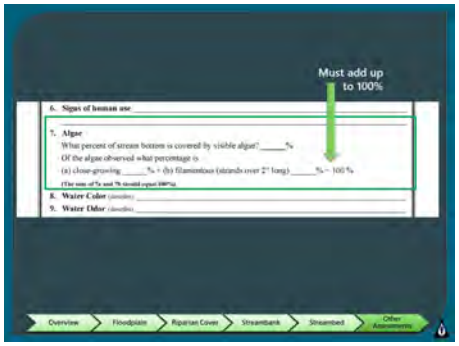
Signs of Human Use



The Visual Survey will assess your site for any signs of human use. This can include, but is not limited to, the following signs:

- Campfires
- Litter
- Fishing tackle
- ATV tracks
- Horse trail

If you see signs of illegal dumping at your stream site, please report that to DNR Solid Waste Program at 573-634-2436.

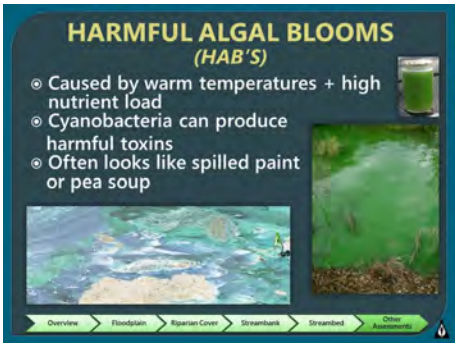


Algae

The Visual Survey data sheet first assesses how much of the stream bottom is covered by algae. Then it has you assess what percentage of that is close-growing (less than 2”) or filamentous (greater than 2”).

Aquatic plants can be confused with algae, especially filamentous algae. Filamentous green algae consists of fine, green filaments that have no leaves, roots, stems, or flowers. It forms green, cottony masses that are free-floating or attached to rocks, debris, or other plants. Sometimes algae bubbles, generated by the plant or created by its decay, get trapped in the mats and make them buoyant. It grows in practically any water that can support life and receives good light. As a general rule, if you don’t see leaves, it’s probably algae. If you can see leaves, it’s an aquatic plant.

Harmful Algal Blooms



Harmful algal blooms, or HABs, are becoming more prevalent, and we encourage volunteers to report them. They are usually caused by warm temperatures combined with a high nutrient load in a water body, and are formed by blue-green algae, or cyanobacteria, which can produce cyanotoxins. These toxins can cause illness and death in humans and animals. They often look like green or blue paint has been spilled on the surface of the water, or like pea soup. They are most common in lakes and ponds, but can also be found in streams, especially in slow moving water or water that is pooled.

If you are unsure whether or not a water body has a harmful algal bloom, remember: ***When in doubt, report, and stay out!***
More information on HABs, including the reporting form, can be found on DNR's website.

Missouri Harmful Algal Blooms (HABS)

When in doubt, report and stay out!

DNR Webpage

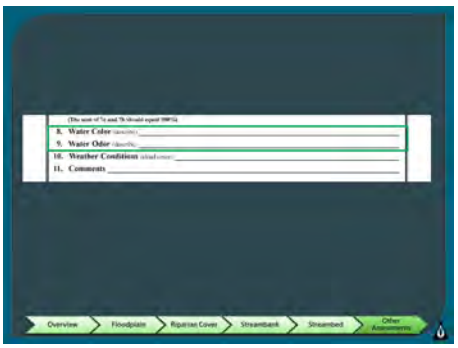
Report HABS

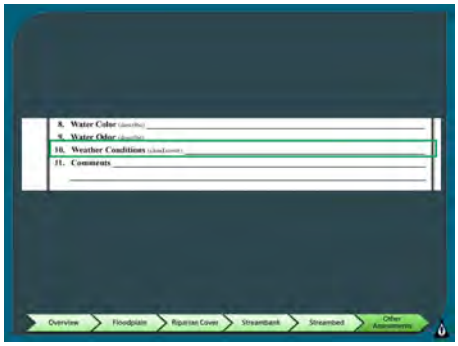
Reported HABS Map Viewer

MISSOURI NATURAL RESOURCES

MISSOURI DEPARTMENT OF HEALTH & SENIOR SERVICES

ITSD





Water Color and Odor

It's easiest to evaluate water color and odor by scooping up some stream water in a clear plastic container.

Water can be a variety of colors. If there is algae in the water, it might be green. With high sediment load, it could be brown. It could even appear milky or have an oily sheen.

Examples of colors are noted on the back of the data sheet.

In many streams, the water will have no odor.

In others, it may smell musty, organic, or even smell like sewage. You might smell chemicals or oil.

Describe the smell to the best of your ability. Examples of odor are also on the back of the data sheet.

Weather Conditions

The last section in the Visual Survey data sheet is Weather Conditions, specifically cloud cover.

Sunny, mostly sunny, partly cloudy, cloudy, rainy, snowy – all are good examples.

Knowing these conditions can help us interpret visual survey data.

Comments

On all data sheets, there is a section for Comments and Fish Present.

In the comments section, add any observations you think might be important or of interest.

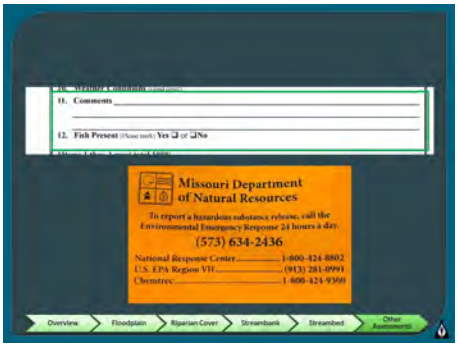
Examples include: “Lowest flow ever observed,” or “Trees recently cleared from banks.”

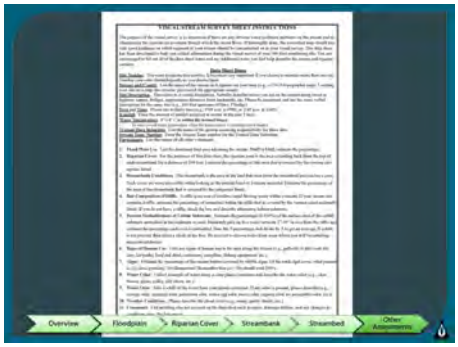
If you observe dead fish or other evidence of a pollution event, it is fine to write it here, but please call the emergency numbers for the Environmental Emergency Response hotline.

Under Fish Present, Simply check the yes or no box if you saw a fish in your site.

We don’t need to know species or quantities. We just care to know that the stream supports aquatic vertebrates.

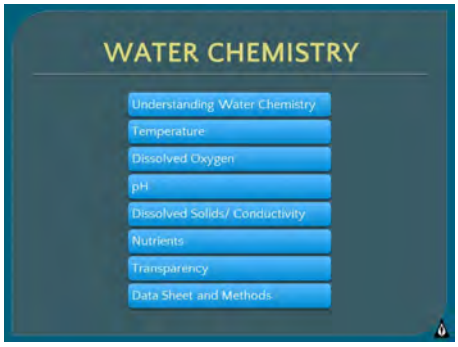
Something else you may want to mention in the comments section is the observation of foam or iron-oxidizing bacteria. Foam in a stream can be caused naturally by decomposition. To determine if it is natural, use the stick test. If the foam breaks apart when wacked with a stick, it is natural. If it doesn’t break apart it could be a detergent or another chemical. This would be a concern. It’s somewhat common to see bright orange slime, often accompanied what appears to be an oily sheen on the water. This is caused by naturally occurring iron-oxidizing bacteria, which get energy from the iron minerals leaching out of the soil. If you can break the sheen with a stick, it is organic and not a cause for concern.





