Chapter 2 -
Designing a Water Monitoring Study

The first step in developing a water monitoring study design is identifying your watershed. The ability of a stream to support beneficial uses such as fishing, boating and swimming is influenced by the major land uses in the watershed, the nature of the stream channel, the diversity of in stream habitats, and the character of the riparian area.

Planning is critical to a successful water monitoring program. Knowing why you are monitoring will determine where, when, and how often you monitor.

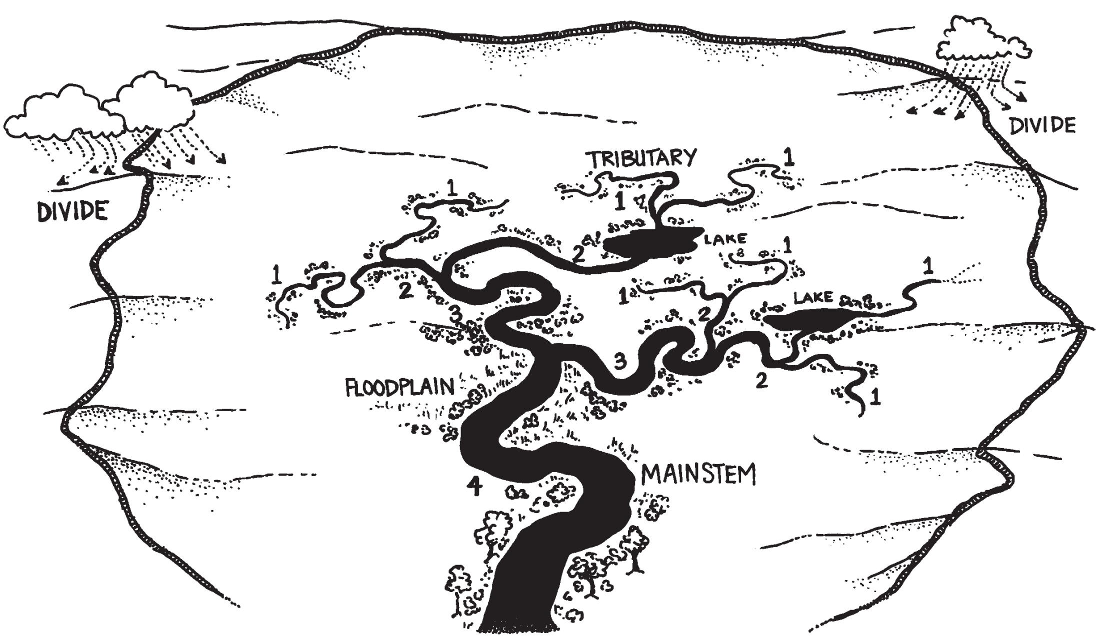
What is Your Stream Address?

"Just as everyone in Indiana lives within the boundaries of a county, everyone also lives within a watershed; although we may live, work or play in different watersheds or in different parts of the same watershed." A watershed is the total area of land that drains into a particular waterbody (wetland, stream, river, lake, or sea). Land uses and run-off in a watershed determine the quality of surface water in smaller streams and waterways. They can then influence the water quality of larger streams. For example, point source discharges, urban run-off from landfills and run-off from agricultural areas may contain sediments, organic material, nutrients, toxic substances, bacteria or other contaminants. When these substances are present in significant concentrations, they may interfere with some stream uses.

Approximately one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called first-order streams. When two first-order streams join, they form a second-order stream. When two second-order streams join, a third-order stream is formed, and so on. (Figure 4) First- and second-order channels are often small, steep or intermittent. Stream orders that are six or greater constitute large rivers.

A stream channel is formed by runoff from the watershed as it flows across the surface of the ground following the path of least resistance. The shape of the channel and velocity of flow are determined by the terrain, unless changes have been made by man. When the terrain is steep, the swiftly moving water may cut a deep stream channel and keep the streambed free of sediments. In flatter areas, the stream may be shallow and meandering, with a substrate comprised largely of fine sediments.

Figure 4



What is your Watershed Address?

