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AMERICAN WATER



# Riffle Beetles to Riparian Buffers

Exploring Methods of Assessing  
Surface Water Quality

- **Grade Level:** 7-12
- **Objective:** Students will evaluate the quality of two water sources using chemical, physical and habitat parameters
- **Subjects:** Biology, Environmental Studies, Mathematics, Chemistry, Geography, Writing

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## INTRODUCTION

The rivers and lakes of North America provide drinking water to millions of citizens. Not only do these surface waters constitute a critical resource for communities and agriculture, but they are also home to myriad species that rely on a healthy environment to survive. Citizens have a vested interest in monitoring the health of these systems to help identify potential problems early on and educate the population at large on the potential for water supplies to be compromised.

Municipalities and corporations have the responsibility to treat and meet drinking water standards before it is made available to citizens and customers. Reducing or eliminating negative impacts on surface waters and monitoring the general health of these systems is increasingly coming under the charge of citizen action groups.

There are three general approaches to monitoring the health of fresh water ecosystems:

- **Chemical and physical parameters:** Testing the water for specific parameters. Several analytical tests are readily available and fairly easy to complete that can be used to evaluate the chemical and physical properties of the surface waters. Because conditions can change quickly based on weather, seasonal fluctuations or anthropogenic activity, samples should be taken at various times during the year.
- **Study of the aquatic life:** Studying the presence of certain species at within a surface water body can be used to evaluate the overall health of an aquatic ecosystem. Because of their abundance and because they have been studied extensively for decades, benthic macroinvertebrates are particularly useful in calculating a biotic index – or a measure of stream, river or lake’s health based on the diversity and abundance of these organisms. Macroinvertebrates have what is called referenced tolerance values, which indicate the degree of tolerance or sensitivity of particular groups to pollution. For example, if the predominant species in a water body are known to be very tolerant of pollution, that would provide an indication that the habitat is under stress. In contrast, if the predominant species identified are known to be sensitive to stressors that would provide a good indication of a healthy aquatic ecosystem.
- **Physical assessment:** Visual observations of the in-stream habitat and riparian zone to assess the state and evidence of potential impacts.

The most comprehensive evaluation of a freshwater body and adjacent habitat will include all three methods.

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## DID YOU KNOW?

The Biotic Index can be used anywhere in the world as some invertebrate groups are common to almost every stream.

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## MATERIALS NEEDED

- Piece of paper
- Pen or pencil
- Calculator
- Enclosed data sheets

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## EXERCISE











Lake Gabriel is the principal water source for the residents living around and near the lake. Two teams of citizens have set out to evaluate the water quality of streams flowing into the lake. Completing chemical and physical analyses, biotic index and habitat assessments, the two teams will establish baseline data for the communities, compare the streams at opposite ends of the lake and identify

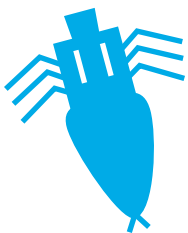
possible reasons for any concerns. Two sets of chemical and physical data, two macro-invertebrate samples and stream photos are provided. Using the reference data provided, students will compare the results from the three sets of data (biotic index, chemical and physical parameters), describe water quality and establish whether the results of the various assessments coincide.

## BIOTIC INDEX REFERENCE SHEET

Each of the following organisms has a tolerance value (a) that indicates the degree of tolerance for pollution. A taxon (macroinvertebrate) with a low tolerance value is not tolerant to pollution and therefore would only be found in a healthy system. A taxon with a high tolerance value can tolerate pollution, but may also be found in healthy habitats. As a generalization, a healthy system will have a high species richness and be home to many different species.