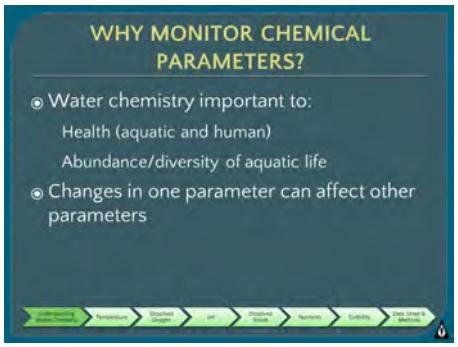
NOTES

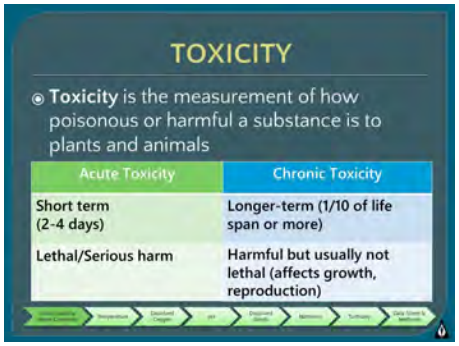
Chapter 8
Chemistry

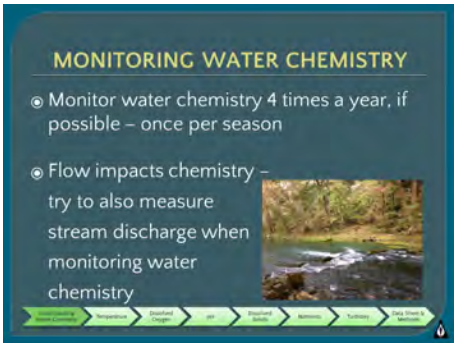


Chemical parameters play an important role in the health, abundance, and diversity of aquatic life. Excessive amounts of some constituents such as nutrients, or the lack of others can result in imbalances in water chemistry. In this chapter, we will discuss:

- Understanding Water Chemistry
- Temperature
- Dissolved Oxygen
- pH
- Dissolved Solids
- Nutrients
- Transparency







Why monitor chemical parameters?

Water carries needed nutrients and minerals to aquatic life and carries waste. Chemical parameters play an important role in:

- ***Health:*** of the stream
- ***Abundance:*** of aquatic insects
- ***Diversity:*** of aquatic organisms
- ***The life within the stream***

Remember that changes in many of the following parameters can affect other chemical parameters.

Toxicity Definitions

Toxicity: A measurement of how poisonous or harmful a substance is to plants and animals

Acute Toxicity	Chronic Toxicity
Short term (2-4 days)	Longer-term (1/10 of life span or more)
Lethal/Serious harm	Harmful but usually not lethal (affects growth, reproduction)

Water Quality Standards (WQS) are set to protect human health and animal life. These standards can be found on the Missouri Department of Natural Resources website.

Monitoring Water Chemistry

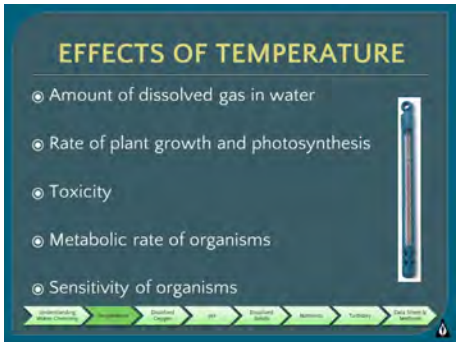
Water chemistry should be monitored at least four times per year, once every season. Some monitors may have specific project goals which require monitoring more frequently. Since stream flow affects water chemistry, also measure stream discharge while collecting water chemistry data.

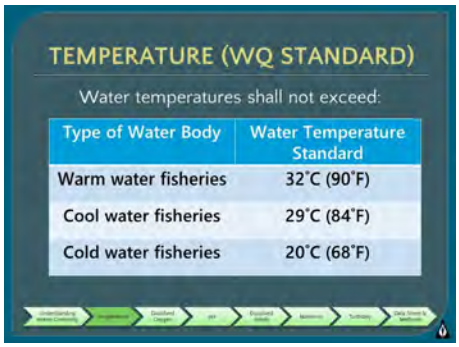
Effects of Temperature

The ***amount of dissolved oxygen in the water, the rate of photosynthesis*** by algae and other aquatic plants, and the ***rate of plant growth*** are all affected by temperature. Plant growth increases with warmer temperatures. When plants die, they are decomposed by bacteria, which use up oxygen. Increased plant growth means more oxygen being removed from the water during the decomposition process.

The ***metabolic rates of organisms*** increase with higher temperatures. As respiration and digestion rates increase, fish, aquatic insects, and aerobic bacteria require more oxygen to survive.

The ***sensitivity rates of organisms*** is also affected by temperature. Many organisms require a specific temperature range, and changing that range may eliminate some organisms from the ecosystem. Under temperature extremes, organisms may become stressed, which makes them more vulnerable to toxic wastes, parasites, and disease.

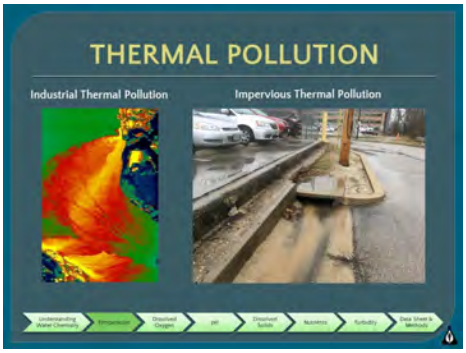




Water Quality Standard for Temperature

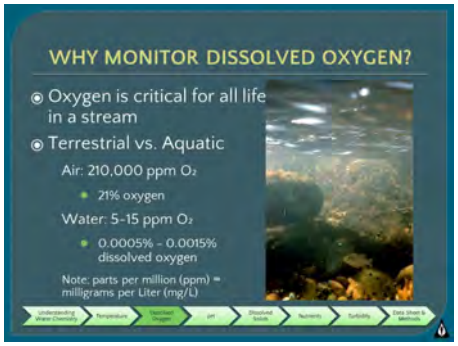
Water temperatures shall not exceed:

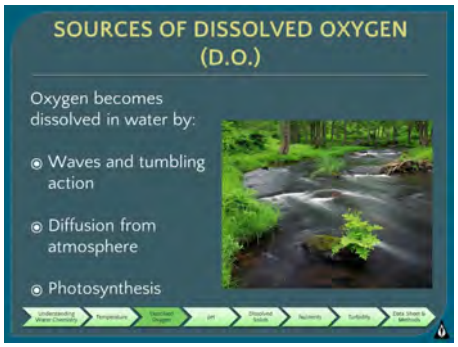
Type of Water Body	Water Temperature Standard
Warm water fisheries	32˚C (90˚F)
Cool water fisheries	29˚C (84˚F)
Cold water fisheries	20˚C (68˚F)