Hydrologic Unit Code Areas

Knowing your “watershed address” is very important to understanding the influences on the water quality in your stream or river. Hoosier Riverwatch organizes data from volunteer stream monitors by watershed location using the map: “ 8-Digit Hydrologic Unit Code (HUC) Areas in Indiana” (Page 15-Figure 6). Delineated by the U.S. Geological Survey, hydrologic units represent the geographic boundaries of water as it flows across the landscape. But not every HUC is a “watershed” in the pure sense, since longer streams are divided along their length. As you can see on the map, each HUC has an associated 8-digit number or code. This number is representative of the size of the basin. Larger basins are represented by smaller numbers. Look at the first six numbers of two or more watersheds near each other on the map; if they are the same (e.g., Chicago, Kankakee, and Iroquois in northwest Indiana, which are 071200), then they are part of the same larger watershed. You could use colored pencils to delineate these larger watershed boundaries on this map.

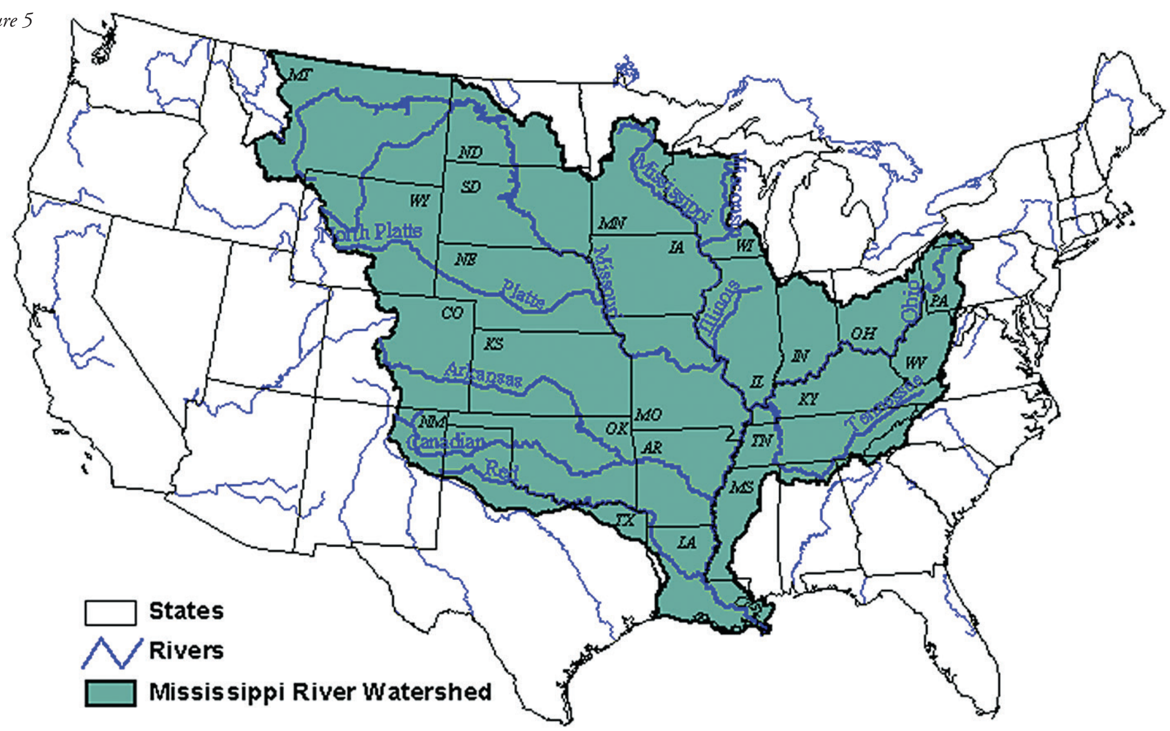
Check the map on page 15 and write your watershed address (HUC) here:

Watershed Name ____

Watershed # ____ ____ ____ ____ ____ ____ ____ ____

Water within watersheds beginning with 04s flow into Lake Michigan or Lake Erie and are part of the Great Lakes Watershed. The 07s flow west into the Illinois River before entering the Mississippi River. Water from the 05 watersheds flows into the Wabash or Ohio Rivers before also joining the Mississippi River and discharging into the Gulf of Mexico. The Mississippi River watershed is the largest in the United States (Figure 5).