## TAXA AND TOLERANCE VALUES

|   |  |  |   |  |
|---|--|--|---|--|
| <b>Mayfly</b><br>a = 2<br>   | <b>Aquatic Worm</b><br>a = 8<br>  | <b>Caddisfly</b><br>a = 3<br>       | <b>Isopod</b><br>a = 6<br>   | <b>Flatworm</b><br>a = 7<br>  |
| <b>Stonefly</b><br>a = 0<br> | <b>Riffle Beetle</b><br>a = 4<br> | <b>Fingernail Clam</b><br>a = 7<br> | <b>Amphipod</b><br>a = 6<br> | <b>Dragonfly</b><br>a = 5<br> |



- Tolerance values per taxon may vary by Biotic Index formula. Some protocols require classification at the family or genus level in which more specific tolerance values can be assigned.
- There are many other benthic macroinvertebrates that can be found in stream systems around the world. Many have tolerance values and can be used for calculating a Biotic Index. See references at the end of this lesson.



## BIOTIC INDEX

The Biotic Index is calculated by the following formula:

$$BI = \frac{\sum (n.a)}{N}$$

- n = # per taxon
- a = tolerance value for that taxon
- N= total # organisms collected in sample

### **BI < 3.75 = Excellent Water Quality**

(no pollution)

### **BI 3.75 - 5.0 = Good Water Quality**

(low pollution input)

### **BI 5.01 - 6.5 = Fair Water Quality**

(moderate pollution input)

### **BI > 6.5 = Poor Water Quality**

(heavily polluted system)

## SAMPLE CALCULATION

A collection of macroinvertebrates results in the following sample:

- 11 mayflies
- 6 dragonflies
- 19 caddisflies
- 3 beetles
- 2 flatworms
- 19 amphipods

### **Biotic Index Calculation**

$$\frac{\{(11 \times 2) + (6 \times 5) + (19 \times 3) + (3 \times 4) + (2 \times 7) + (19 \times 6)\}}{60}$$

### **Results**

- BI = 4.15
- Good water quality (low pollution input)

Note: There are several Biotic Index Formulas that are used by scientists and citizen groups alike. The formula referenced in this lesson plan is for general use.

## HABITAT ASSESSMENT/ LAND USE REFERENCE WORKSHEET

The following characteristics are characteristic of healthy small streams and rivers:

### **Riparian Habitat**

- Unbroken presence of forest along both banks
- Stream banks that are stable; erosion is not apparent
- Vegetation along the bank includes a variety of plant types; trees, shrubs, herbs

### **In Stream Habitat**

- Clear water
- Rocky substrate (bottom type) with variable particle size
- Some emergent vegetation
- Diversity of habitat; logs and other natural debris adjacent to the bank and/or in the stream

- Riffles (habitat where the water spills over rock or other structures), runs (swiftly flowing non-turbulent water) and pools (deeper slower moving water)

### **Land Use/ Human Impact**

- No impervious surfaces directly adjacent to the stream
- No pipes or drainage ditches emptying into the stream
- Vegetation along the bank is not cut or removed
- Recreational, municipal and residential activities near the stream are buffered by healthy riparian vegetation



## CHEMICAL, MICROBIAL AND PHYSICAL PARAMETER REFERENCE SHEET

### Dissolved Oxygen (DO)

Needed by almost all organisms living in aquatic ecosystems, DO should be at least 4-6 ppm (mg/L) to support aquatic biota. Dissolved oxygen in small, swiftly moving, cool streams can exceed 12 ppm. Values below 4-6 ppm indicate system stress. This may be caused by elevated levels of organic wastes from sewage and/or runoff. Oxygen levels decline as bacterial activity increases.

### Nitrates

Along with phosphates, nitrates are typically found in fertilizers. Healthy fresh water bodies will have nitrate levels less than 1 ppm. Elevated levels from fertilizer runoff, effluent seepage or animal waste can contribute to a build-up of algae. This process is known as “cultural eutrophication.”

### Phosphates

Another component of fertilizers, but also found in detergents, phosphate levels in undisturbed streams should not exceed .03 ppm. As with nitrates, elevated levels contribute to cultural eutrophication.

### Turbidity

Suspended particulate matter causes the water to appear cloudy. This can be measured using a turbidity column, a transparent tube calibrated in cm up to 1.25 meters. If the water is clear, a small black and white disk (secchi disk) at the bottom of the column can be seen when the column is filled with sample water. If there is sediment or a large amount of algae, light cannot penetrate so as to see the disk at the bottom. A valve lets water out of the bottom of the column and as the water drains, an observer documents the column height when the disk is visible. In very turbid systems, the height of the column might only read 10 or 20 cm. Erosion, runoff and storm events can increase turbidity. It is important

to note that the higher the value from the turbidity column the less turbid the system. So a highly turbid stream will have a low column reading in cm.