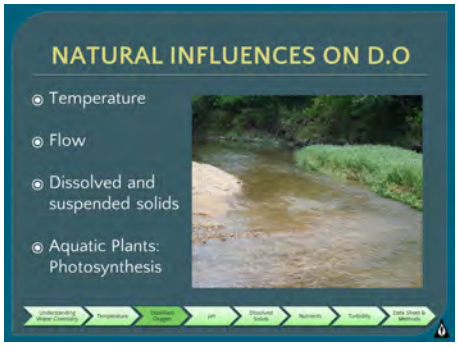


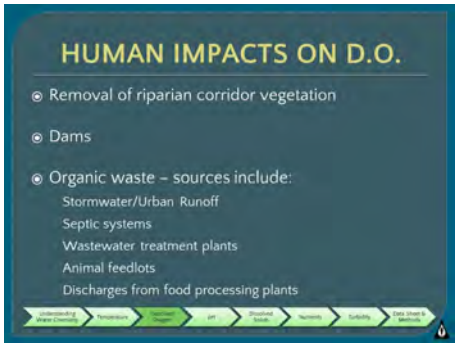
Effects on Temperature

- ***Riparian cover removal:*** What if the trees in the riparian zone were removed from a cold-water trout stream? It is likely that our cold-water stream would not remain cold as long, because there would no longer be any shade.
- ***Soil Erosion:*** increased turbidity
- ***Thermal Pollution:*** Sources of thermal pollution include warm or hot water from a power plant or industrial discharge and runoff from impervious surfaces such as parking lots and streets.
- ***Impervious Surfaces:*** Impervious surfaces are anything that does not absorb water such as concrete, asphalt, roof tops and compacted soils. Impervious surfaces get very hot in the summer and stormwater runoff from these surfaces can reach as much as 120° Fahrenheit.









Dissolved Oxygen

Dissolved oxygen (DO) is essential for the maintenance of healthy waterways. Aquatic life needs a certain level of dissolved oxygen for survival and a depletion of DO can cause a major shift in the organisms present in a stream. Dissolved oxygen comes from 3 major sources:

- ***Atmosphere:*** The air we breathe contains approximately 21% oxygen, which equates to 210,000 ppm oxygen. Some of this oxygen diffuses into streams. Most surface waters contain between 5 and 15 ppm dissolved oxygen.
- ***Aeration:*** Waves and tumbling saturate water with oxygen from the atmosphere like an aquarium aerator.
- ***Photosynthesis:*** Algae and other aquatic plants deliver oxygen to water.

Waters with consistently high D.O. are considered healthy and stable aquatic systems – a positive sign. Absence of D.O. is a sign of severe pollution.

Water Quality Standard for Dissolved Oxygen

The Water Quality Standard for D.O. is no less than 5 mg/L (5 ppm)

Influences and Impacts on Dissolved Oxygen

Natural Influences:

- Temperature
- Flow
- Dissolved and Suspended Solids
- Aquatic Plants

Human influences:

- *Removal of Riparian Corridor Vegetation*
- *Dams*
- *Organic Waste*
- *Urban Runoff*

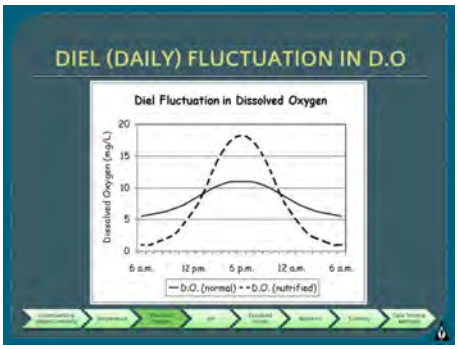
Diel Fluctuation in Dissolved Oxygen

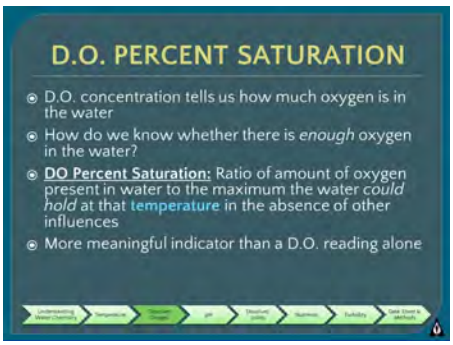
Dissolved oxygen fluctuates throughout the day. It is natural to be lowest just before sunrise and peak during the middle of the day. This is because algae and other aquatic plants switch from photosynthesis to respiration at night and are therefore using oxygen, not producing it.

Some of the factors that can cause extreme fluctuations in DO include:

- Removal of trees
- Excess nutrients

It's best to sample water quality first thing in the morning to measure the lowest dissolved oxygen for your stream.





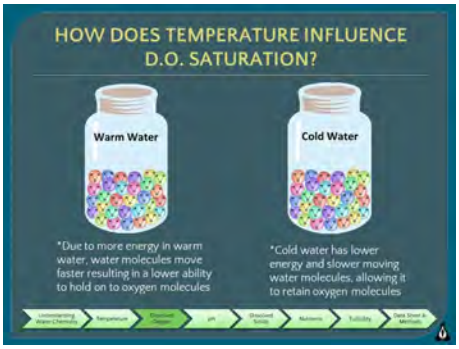
Dissolved Oxygen Percent Saturation

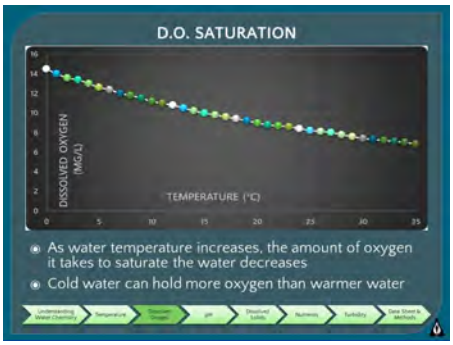
Dissolved Oxygen Saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature, in the absence of other influences.

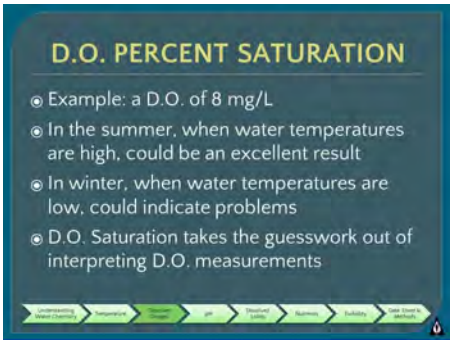
Percent Saturation is the percentage of dissolved oxygen concentration relative to that when completely saturated. This tells us whether a DO measurement is good or bad.

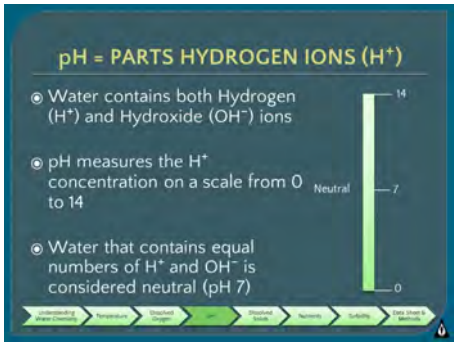
As water temperature increases, DO saturation decreases, and as water temperature decreases, DO saturation increases. Therefore, cold water will hold more DO than warm water.

