4.7 Water Quality Testing

Looking at the Health of a Stream

Overview

Students will learn to conduct and interpret water quality tests to assess the health of a stream or river. They will test for:

- **Dissolved Oxygen**, which is essential for all aquatic plant and animal life;
- **pH**, which determines if the water is acidic, basic or neutral;
- **Turbidity**, which is a measure of the cloudiness of the water; and
- **Nitrates** & **Phosphates**, nutrients essential for aquatic plants in small quantities but harmful if overabundant.

These tests may be practiced in the classroom, and then conducted in the field to determine the health of a local stream.

Lesson Characteristics

Use the table below for lesson planning purposes.

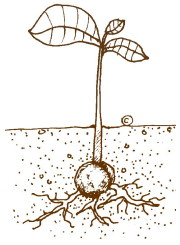
Time Required	Testing Time: 2 hours
Key Concepts/Terms	Turbidity, Water Quality, Nitrates, Phosphates, pH, Dissolved Oxygen
Prerequisites	None
Setting	Indoors/Outdoors, Small Group

Learning Objectives

After completing this activity, students will be able to…

- Test water for levels of dissolved oxygen, pH, turbidity, nitrates and phosphates;
- Explain the importance of, and acceptable limits for, each of the water test parameters; and
- Determine the relative health of a body of water based upon their test results.

Continued on next page



Materials Required

The following materials are required for this activity:

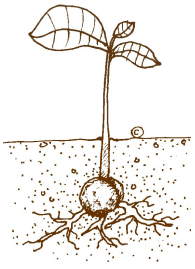
Note: There are several options for water testing kits. Each kit will have its own set of testing directions.

Item	Quantity	Per
Safety Goggles	One	Student
Water Quality Test Kits for: • Dissolved Oxygen • pH • Nitrates • Phosphates • Turbidity	One	Group (You can rotate the tests between groups)
Student Information Sheets, pgs.53-57, for each Water Quality Test parameter you are covering.	One Set	Group
Rinse Bottles of clear water for cleaning equipment.	One	Group
Waste bottles to collect used samples.	One	Group
Student Data Sheets, pg. 58	One	Student
Water Sample for testing (This can be from a local stream or a classroom fish tank.)	One	Group

Background Information

Why Should We Care About Clean Water?
(reprinted, with permission, from *Bridging the Watershed*, Alice Ferguson Foundation)

Most forms of life on Earth require clean water and cannot survive without it. Though the supply used to be plentiful, the situation changed over time so that, by the 1970's, at least 65% of the water tested in U.S. waterways was unsafe for fishing and swimming because of pollution. The U.S. Congress was so concerned that it passed the Clean Water Act in 1972. The goal of the act was to provide all Americans with waterways safe enough for swimming and fishing. With the act, we rejected some old ideas and practices that led to widespread water pollution, decided to clean up the pollution already present, and made a commitment to keep the waterways clean using good resource management practices.



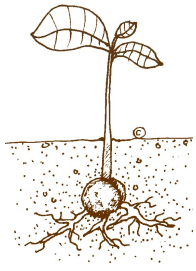
Continued on next page

Background Information (continued)

Today, only about 33% of this nation's waters are considered unsafe for fishing and swimming. That's some improvement, but not enough, and many of those "safe" areas are now threatened by new sources of pollution. Most of the pollution we've been able to eliminate is from traceable sources like a factory or a sewage treatment plant. This type of pollution is called "point source pollution" because we can point to one place – one point—as the source of the problem. Unfortunately, most of the really damaging pollution is untraceable because it comes from multiple sources, reaching the waterways in runoff. When it rains, whatever is on the land washes into rivers, lakes and oceans. Wetlands, stream corridors, and coastal areas are especially vulnerable to this type of pollution, called "non-point source pollution." It's a deadly combination of substances, including various pollutants from urban and suburban streets and parking lots; fertilizers and pesticides from lawns and farms; and other substances from forestry, ranching, and mining operations—essentially many of the different ways we use the land. All these runoff pollutants threaten environmental balance as well as human health. Every year, there are more warnings for people not to swim at certain beaches or eat certain fish or shellfish because of pollution. New threats to health arise as a consequence of new or continued pollution.