### Bacteria

E.Coli and other bacteria can be found naturally in stream systems, but often elevated levels indicate anthropogenic input – sewage, animal waste or other agricultural waste. Healthy streams have total bacterial counts of less than 1 colony per 100 mL of sample. To permit body contact the level must be below 100 colonies per 100ml and for fishing and boating the value is less than 1000 colonies/ 100 mL.

### Temperature

Measured in degrees Celsius, the temperature of any natural stream, river or lake should not fluctuate dramatically and should be seasonally appropriate. Deforestation along the bank, increased sediment load or thermal input can increase the temperature and potentially stress aquatic inhabitants.

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## LAKE GABRIEL STREAM 1 DATA SHEET

### Chemical, Microbial and Physical Data

- Dissolved Oxygen: 4 ppm
- Nitrates: 1.9 ppm
- Phosphates: 0.9
- Turbidity: 41 cm
- Temperature: 22 degrees Celcius
- Total Bacteria: 320 colonies



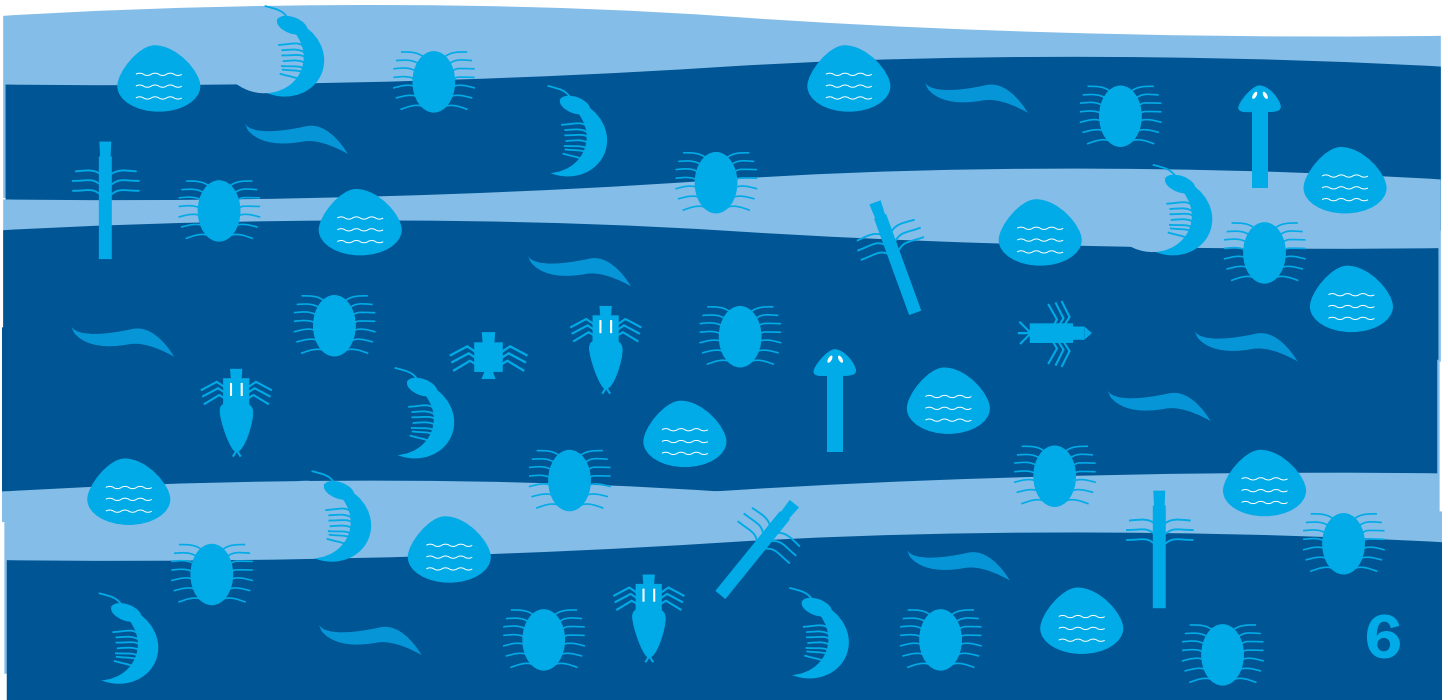