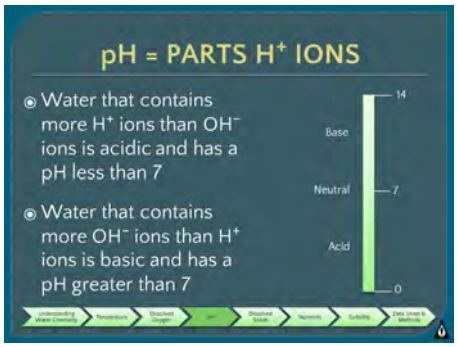
Acceptable D.O. Percent Saturation Levels	
Ozark Stream (high gradient, rocky bottom)	>80% D.O. Saturation
Prairie Streams (Low-gradient or slow moving)	>60% D. O. Saturation

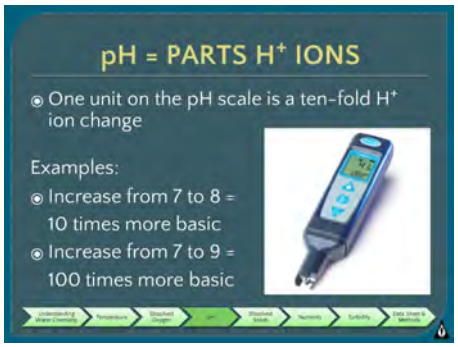


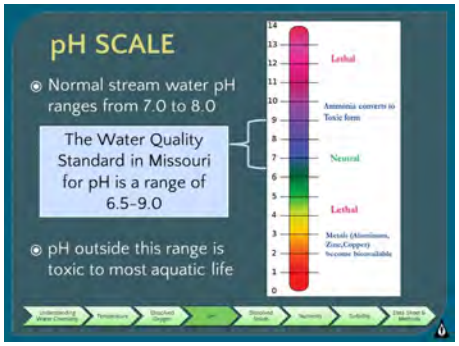












pH

Water contains both Hydrogen (H+) and Hydroxyl (OH-) ions. ***pH*** measures the H+ concentration on a scale from 0 to 14.

- ***neutral (pH 7)*** contains equal numbers of H+ and OH– ions
- ***acidic (pH < 7)*** contains more H+ than OH- ions
- ***basic (pH > 7)*** contains more OH– ions

The pH scale is logarithmic, meaning that every one-unit change on the pH scale is a ten-fold H+ ion change. A one-point pH change indicates the strength of the acid or base has increased or decreased tenfold. A two-point change indicates a 100-fold change.

- Increase from 7 to 8 = 10 times more basic
- Increase from 7 to 9 = 100 times more basic

pH Effects on aquatic life

Normal stream water pH ranges from 6.5 to 8.0. Most organisms have adapted to life in water of a specific pH and may die if that fluctuates even slightly. ***At extremely high or low pH values (11.0 or 4.5) the water becomes lethal to most organisms.***

Waters that are acidic can cause metals such as zinc, aluminum, and copper to be released into the water column and accumulate in the food chain. Copper and aluminum can accumulate on fish gills and cause deformities in young fish, reducing their chance of survival. Ammonia compounds convert to a toxic form in basic water. The more basic the water, the more toxic the ammonia that is present.

Water Quality Standard for pH

The Water Quality Standard in Missouri for pH is a range of 6.5-9.0

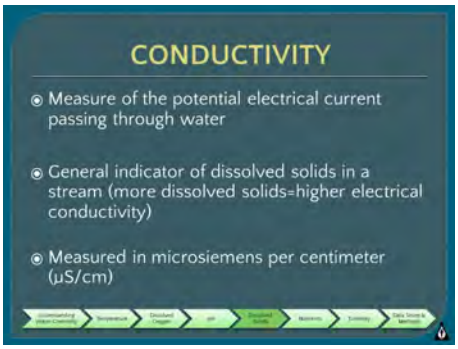
Conductivity

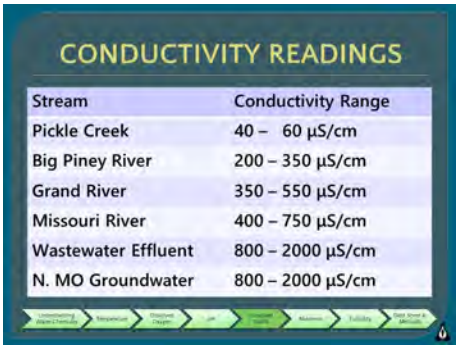
Conductivity is a measure of the electrical current passing through water. It is a general indicator of water quality trends because it tells us the amount of dissolved solids are in the water. ***Conductivity measurements do not tell us which dissolved substances are in the water, only how much.*** Small amounts of certain dissolved solids, such as some metals, can cause significant changes in conductivity.

Common dissolved solids which influence conductivity:

- Bicarbonate
- Calcium
- Magnesium
- Sulfate
- Chloride
- Sodium
- Potassium

Sources of dissolved solids in streams include: rainfall, vegetation, rocks, soil, and groundwater. The three most abundant dissolved substances come from the dissolution of limestone and dolomite. The remaining one percent of dissolved solids can vary considerably, but can include nitrates, metals, ammonia, phosphorus, and manmade compounds such as pesticides and fuel.



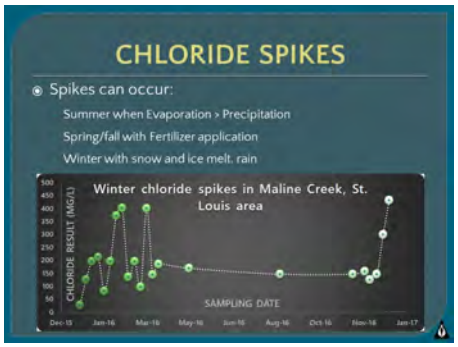


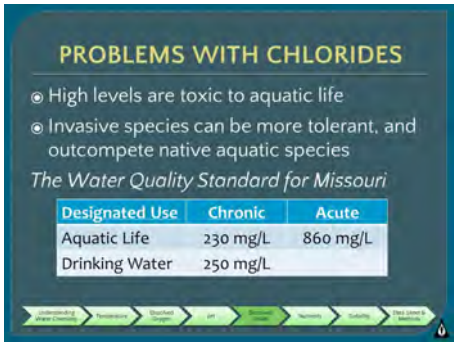
Water Quality Standards for Chlorides

There is currently no Water Quality Standards for conductivity in Missouri

Conductivity Ranges in Missouri

Stream	Conductivity Range
Pickle Creek	40 – 60 µS/cm
Big Piney River	200 – 350 µS/cm
Grand River	350 – 550 µS/cm
Missouri River	400 – 750 µS/cm
Wastewater Effluent	800 – 2000 µS/cm
N. MO Groundwater	800 – 2000 µS/cm





Chlorides

Chlorides are salts resulting from the combination of chlorine gas and various metals. Most chlorides come from sodium chloride (NaCl) applied to roads and sidewalks to melt ice.