The United States recognized the connection between land use and clean water as an environmental crisis. In 1992, the General Assembly of the United Nations invited all countries on Earth to a conference in Brazil to discuss the problem. The leaders at this conference understood that all of us in the rapidly rising world population are trying to improve our standard of living. As we do so, we destroy the environment at an alarming rate. We clear land for new housing, transportation, growing food, and manufacturing, and we pollute. This disrupts many natural cycles like the water cycle, food chains, and the oxygen and carbon dioxide cycles. Clearing land also reduces the supply of clean water for all organisms on Earth. The conference participants addressed the global question of how to allow for development while maintaining the natural ecosystems. They knew about the "interconnectedness" of all life on Earth and agreed that development must be balanced by environmental protection. They understood that if we fail to do this, there would soon be nothing left to develop. Humans cannot survive if the delicate balance of ecosystems on Earth is destroyed.

Many great leaders have understood the importance of maintaining the quality of our land and waters, not just for ourselves in the "here and now," but for future generations of humankind as well as all of Earth's life forms.



Continued on next page

Background Information (continued)

Theodore Roosevelt once said:
"*The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value.*"

How Can We Measure Water Quality?

The National Sanitation Foundation created a standard index, called the Water Quality Index (WQI) that can be used to compare water quality over time, water quality from different segments of the same river, and water quality of different rivers. Each water parameter is rated on a scale from 1 to 100, with 100 indicating an excellent level for that parameter.

What Does Each Water Quality Parameter Mean?

See ***Student Background Information Sheets***, pgs. 4-53 through 4-57 for specific information on each test parameter.

Procedure

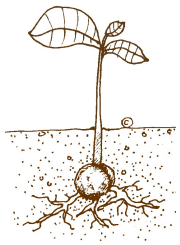
Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	Conduct the activity, ***Sediment: Choking the Life Out of the Bay***, pg. 4-39. This demonstrates the effects of erosion and sedimentation and introduces several of the water quality parameters students will be testing during this field study.
Explore	2	Have students look at and smell the water sample to be tested to form a hypothesis regarding the water quality. They should rate it on a scale from 0 to 100 (with 100 being excellent).
	3	Assign water parameters to student groups. Each group may do one test and then share results with the class, or each group may do all of the tests, dividing tasks within each group. Modify the ***Student Data Sheet***, pg. 4-58, to fit. The parameters to be tested are: • Dissolved Oxygen • pH • Turbidity • Nitrates • Phosphates

Continued on next page

Procedure (continued)

Phase	Step	Action
Explore	4	Distribute ***Student Background Sheets***, pgs. 4-53 through 4-57, for use as references regarding the parameters being tested.
	5	Introduce test procedures through demonstration, or distribute tests and instructions for a self-guided activity.
	6	Distribute testing materials (including rinse and waste bottles).
	7	Demonstrate/explain rinse and water disposal methods. Labware should be rinsed before and after using with the rinse water. All rinse and tested water should go in the waste container to be disposed of properly.
	8	Have students conduct the tests as assigned and record their data on their ***Student Data Sheets***.
Explain	9	When every group has finished, introduce the concept of Q values: a. Distribute ***Q Value Sheets***, pg. 4-59 b. Explain that these Q values are a way of comparing very different measurements and giving each one a grade. c. Show students how to use the Q value graph to find their score for a particular test: i. Find the test reading on the X-axis (horizontal). ii. Draw a vertical line up into the graph until you intersect the graph line. iii. Draw a horizontal line from this point on the graph to the Y-axis (vertical). iv. The number where your line intersects the Y-axis is your score for that test.
	10	Have students compare the water quality rating with their original hypothesis. Were the results what they expected?