### In-Stream Habitat Check List

- In-stream Vegetation  Present  Absent
- Natural Debris (woody/leaf material)  Present  Absent
- Litter  Present  Absent
- Bottom Type  Bedrock  Boulder  Cobble  Pebble  Sediment

### Riparian Habitat (Stream Bank)

- Vegetation along the Bank  Trees  Shrubs  Herbaceous Plants
- Evidence of Erosion  None  Some  Extensive
- Evidence of Human Activity  Pipe  Bridge  Mowed Lawn  Paved Surface

### Aquatic Life Found In-Stream



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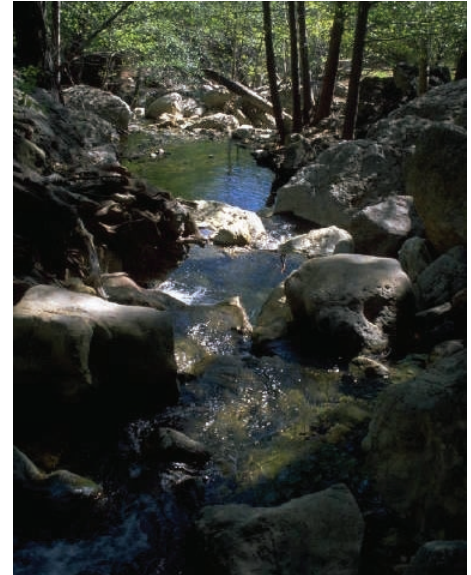
## LAKE GABRIEL STREAM 2 DATA SHEET

### Chemical, Microbial and Physical Data

- Dissolved Oxygen: 10 ppm
- Nitrates: 0.3 ppm
- Phosphates: 0.01
- Turbidity: 125 cm
- Temperature: 18 degrees Celcius
- Total Bacteria: 2 colonies

### In-Stream Habitat Check List

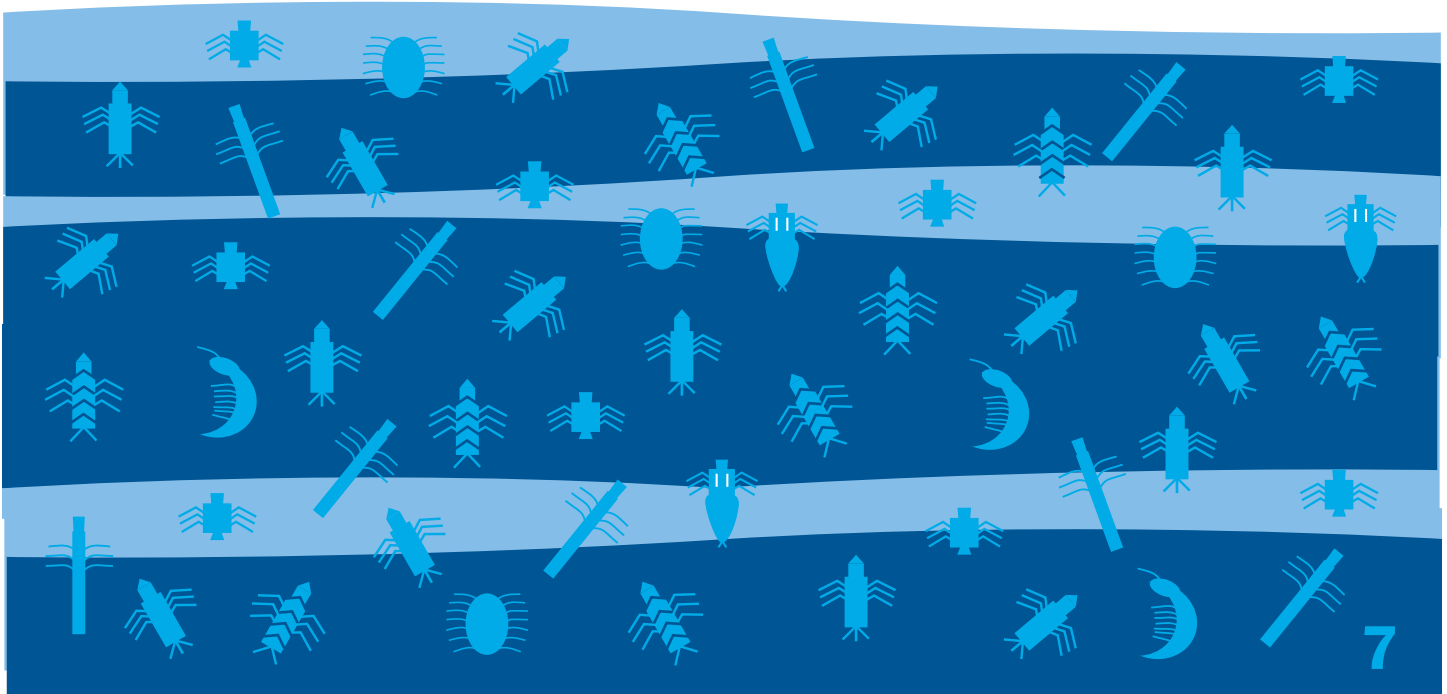
- In-stream Vegetation  Present  Absent
- Natural Debris (woody/leaf material)  Present  Absent
- Litter  Present  Absent
- Bottom Type  Bedrock  Boulder  Cobble  Pebble  Sediment