Application of these road salts has drastically increased since the 1970s. These salts can travel up to 130 ft from the roadway and often have heavy metal additives, so other harmful substances may be present.

High levels of chlorides are toxic to aquatic life. They interfere with osmoregulation in freshwater organisms and can lead to fish kills.

Some invasive species (e.g. Eurasian water milfoil) are more tolerant to chloride and can outcompete the native species of the area.

Spikes can occur during the summer during low flows and during the spring and fall after fertilizer applications.

Water Quality Standards for Chlorides

Designated Use	Chronic	Acute
Aquatic Life	230 mg/L	860 mg/L
Drinking Water	250 mg/L	

Nitrogen

Nitrogen is an essential plant nutrient required by all living plants and animals for building protein. All living, organic matter contains nitrogen**.** As aquatic plants and animals die, bacteria break down the organic matter. Ammonia (NH_3) is oxidized (combined with oxygen) by bacteria to form nitrites (NO_2) and nitrates (NO_3).

What affects nitrogen levels?

- Leaf fall
- Organic decay
- Anthropogenic impacts:
    - Poorly functioning septic systems
    - Wastewater from treatment plants
    - Runoff from animal production
    - Runoff from fields and lawns
    - Storm drains
    - Combined sewer overflows (CSO)

Nitrate

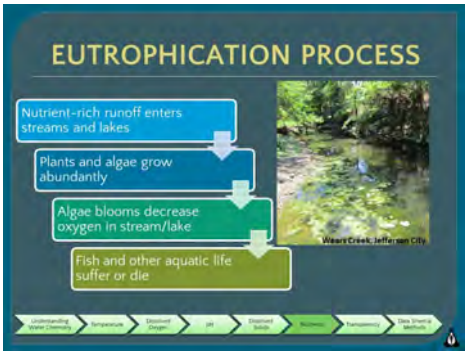
VWQMs measure nitrate. It is expressed at nitrate-nitrogen (NO_3-N), which means nitrogen in the form of nitrate. Nitrate is the most stable nitrogen compound and is an indicatory of excess nitrogen loading.

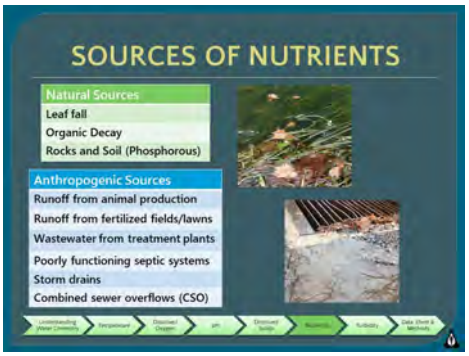
Here are average nitrate readings in Missouri streams:

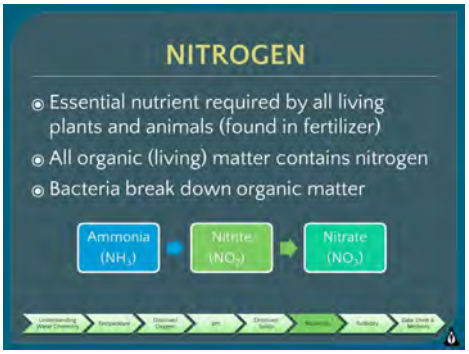
Stream	Average Value	Range
Mississippi	2.39	0.56 – 4.53
Chariton	0.73	0.38 – 1.43
Pomme de Terre	0.15	0.02 – 0.81
Jacks Fork	0.35	0.31 – 0.39

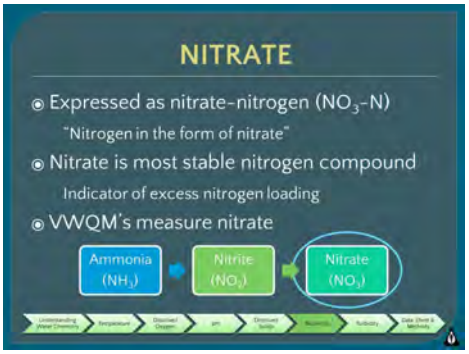
Water Quality Standard for Nitrate

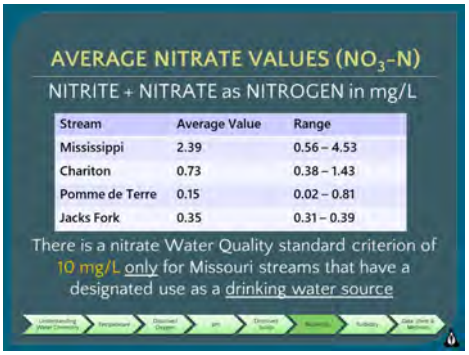
There is a nitrate Water Quality Standard criterion of **10 mg/L** only for Missouri streams that have a designated use as a drinking water source.

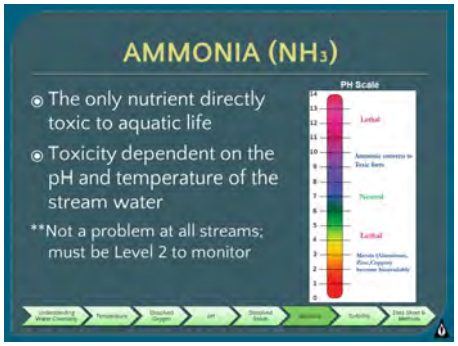


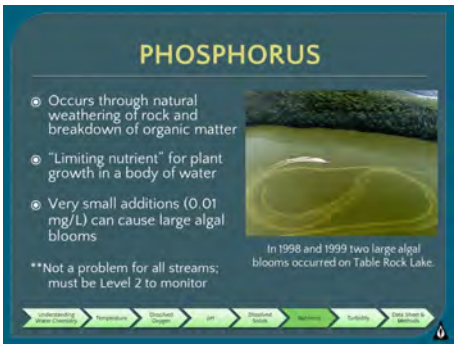












Ammonia

Ammonia (NH_3) is the only nutrient that is directly toxic to aquatic life. However, the toxicity of ammonia is dependent on the pH and the temperature of the water.

Ammonia levels are not usually a problem in most Missouri streams. Ammonia is only monitored by Level 2 VWQM certified monitors when a need is determined.

Phosphorus

Phosphorus is also a plant nutrient. It is most readily available to plants as ***orthophosphate,*** a reactive form of phosphorus commonly referred to as "phosphate" (PO_4). Phosphorus occurs naturally in rocks and enters the water column through the weathering of rock. When additional phosphorus enters an aquatic system, even very small amounts (0.01 mg/L) can cause large algal blooms.

In Missouri, phosphate is the nutrient that limits plant growth in a body of water in a process called "primary productivity."

Natural:

- ***Rocks and soil***
- ***Breakdown of organic matter***

Anthropogenic:

- ***Runoff from animal production:*** especially from poultry litter
- ***Wastewater from treatment plants***
- ***Poorly functioning septic systems***
- ***Runoff from fields and lawns:*** Many people fertilize their lawns in urban areas. Runoff from rainfall events following application can cause high phosphorus levels after storm events.
- ***Storm drains -*** Storm drains may carry waste from pets, lawn fertilizer, broken wastewater lines and septic systems.
- ***Combined sewer overflows (CSO)*** - These systems caused excessive algae blooms in Lake Erie in the 1960's. Starting in 2011, projects began to reduce the volume of discharges by CSOs around Lake Erie.