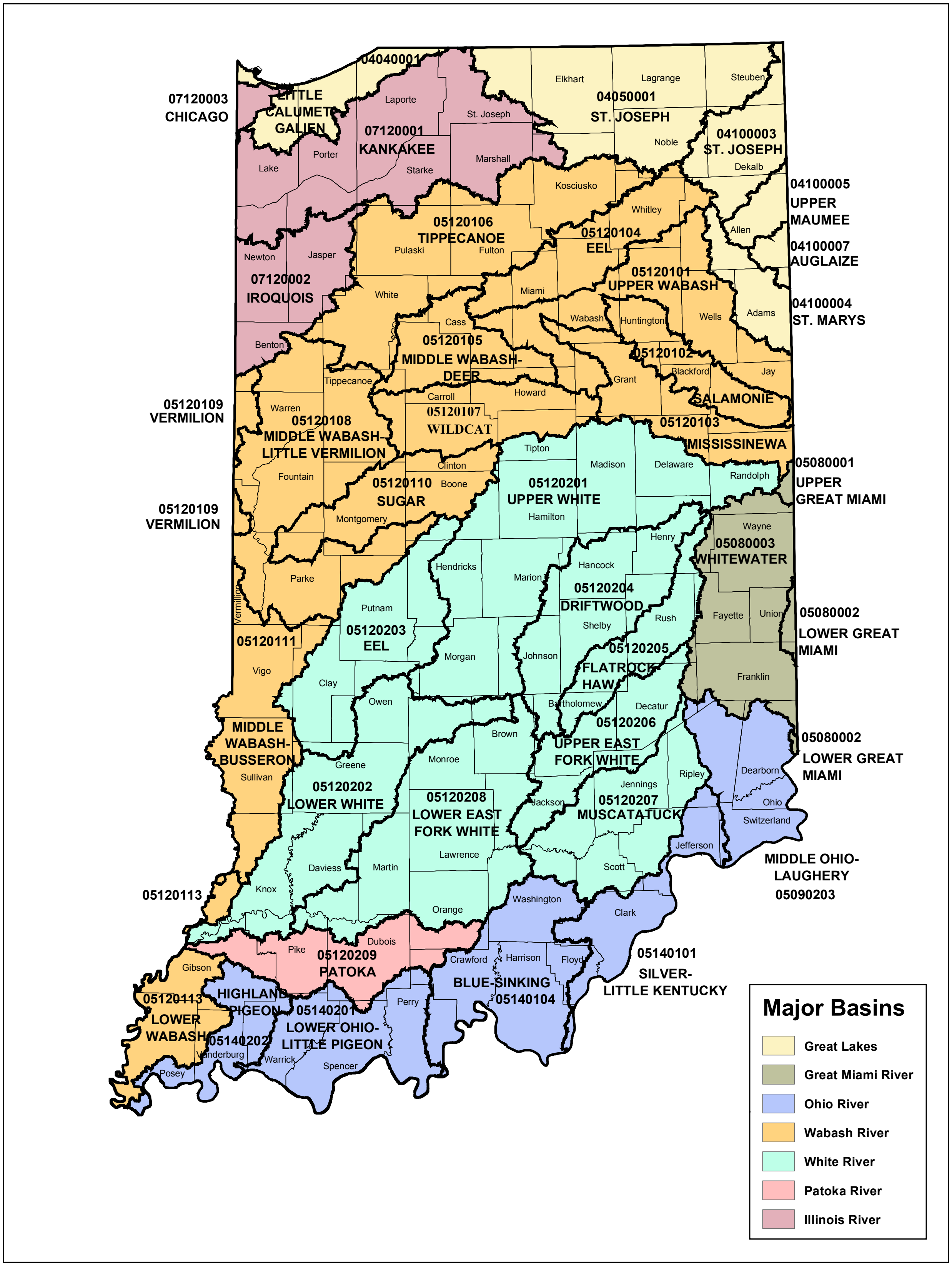
Figure 5



Indiana is divided into 39 watersheds at the 8-digit level (including Lake Michigan proper). Each of these watersheds can also be divided into smaller sub-watersheds which are represented by 10-digit numbers, and even smaller units with 12-digit numbers. Visit, http://www.idem.IN.gov//cleanwater/pages/huc to find your watershed.

8-Digit Hydrologic Unit Code (HUC) Areas in Indiana

Figure 6



This map is intended to serve as an aid in graphic representation only. This information is not warranted for accuracy or other purposes.