Continued on next page

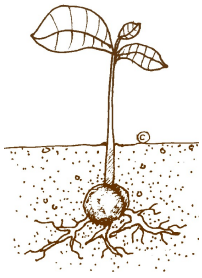
Procedure (continued)

Phase	Step	Action
Elaborate	11	• Take students to a body of water, such as a stream near the school, and conduct the water tests to determine the health of the stream. • Adopt a local stream to monitor and test it several times throughout the year.
Evaluate	12	Use ***Student Data Sheets*** for evaluation.

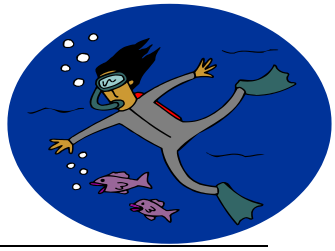
Vocabulary

The following terms are useful in this activity.

Term	Definition
Dissolved Oxygen	Oxygen in a gas form in water
pH	A measure of the acidity/basicity of a substance
Nitrate	The form of nitrogen which is necessary for the growth of living things.
Phosphate	The form of phosphorus necessary for plant growth and reproduction
Turbidity	A measure of the cloudiness of the water



Water Quality Parameter Fact Sheet:
DISSOLVED OXYGEN (DO)
Student Background Information



Importance of DO

Healthy water has to have enough dissolved oxygen (DO) so things can live there. Fish, invertebrates, plants and aerobic bacteria all need oxygen, just like we do.

Sources of Dissolved Oxygen

Most of the DO in water comes from the **atmosphere**. Oxygen in the air mixes into water at the surface. This happens because of rain, wind, waves, and currents. Faster moving water has more DO than slower water. This is because when it splashes over rocks it touches the air more than slower water.

Plants that live in the water also make DO during photosynthesis. The more plant life in the water, the more DO it has.

So What is the Problem?

Low DO levels are caused by:

- **Low Temperature:** Warm water holds less oxygen than cold water. DO levels rise and fall during different seasons and times of day because the water warms or cools.

- **Low Light Level:** All plants need light to produce oxygen, so if there isn't a lot of light, there isn't a lot of DO. This happens on cloudy days, at night, or when the water is too cloudy for light reach plants.

How is DO Measured?

We measure DO in one of two ways:

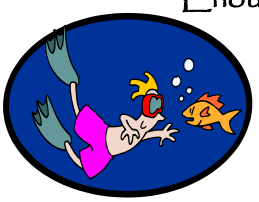
- in **milligrams** of oxygen **per liter** of water **(mg/L)** or
- in **parts per million (ppm).**

We then change those measurements to **percent (%) saturation**. This is a measure of the percentage of oxygen in the water compared to the maximum it could possibly hold. Remember that temperature affects how much DO water can possibly hold.

How Much is Enough?

Different aquatic animals need different amounts of dissolved oxygen. Some, like a catfish, can live with very low levels. Others, like trout, need much higher DO.

A rule of thumb is 5 ppm as a minimum for aquatic life.



Water Quality Parameter Fact Sheet – pH

Student Background Information

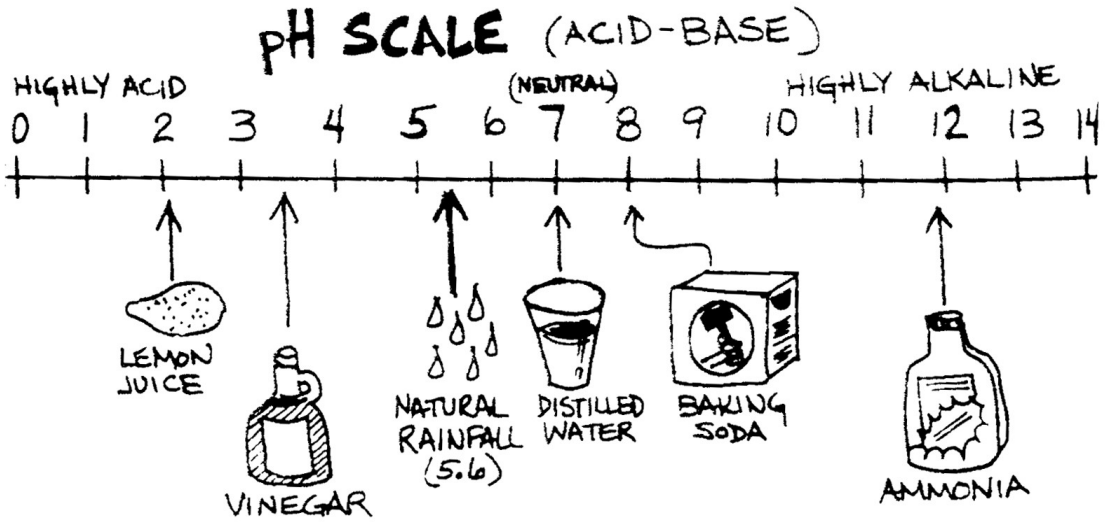
What is pH?