Phosphate is only monitored by Level 2 VWQM certified monitors when a need is determined.

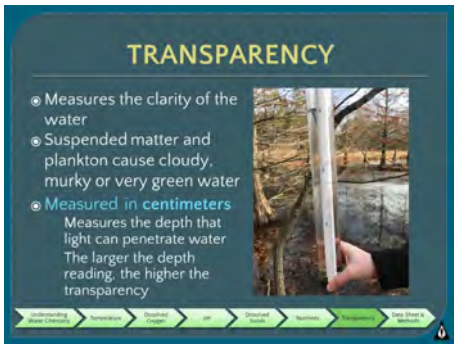
Transparency

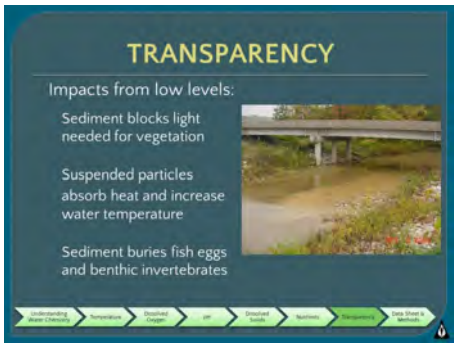
Transparency is a measure of water clarity. It measures the depth in centimeters that light can penetrate the water. Suspended matter and plankton can cause cloudy, murky, or green water. A larger reading means the transparency is higher, thus the water is clearer.

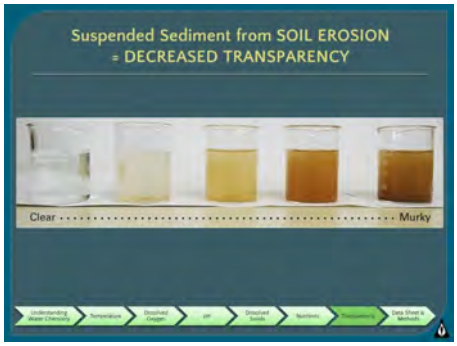
Having a low transparency is detrimental to aquatic life. Sediment can block out light needed for vegetation, and it can bury fish eggs and benthic invertebrates. Suspended particles can also absorb heat and increase the water temperature.

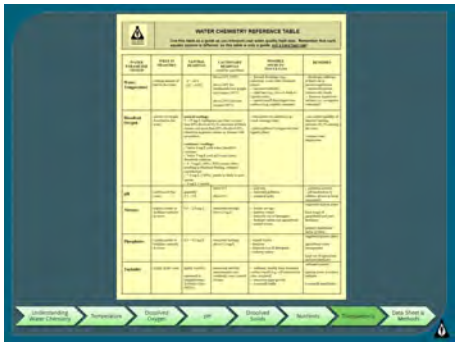
Monitoring transparency can be particularly valuable:

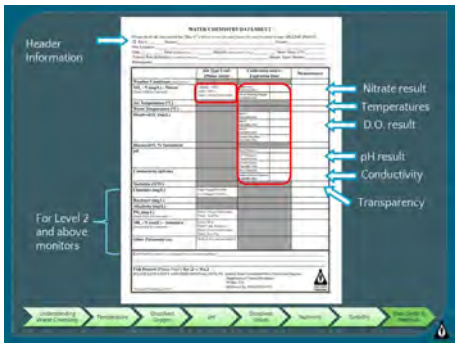
- In areas being developed
- Agricultural areas not adopting best management practices to prevent soil erosion
- Downstream from quarries and gravel mining operations

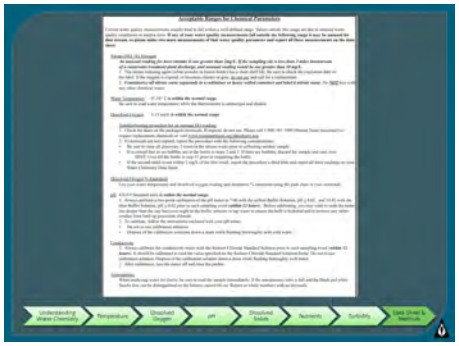


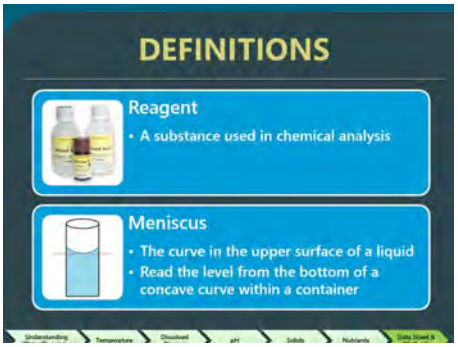












Water Chemistry Reference Table

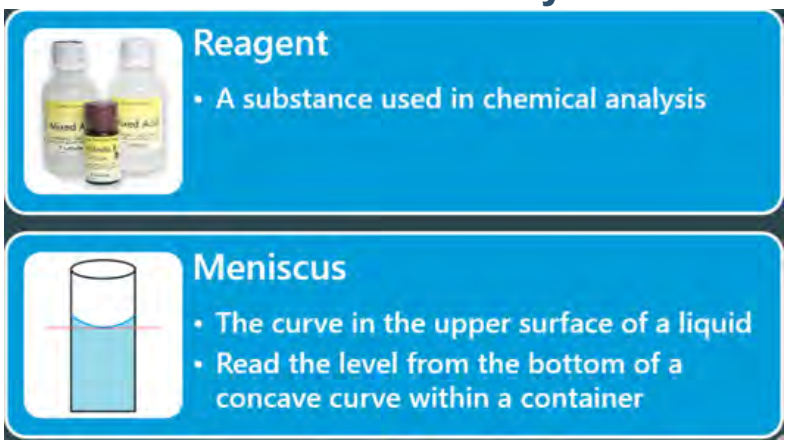
The Water Chemistry Reference Table can be found on the Missouri Stream Team website. This provides natural readings for Missouri streams, cautionary readings, possible sources affecting readings, and remedies. This resource should only be used as a guide. If there are concerns at your site, please contact Missouri Stream Team staff or Department of Natural Resources Environmental Response in case of emergency.

Water Chemistry Data Sheet

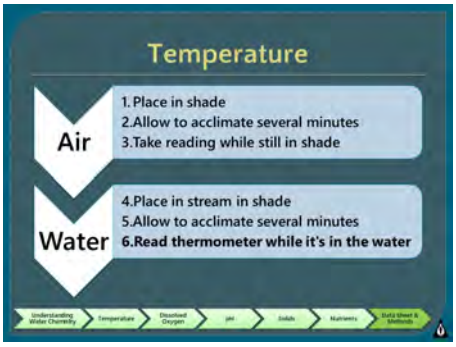
- ***Header:*** This section includes required information such as stream name, site number, site description, date and time monitored, name of trained volunteer, and Stream Team number. Additionally, it asks for the amount of rainfall in the last seven days, water temperature (in Celsius), and the name of any other participants assisting you.
- ***Weather Conditions:*** Record the weather conditions on the date you monitored your stream. You will also need to take an air temperature reading (in Celsius). Be sure to take the air temperature reading in the shade and before taking a water temperature reading.
- ***Nitrate***
- ***Dissolved Oxygen***
- ***pH***
- ***Conductivity***
- ***Transparency***
- ***Chlorides****
- ***Hardness****
- ***Alkalinity****
- ***PO_4****
- ***Ammonia****

**Not standard issued chemical monitoring kits. This parameters are not commonly measured. If you have a need to monitor these parameters, contact Missouri Stream Team staff.*

Definitions for Water Chemistry



Measuring Temperature



VWQM data sheets include air and water temperature, which should be measured in the shade. Measure air temperature first to avoid residual water on the thermometer affecting the temperature reading. When measuring water temperature, read the temperature while the thermometer is still submerged. Always allow several minutes for the thermometer to acclimate, especially in extreme temperatures.