Mapped By: Joanna Wood, Office of Water Quality
Date: 11/05/2014

0 10 20 40 Miles

0 10 20 40 Kilometers

N W E S

County Boundary

8-Digit HUC Areas

IDEM

Data Sources - Obtained from the State of Indiana Geographic Information Office Library
Map Projection: UTM Zone 16 N Map Datum: NAD83

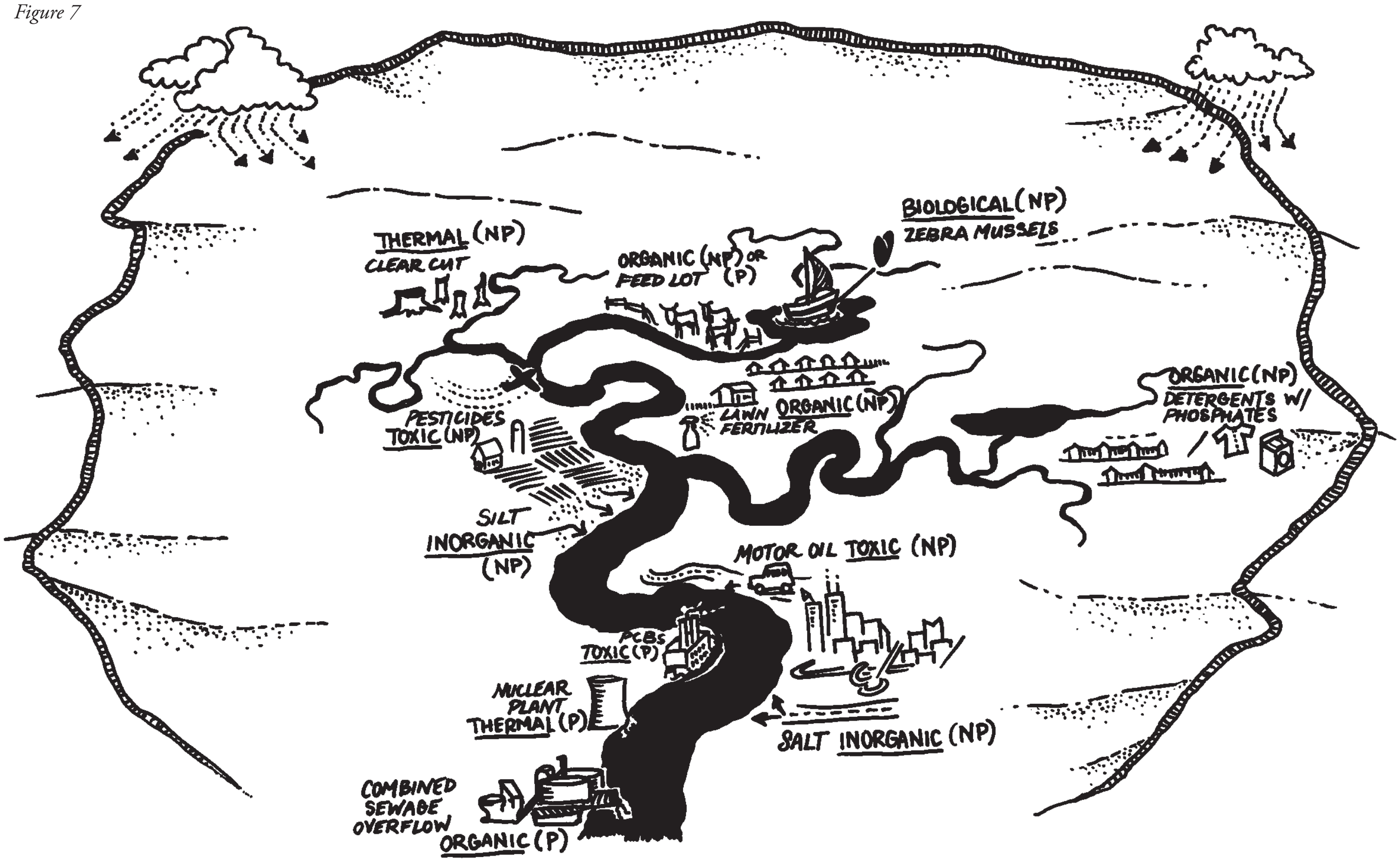
What is Water Pollution and Where Does it Come From?