pH is a measure of how acidic or basic something is. Lemon juice is very acidic, and ammonia is very basic. Animals and plants can live in water that is in the middle, not too acidic or too basic.

How is pH Measured?

pH is measured on a scale from 0 – 14. There are no units of measurement. 7.0 is considered neutral. Less than 7.0 is acidic. Closer to 0 means more acidic. The opposite is true for basic substances. Higher than 7.0 is basic and the higher numbers mean more basic.

A sample scale is shown with common items below:



What is a Good pH for Water Quality?

Aquatic organisms can usually survive in water with a pH between **6.5 and 8.5.**

What Causes pH Problems in Our Water?

Many things can change the pH of water. Some of these are:

- Acid rain,
- Minerals from rocks,
- Melting snow,
- Heavy precipitation, and
- Accidental spills, runoff from the land, and when sewers overflow.

Water Quality Parameter Fact Sheet –PHOSPHATES

Student Background Information

What is Phosphate?

All living things need **phosphate**, which is a natural chemical. Naturally most water has very little phosphate. Underwater plants compete for these phosphates. So, how fast plants can grow and reproduce depends on how much phosphate they can get.

What is the Problem?

Here is what happens when there is **too much phosphate:**

Tiny green plants called algae use the phosphate and reproduce quickly. This is called an "**algae bloom**," which means that the water is covered with algae, and…

1. No sunlight can reach plants on the bottom, so they die. Fewer plants = less Dissolved Oxygen in the water.
2. When the algae have used all of this phosphate and there isn't any more, they begin to die off.
3. Bacteria decompose these dying plants and use all of the dissolved oxygen in the water.
4. This means fish and other animals in the water don't have enough oxygen. They suffocate, and the whole aquatic ecosystem collapses.

Causes of Too Much Phosphate

The most common reasons that too much phosphate gets in our water are:

- People put too much **fertilizer** on their lawns or farm crops;
- People use **detergents** with extra phosphate in them; and
- Some companies release **industrial wastes** into the water.

Units of Measurement

Phosphates are measured in **mg/L.** This stands for **milligrams** of phosphate **per liter** of water.

What is a Good Level for Phosphates?

<u>In natural bodies of water, a phosphate level of 1.0 mg/L is considered excellent.</u>

In water with levels of 2-3 mg/L, there is more plant growth and algal blooms.

Levels of 4.0 mg/L and higher usually have an algal bloom.

Water Quality Parameter Fact Sheet –NITRATES

Student Background Information

What are Nitrates?

Nitrate is a form of **Nitrogen,** a natural chemical that all plants and animals need to grow.

In nature, there is much more nitrogen than phosphorus. Nitrogen is most commonly found in the **atmosphere**. In fact, it makes up about 79% of the air we breathe. This kind of nitrogen is useless to both plants and animals.

In order for plants to be able to get nitrogen, it has to be changed to **nitrate** by organisms like bacteria that live on the roots of some plants. This puts nitrate in the soil so plants can get it. Animals get it by eating those plants.