Air

1. Place in shade
2. Allow to acclimate several minutes
3. Take reading while still in shade

Water

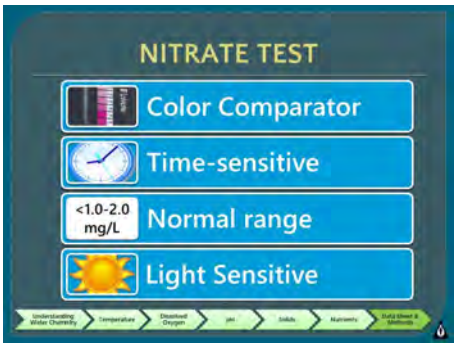
4. Place in stream in shade
5. Allow to acclimate several minutes
6. **Read thermometer while it's in the water**

Temperature Tips

- *Temperature should be measured with the program provided liquid-in-glass thermometer.*

  Do not measure temperature using the pH or conductivity meters.

- *Routinely inspect your thermometer for air bubbles in the liquid column. If liquid becomes separated, request a new thermometer from Missouri Stream Team.*



Measuring Nitrate

1. Rinse the sample bottle three times with stream water.
2. Fill sample bottle with sample water.
3. Fill one test tube to the 5.0 mL line with water from the sample bottle.
4. Add one Nitrate #1 Tablet.
5. Cap and mix until the tablet disintegrates.
6. Place the test tube in foil protective sleeve.
7. Add one Nitrate #2 Tablet.
8. Cap the test tube and mix for (2) minutes to disintegrate the tablet.
9. Set a timer and wait (5) minutes
10. Remove the test tube from the foil protective sleeve
11. Inset the test tube into the Octa-Slide 2 Viewer (color comparator).
12. Hold the Viewer so that non-direct light enters through the back.
13. Match the sample color to a color on the Viewer.
14. Record the result on the data form as: NO3-N mg/L.
15. Record a range or number on the data form at NO3-N mg/L. *Do not use the multiplier on the instructions.*
16. Containerize the liquid waste in a waste container and pour down the drain after returning home.

Nitrate Tips

- Nitrate Tablet #2 is sensitive to sunlight. The test tube must be kept in the kit provided foil sleeve when adding the tablet and while the chemical reaction is processing. If exposed to sunlight the reaction will be yellow
- A yellow color may also be observed at very low levels, even when not exposed to sunlight. If your reaction is yellow and you did not expose it to sunlight, record nitrate as **<1 mg/L**.
- Waste from the nitrate tablet kit may be containerized, taken home, and poured down the drain while flushing with cold water.
- If your nitrate reading appears to be between two values on the color comparator, Record the nitrate reading as a range on the data sheet. For example, if the nitrate reading looks to be between 6 and 8 on the colorimeter, record this as, “>6 <8.”

Measuring pH

Calibration (within 12 hours prior to monitoring):

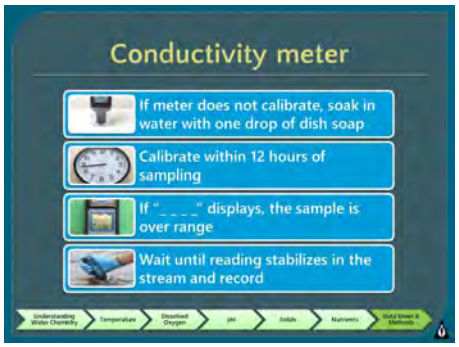
1. Set the power to on and remove the cap from the sensor.
2. Push to go to calibration mode. The auto-recognition standard (7.00) the tester expects will display at the bottom of the screen..
3. Pour the yellow pH 7.00 buffer solution into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push to save the measurement. The measured value flashes three times.
6. Repeat steps 3-5 with blue pH 10.01 buffer solution.
7. Push and hold to go to continuous measurement mode. "END" shows on the display.
   Note: "ECAL" shows on the display if the calibration was not successful.
8. Rinse the sensor and cap with deionized water and blot dry.

Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.

pH Tips

- Routinely inspect the bulb on the pH meter for cracks or air bubbles. If the bulb has an air bubble, hold the meter in your hand firmly with the bulb facing the ground. Give the meter a quick fling downwards as if you are flinging water from the meter. This should force the air bubble out.
  If meter bulb is cracked or dry, contact Missouri Stream Team for a replacement.
- After storage you may see a white cystalization around the bulb. This is potassium chloride and completely normal. Soak the meter bulb in tap water for a few minutes to rinse.
- The PocketPro pH meter is designed to be stored with residual water on the bulb. Do not pat dry. Do not store in DI water.



Measuring Conductivity

Calibration (within 12 hours prior to monitoring):

1. Set the power to on and remove the cap from the sensor.
2. Push to go to calibration mode. The auto-recognition standard (1413 or 147 µS/cm) the tester expects will display at the bottom of the screen.
3. Pour the 1413 µS/cm calibration standard shown into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push to save the calibration and go to continuous measurement mode. The measured value will flash 3 times and then stop. Then, "END" shows on the display.
6. Rinse the sensor and cap with deionized water and blot dry.

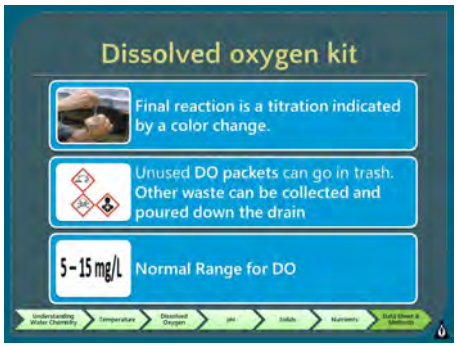
Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.

Conductivity Tips

- The PocketPro conductivity meter is prone to calibration challenges until it is well conditioned. There is a protective coating on the meter electrodes. Do not wipe these, but they should be cleaned by soaking in a cap of tap water with a drop of dish soap. Rinse well before calibrating. An indicator that the electrodes need to be cleaned is if the meter is reading too low to be calibrated successfully.
- Hold the conductivity meter by the top while measuring. Holding it by the cap or setting it on a metal surface will affect the reading.
- If your meter displays " - - - - " while measuring conductivity, the measurement is out of range. Low range conductivity meters can only measure up to 1990 µS/cm. Conductivity measurements exceeding 1990 µS/cm can be expected in large cities, such as St. Louis, Kansas City, and Springfield, during winter after road salt applications. If an out of range reading occurs and is unexpected for your stream site, contact VWQM program staff to report the high conductivity reading.