Many volunteers monitor because they are concerned about pollution. Volunteer monitors check for current pollution and develop a baseline to gauge future pollution. Water pollution can typically be placed in one of two categories: point or nonpoint source pollution. **Point source pollution** is easy to identify because it is discharged from the end of a pipe. It accounts for about 25% of all water pollution.

Point sources are regulated with permits by the Indiana Department of Environmental Management.

Nonpoint source pollution originates primarily from runoff and is more difficult to identify. It is a product of land use throughout the entire watershed, and makes up about 75% of water pollution. Different types of pollution are described below and shown (Figure 7).

Figure 7



Point sources are indicated by a "P"; nonpoint sources are "NP."

1. **Organic Pollution** - decomposition of once-living plant and animal materials
2. **Inorganic Pollution** - suspended and dissolved solids (e.g., silt, salt, minerals)
3. **Toxic Pollution** - heavy metals and lethal organic compounds (e.g., iron, mercury, lead, PCBs) - some of these are transferred via the atmosphere and air deposition
4. **Thermal Pollution** - heated water from runoff (e.g., streets, parking lots) or point source discharges (e.g., industries, nuclear or other power plant discharges)
5. **Biological Pollution** - introduction of non-native species (e.g., zebra mussels, purple loosestrife, Eurasian watermilfoil)

Sediment is a Leading Source of Water Pollution by Volume to Indiana Streams and Rivers!

Soil erosion and sediment as a result of poor construction, logging, landscaping, and agricultural practices, as well as eroding stream banks, cause many physical changes in streams that lead to decreased water quality.

Sediment impacts on streams	Resulting Direct and Indirect Effects on Aquatic Organisms
• Heat is absorbed resulting in increased water temperature.	• Metabolic rates of organisms increase, leading to wasted energy not available for growth and reproduction.
• Water clarity is decreased, thereby increasing turbidity. • Increased siltation and embeddedness on stream bottom (Figure 8).	• Reduction in visual feeding and visual mating. • Clogging of gills during breathing and feeding. • Smothering of nests and eggs. • Change in habitat and filling of crevices in bottom gravel.
• Excess organic debris is carried with soil, which may result in increased Biochemical Oxygen Demand (BOD) and decreased dissolved oxygen.	• Oxygen sensitive species are detrimentally affected. • pH is reduced (water becomes more acidic) resulting in: ¤ Phosphorus becoming more available ¤ Ammonia becoming more toxic ¤ More leaching of heavy metals.
• Excess phosphorus is attached to soil particles and is carried into streams.	• Phosphorus acts as a “fertilizer,” so algal growth increases, leading to higher daytime dissolved oxygen and lower nighttime levels. • Can upset normal feeding on the aquatic food chain.
• Heavy metals may be leached from the soil leading to increased toxicity.	• Developmental deformities. • Behavioral changes in feeding, mate attraction and activity, and parental care.

One way to measure sediment impacts on a stream is by looking at embeddedness (Figure 8), which refers to the degree to which rocks, gravel, cobble, boulders, and snags are covered or sunken into silt, sand or mud of the stream bottom.