Nitrate Sources

Nitrates are in all plant and animal bodies. Nitrates get returned to the soil when these bodies die and decompose (rot). Those nitrates are then used as fertilizer for new plants. This is called the nitrogen cycle.

What's the Problem?

Small amounts of nitrate are necessary for plants and algae to grow in water. Too much nitrate in water, combined with too much phosphate, can cause an algae bloom. This means that:

1. The tiny green algae reproduce very quickly and completely cover a pond, stream or river.
2. When the algae uses up all of the nitrates and phosphates, they start to die.
3. Bacteria decompose the dead plants and use up all of the Dissolved Oxygen.
4. So, an algae bloom takes out so much dissolved oxygen from the water that fish and other animals can't breathe. They suffocate, and the whole aquatic ecosystem collapses.

Causes of Too Much Nitrate

High Nitrate levels are caused by:

- People use too much **fertilizer** on their lawns or agricultural fields. This washes off into nearby streams or rivers when it rains.
- This runoff can also carry **animal wastes**, or manure, into streams as well.

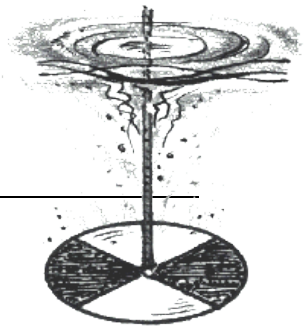
Measurement

Nitrates are measured in **mg/L**, which means **milligrams** of nitrate **per liter** of water.

How Much is Too Much?

Normally, stream or river water has a nitrate level of 2.0 mg/L or less. Water with nitrate levels above 4.4 mg/L is unsafe for drinking.

Water Quality Parameter Fact Sheet – TURBIDITY



Student Background Information

What is Turbidity?

Turbidity is a measure of the how cloudy water is. The more tiny pieces of sediment (soil) and other material floating in the water, the cloudier it is.

When is it a Problem?

Underwater plants need light to make food (photosynthesis). When water is cloudy or "**turbid,**" less light can reach plants that live in it.

When there is A LOT of turbidity, all these tiny pieces floating in the water can **clog fish gills.** This makes it hard for them to breathe. The particles in the water can also **smother fish eggs and other organisms in the water**.

Turbidity can also **increase water temperature** because the particles floating in the water soak up heat. Warmer water means **less dissolved oxygen (DO)** for plants and animals that live there because warm water holds less oxygen than cold water.

Causes of Too Much Turbidity

Erosion is when wind or water move soil. This is a natural process that forms land such as the Grand Canyon. Unfortunately, many human activities speed up erosion. This puts too much soil into our rivers and streams (SEDIMENTATION).

Causes of increased erosion can include:

- Construction of new homes, schools or businesses. This can remove trees and leave large areas of open soil that wash away when it rains.
- When farms fields are left open with no plants after a harvest.
- Cutting of forests for lumber, paper, etc. This can leave soil open to rain and snowmelt.

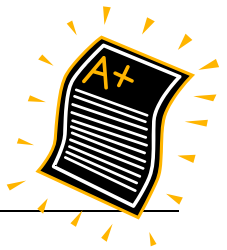
Units of Measurement

Turbidity is measured in Jackson Turbidity Units, or JTU's.

How Much is Too Much?

In a stream, you don't want the turbidity to be higher than 40 JTU's because it can harm the gills of fish.

Drinking water should have a turbidity of less than 5 JTU's.



Student Data Sheet of Water Quality Testing

Hypothesis My hypothesis about the quality of this water is _____

(Give a score from 0 (very bad) to 100 (excellent).)

	Group 1		Group 2		Group 3		Group 4		Group 5		
WATER QUALITY PARAMETER	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Average Q-Value
Dissolved Oxygen											
pH											
Phosphates											
Nitrates											
Turbidity											
Average Q-Value											

Average Q Value of All Tests = _____

What is your conclusion about the quality of this water? _____

_____

Q Values

A Means of Weighting Water Quality Test Values

Overview

140 different scientists "graded" water quality from 0 (worst) to 100 (best) for each of the tests you did.