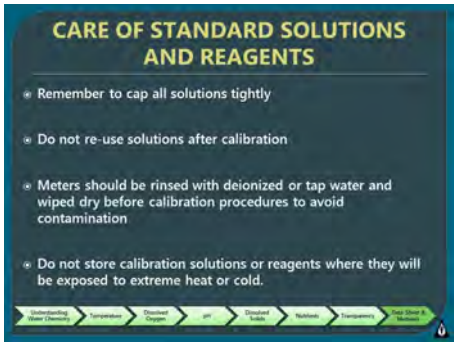
Measuring Dissolved Oxygen

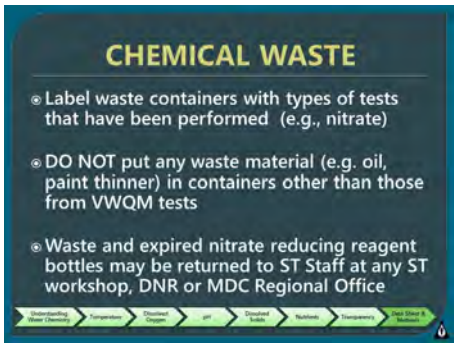


1. Fill the dissolved oxygen bottle with sample water to the middle of the frosted area by submerging it in the stream.
2. Add the contents of one Dissolved Oxygen Reagent 1 packet and one Dissolved Oxygen Reagent 2 packet.
3. Stopper the bottle without trapping air bubbles.
4. Shake the bottle vigorously to mix.
5. Wait for flocculent to settle to approximately half the bottle volume.
6. Shake the bottle vigorously again.
7. Wait for the flocculent to settle to approximately half the bottle volume.
8. Remove the stopper and add the contents of one Dissolved Oxygen 3 Reagent powder pillow.
9. Stopper the bottle and shake the bottle vigorously (flocculent will dissolve and sample will turn yellow if oxygen is present).
10. Fill the plastic tube to the top with sample from dissolved oxygen bottle.
11. Place the square bottle over the full plastic tube and invert to pour the contents into the square bottle.
12. Add Sodium Thiosulfate Standard Solution one drop at a time to the mixing bottle (making sure to hold the dropper vertical). Count each drop. Swirl to mix after each drop. Add drops until the sample becomes colorless.
13. Record the number of drops used in Step 12. One drop equals one mg/L.

Dissolved Oxygen Tips

- If an air bubble is observed in the sample vial while adding DO 1, 2, or 3, please start over. The air bubble will affect the chemical reaction.
  If there is a residue on the bottom of the sample bottle after restarting a test, add DO 3 to complete the chemical reaction and break apart the residue.
- Waste from the DO kit can be containerized and taken home to be poured down the drain while flushing with cold water.
- Extremely cold water or high chloride levels will affect how the floc settles. If floc does not settle after 10 minutes, shake the bottle once more and continue with the test.
- Hold sodium thiosulfate dropper vertical and give confident, firm squeezes to ensure full drops. Release dropper bulb between drops. Do not allow drops to run down the side of the titration bottle.





Water Chemistry Reminders

- Check expiration dates of reagents well before monitoring. Equipment orders take 2-4 weeks to arrive.
- Double check data sheet and online data entry for errors
- Save a copy of your data collected in case of follow-up questions or errors
- When adopting a new monitoring site, submit site map to StreamTeam@dnr.mo.gov
- Liquid waste can be poured down the drain while flushing with cold water. Containers for liquid waste can be requested through Missouri Stream Team staff.
- Dry waste can be kept in original packaging and discarded in trash
- Keep all chemicals and waste out of reach from children and pets.

Next Steps

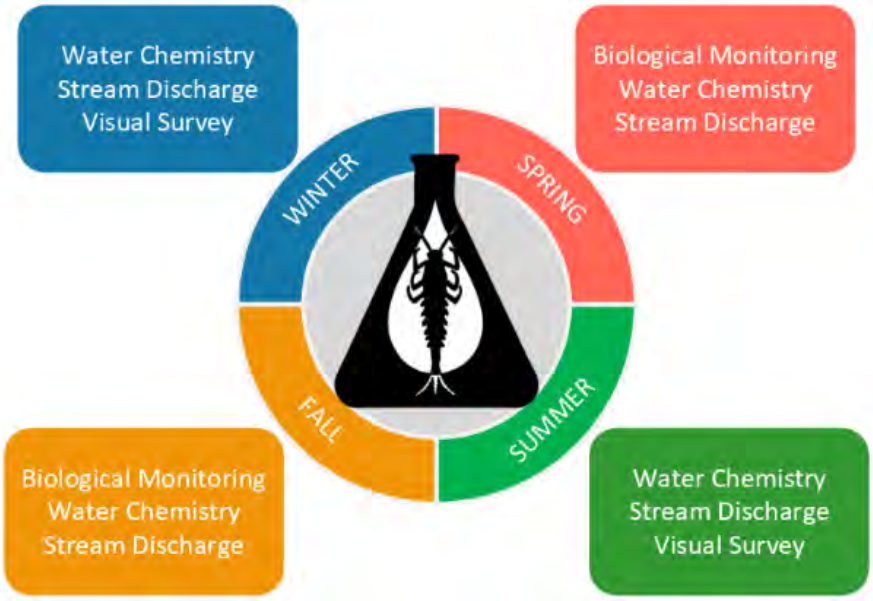
After completion of the virtual trainings, you are eligible to attend the field certification. Check mostreamteam.org for field certification opportunities. Individuals that complete the field training are VWQM Level 1 certified and are eligible to receive the following monitoring equipment:

Stream Discharge
- Flow balls
- Measure tape

Biological Monitoring
- Kick net
- Vials
- Magnifiers
- Forceps

Water Chemistry
- Thermometer
- Transparency tube
- DO kit
- Nitrate kit
- Conductivity meter
- pH meter

Water Quality Monitoring Procedures



Volunteer Water Quality Monitoring Field Checklist

General supplies

- _____ Clipboard*
- _____ Litter bag*
- _____ Thermometer*
- _____ Appropriate footwear
- _____ Pencil

Stream Discharge

- _____ Stream Discharge Data Sheet*
- _____ Float balls*
- _____ 100-foot measure tape*
- _____ Stopwatch
- _____ Two sticks or stakes
- _____ 10-foot rope
- _____ Depth rod marked in tenths of a foot

Visual Survey

- _____ Visual Survey Data Sheet*

Biological Monitoring

- _____ Macroinvertebrate Data Sheet*
- _____ Hand lens or magnifier*
- _____ Kick net*
- _____ Forceps*
- _____ Two 1 1/8th inch diameter rod for sides of kick net
- _____ White ice cube trays for sorting
- _____ Squirt bottle

Chemical Monitoring

- _____ Water Chemistry Data Sheet*
- _____ Thermometer*
- _____ Transparency tube*
- _____ Dissolved oxygen kit*
- _____ Nitrate kit*
- _____ pH meter*
- _____ Conductivity meter*

**Program provided items*

Items can be reordered at mostreamteam.org

MISSOURI STREAM TEAM

MISSOURI DEPARTMENT OF CONSERVATION

MISSOURI DEPARTMENT OF NATURAL RESOURCES

CFM Conservation Federation MISSOURI