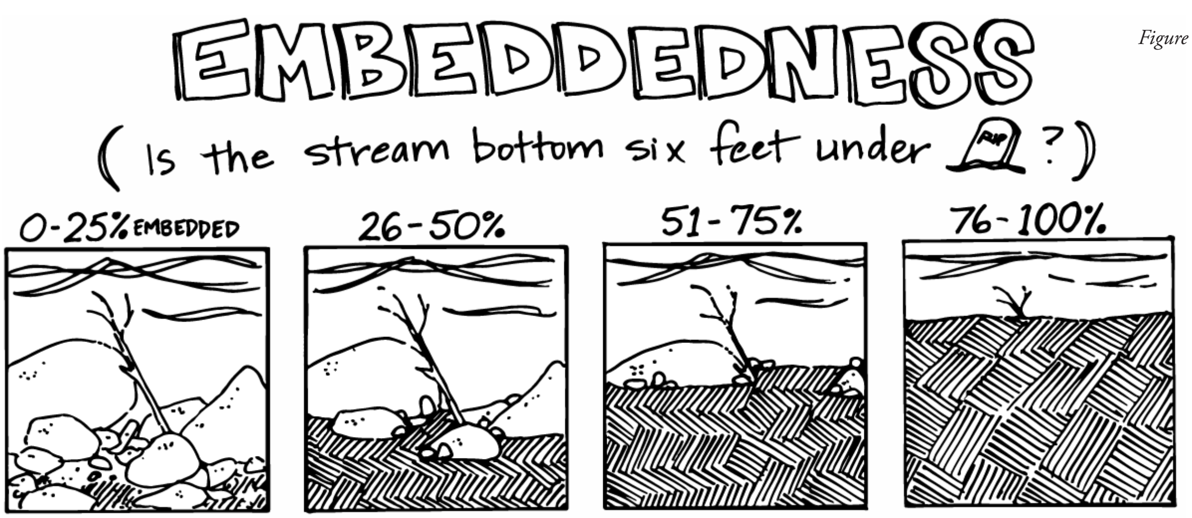


Figure 8

Watershed Inventory

Information in this section is reprinted and modified from Hudson Basin River Watch Manual, Ohio EPA Explore Your Stream, and the IOWATER Program Handbook.

We know where water pollution might originate, now it's time to take a look around your watershed and discover the potential pollution sources there. The purpose of a watershed inventory is to learn about the current uses, values, and threats to the water resources in your watershed. In general, there are two ways to gather information:

Desktop Inventory: Use maps and aerial photos. Get copies of existing reports, including possible watershed management plans. Visit www.IN.gov/idem/nps/3180.htm to see if a watershed plan has been developed for your community. Find out the designated uses for streams in your area. Identify your water's special attributes and threats to these uses and values. Survey people. Know what municipalities govern your watershed.

Field Inventory: No matter how much information you discover through your research, the best way to know what's really going on is to get out into the field. You can perform a driving survey or "windshield tour" and also get out of your vehicle and take a look around (respecting private property rights, of course). What should you be looking for? ANYTHING that may affect your stream.

Land Use

This list includes just a few things to look for and is not a complete list. It's meant to start you "down the road" considering what is in your own watershed and what may impact your water quality as you begin your water study. The information collected during your watershed inventory is for your use only - but it is strongly recommended that you consider doing it at the beginning of your monitoring!

- **Agricultural Crops/Fields** - Are buffers in place? What kind of tillage is occurring? What kind of fertilizer is being applied and is it staying on the field
- **Pasture/Livestock** - Is there a manure management system? Is the waterway protected with fences?
- **Logging** - Are there clear-cuts (all trees) or selective cuts of individual trees?
- **Mining** - What kind: surface, underground, quarry? Is it active, abandoned, reclaimed?
- **Waste Disposal** - What kind: landfills, home septic systems, sewers, pet waste?
- **Construction Areas** - What types: homes/buildings, roads, bridges? Is sediment contained or buffered?
- **Residential/Suburban** - Are there storm drains, lawns, commercial businesses (malls/strip malls, retail shops, car washes, gas stations, restaurants), dog parks?
- **Urban** - How are services provided: drinking water/wastewater treatment facilities, factories, power plants? Are there known brownfields, leaking underground storage tanks (LUSTs), other remediation sites, combined sewer overflows (CSOs)?
- **Recreation Areas** - What types do you have: zoos, forests, nature preserves, parks, greenways, campgrounds, golf courses, hiking and horseback trails, swimming areas, fishing areas, power boating?

Instream Conditions

As you walk along the stream bank, take note of...

- **Litter/Garbage** - small litter, piles of trash, illegal dump, appliances
- **Algae** - floating, attached, color
- **Water Color** - clear, muddy, milky, tea-colored, red, gray, green, black
- **Water Appearance** - oily sheen, lots of foam/bubbles, scum
- **Water Odor** - sewage, petroleum (gas), rotten eggs, fishy, chlorine, soapy
- **Discharge Pipes** - field tiles, storm drain, industry, municipal wastewater, sewer, flowing in dry weather.

Study Design - 5 Ws of Water Quality Monitoring

WHY - Define your purpose or goal. Initially this may be simple and straightforward, is the water safe for recreational activities (swimming, wading, and boating)? However, over time, the knowledge you gain may prompt you to ask bigger questions and prompt action in your watershed.

Goals will differ among groups. Some common reason folks may monitor include:

- Identify pollutants and sources
- Establish baseline data
- Document changes and trends
- Measure effectiveness
- Inform stakeholders
- Assess use attainment
- Provide information and data to support modeling
- Characterize the watershed

This definition will influence decisions on what, where, when…

WHAT - What parameters you choose to monitor will depend upon your goals. There is no right or wrong answer; however, parameters should align with the question you want to answer and your budget for monitoring. For example, if you are interested in algae blooms, you may sample for nutrients and collect representative algae samples for identification.