### Riparian Habitat (Stream Bank)

- Vegetation along the Bank  Trees  Shrubs  Herbaceous Plants
- Evidence of Erosion  None  Some  Extensive
- Evidence of Human Activity  Pipe  Bridge  Mowed Lawn  Paved Surface

### Aquatic Life Found In-Stream







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## DEFINITIONS

- **Anthropogenic:** Effects, processes or materials that are derived from human activities, as opposed to those occurring in biophysical environments without human influence.
- **Benthic Macroinvertebrates:** Invertebrates belonging to a variety of taxa that live on or in the bottom substrate of a body of water, such as a stream or lake.
- **Biotic Index:** A scale for showing the quality of an environment by quantifying the types of organisms present in it.
- **Drinking Water Treatment:** A treatment process that functions to remove existing contaminants in the water or reduce the concentration of contaminants so the water becomes fit for its desired end-use.
- **Surface Water:** A body of water that exists and remains at the surface, such as a stream, river, lake, wetland and marine basin.

## RESOURCES

- Mitchell and Stapp Field Manual for Water Quality Monitoring
- J. Reese Voshell A Guide to Common Freshwater Invertebrates
- [www.stroudcenter.org](http://www.stroudcenter.org)
- [www.epa.gov/waters](http://www.epa.gov/waters)
- [www.lamotte.com](http://www.lamotte.com) (for field sampling equipment)
- [www.forestry-suppliers.com](http://www.forestry-suppliers.com) (for field sampling equipment)
- For additional lesson plans, visit [www.amwater.com](http://www.amwater.com).

## COMMENTS

We want to know what you think. Feedback and/or suggestions for improving this lesson plan can be e-mailed to [joi.corrado@amwater.com](mailto:joi.corrado@amwater.com).

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In a world where everything we touch frequently changes, water is our constant. We've never stopped needing it to drink, to cook, to clean, to live. We'll always need it for sanitation, for fire protection, for watering our lawns and washing our cars.

It's easy to take water for granted. And because so many do, we don't.

We are scientists, environmentalists, innovators, and protectors. We are also residents and employees in the communities we serve. We understand how important, how precious, and how critical water is to daily life.

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**A special thanks** to Ron Smith for developing the core content of this lesson plan. Ron Smith, a science educator from NJ, has been teaching biology, environmental science and interdisciplinary studies in the classroom, lab and field for 18 years. It was important for us that our lesson plans be crafted by an educator for educators. We appreciate his hard work.

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