WHERE - Where you monitor depends upon your sampling goals/objectives. Before you select one or more sites, it is important to research, visit, and learn about your watershed, land uses, and potential sources of pollution. If you are interested in the effects of agriculture on water quality, you may want to sample a stream with a primarily agricultural watershed. If you want to determine the effects of industrial discharge on stream water quality, you may choose to monitor at three points, one upstream (control site), immediately below the source, and one further downstream to gauge recovery. It is up to you to choose where you would like to monitor.

If you need help choosing a spot, your watershed specialist (Appendix F, page 155) or your county Soil and Water Conservation District (www.iaswcd.org) may have some suggestions. A watershed management plan may be in development in your community.

Each sampling site is 200 feet in length.

Each sampling site is a 200-foot stream segment. You should use local landmarks (bridges, trees) or survey tape to define the boundaries of your sampling site. Take photos, but also sketch your site to capture things missing from photos. You must also ensure safety by considering bank accessibility, water depth, and private property rights. Review the safety section (Chapter 1) for other important safety considerations.

WHEN - Once again, when you monitor will depend upon your goals. Consider the following impacts on water quality to help determine your sampling schedule.

Trend monitoring is the primary testing method preferred by Hoosier Riverwatch. To get an accurate picture of a stream's water quality, tests have to be performed on a regular basis (consistently), over a period of years (persistently). Without long-term continued monitoring, data obtained by Riverwatch volunteers may have limited uses. A random, one-time sample provides a limited picture of water quality and overall health of a water body at the particular site and time it was monitored. Many things can affect a one-time sample, and weather can be the largest single outside influence on many water quality parameters. Trend monitoring provides a broad view of the stream allowing the seasonal variations to be sorted out from long-term changes. In order to obtain data useful for trend analysis, volunteers should consider the long-term commitment involved in this type of monitoring.

Daily Changes - Water samples taken at different times of the day may yield different results. Changes in stream flow, air temperature, and photosynthesis of aquatic plants influence chemical properties of water.

Seasonal Changes – Nutrient levels may vary by season depending on the number of aquatic plants, as they take up nutrients from the water. Spring run-off may increase water levels, thereby changing the pollutant levels one may find. In addition, macroinvertebrate populations vary seasonally. You should find the greatest diversity in spring and fall.

The best way to ensure you get out to the stream is to make a sampling schedule. Consider how many people will be monitoring, how many sites you or your group plan to sample, and whether sampling is feasible year-round (e.g., due to drought, flooding, or ice cover). Think about the types of tests you will perform, the time requirements, and the goals you have set.

Many Riverwatch groups monitor four times a year, but if sampling can only be done once or twice a year, it is preferable to do it in early spring and fall.

WHO - Groups of 2-3 students or adults can take measurements. Tasks within a group include collecting samples, processing samples, and recording data. It is very useful to have multiple groups testing for each parameter (for example, two groups measure dissolved oxygen). This allows more participants to get involved and builds in some quality control. Groups conducting the same test should compare results to determine if the data are similar. If there are different results for the same sample, group members should check the procedures and repeat the test to determine the cause of the difference. Quality control is an important part of the science and the learning experience.

Remember – no matter what your goal for monitoring, any water study must be founded on sound, scientific, and objective research.

Quality Assurance & Quality Control

Many volunteers strive to obtain the best data possible. We think this is important, as YOU are one of the primary users of the data. The following are some suggestions on how you can improve the quality of your water monitoring data.

A **Quality Assurance Project Plan (QAPP),** is a written document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements. A QAPP helps the data user and monitoring project leaders ensure that the collected data meet their needs and that the quality control steps needed to verify this are built into the project from the beginning. By law, any EPA-funded monitoring project must have an approved QAPP before it can begin collecting samples.

The American Society for Quality states that **"quality assurance"** and **"quality control"** are often used interchangeably to refer to ways of ensuring the quality of a service or product. They do, however, have different meanings.

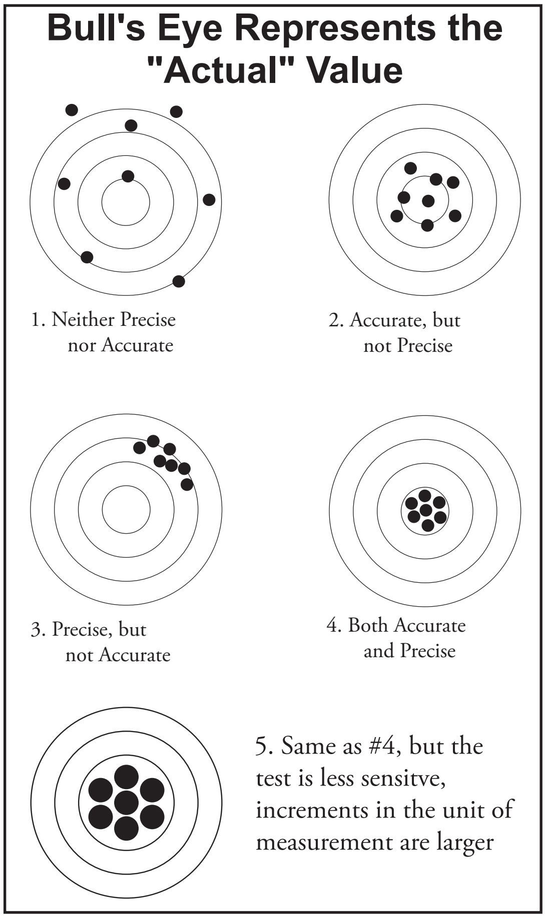
- **Quality Assurance:** The planned and systematic activities implemented in a quality system so that quality requirements for data will be fulfilled.
- **Quality Control:** The observation techniques and activities used to fulfill requirements for quality.

Accuracy and Precision

The reliability of water quality data depends on its accuracy and precision (Figure 9). Both tend to increase when more sophisticated technologies are used. Even though Riverwatch uses less sophisticated technologies, and limitations to the data exist, it is still valuable and can be used to identify trends, "hot" spots, areas in need of further monitoring, and, if enough data is available, can be used for watershed planning. This is possible because Riverwatch data are comparable to professional data. Although not exact, the data provide a "ball park" figure.

Data collected following Riverwatch methods may be considered accurate, but not as precise (#5) as methods utilizing higher technology. For example, using the pH test strip, a volunteer can consistently find the result to be 8.5 (showing precision); however, if the actual value was 8.65, she would not be able to obtain this result (with accuracy) because the pH test strip has the limitation of a 1/2 unit on the pH scale.

Figure 9



Comparability refers to how well data can be compared with other data from the same project or data from another project. **Reliability** in both accuracy and precision is achieved by:

- Collecting the water sample as directed
- Rinsing bottles and tubes with sample water before collecting the sample and with distilled water after completing the test
- Performing tests immediately after collecting the water sample
- Careful use and maintenance of testing equipment (check by using blanks and standards)
- Following the specific directions of a testing protocol exactly as described
- Repeating measurements to check for accuracy and to understand any sources of error
- Minimizing contamination of stock chemicals and testing equipment
- Storing kits away from heat and sunlight
- Checking expiration dates on chemicals and replacing before they expire
- Checking to be sure the results submitted to the Hoosier Riverwatch database are the same as those recorded on the data sheets.

Replicating Measurements

By replicating or repeating measurements, volunteers collect better data. Streams and rivers are variable. The water flowing past a point in the stream constantly changes. Taking *multiple measurements* and *averaging the values* captures some of the natural variation and provides a more representative result. In addition, taking more than one measurement reduces the chance of reporting incorrect data. If more than one person and/or testing kit are used, replicates provide an opportunity to test for both operator error and bad reagents. If one person obtains a value considerably different from another, repeat the test. If you are working with a group of student or adult volunteers, the purchase of a few additional items for chemical and biological monitoring (e.g., nets, color comparators) will improve efficiency in performing replicates.

Standards, Blanks and Splits

A standard is a sample of known concentration. Standards can be purchased from Hach or other chemical companies. A blank is a sample run using distilled water. By testing standards and blanks, volunteers can check for bad reagents and equipment contamination. A split is one sample tested twice (for example, two nitrate tests performed out of the same bucket of water taken from a stream). Splits test for operator error, as both tests should yield the same result.