To see how this works, let's look at pH. The best pH for living things in a stream is about 7.4; so on the pH test a result of 7.4 gets was given a grade of 100 (best). As pH scores get lower or higher than this, the grade gets lower, because fewer things can live in that water.

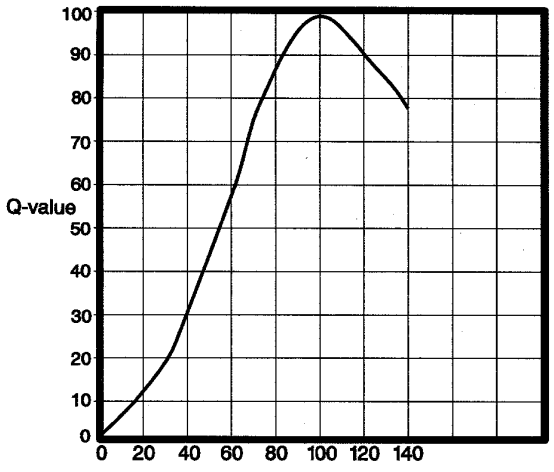
The scores from each scientist were averaged and a graph was made for each test. You'll use these graphs to give your water a "grade," called a Q-value, for each test.

Calculating Q Values

Calculate Q-values for each parameter as follows:

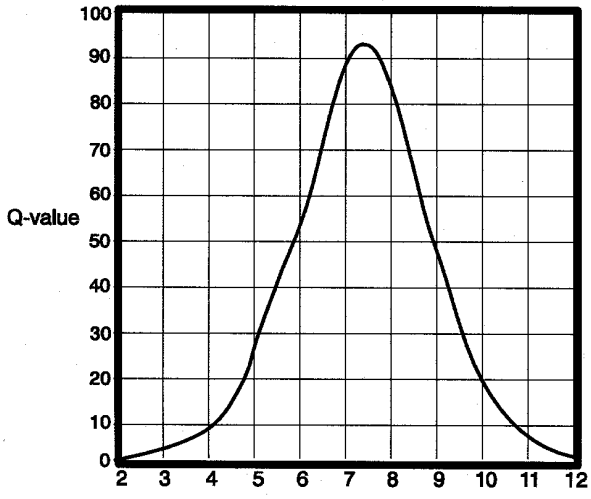
a. Find the weighting curve graph for your test.
b. Mark your test result with a pencil on the X-axis (horizontal) of the weighting curve graph.
c. Draw a vertical line from that point to the weighting curve. Then draw a line from the intersection point on the curve to the Y-axis (vertical) of the graph. The point where your line intersects the Y-axis is the Q-value for your test result.

Dissolved Oxygen



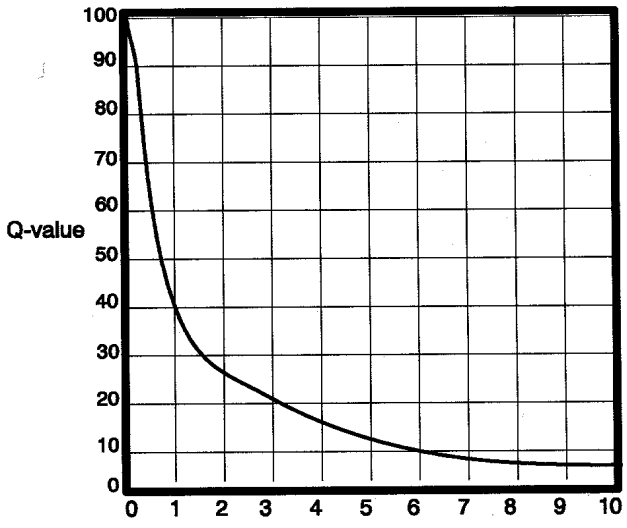
Dissolved Oxygen: % saturation
Note: Q = 50.0 if DO% saturation >140.0

pH



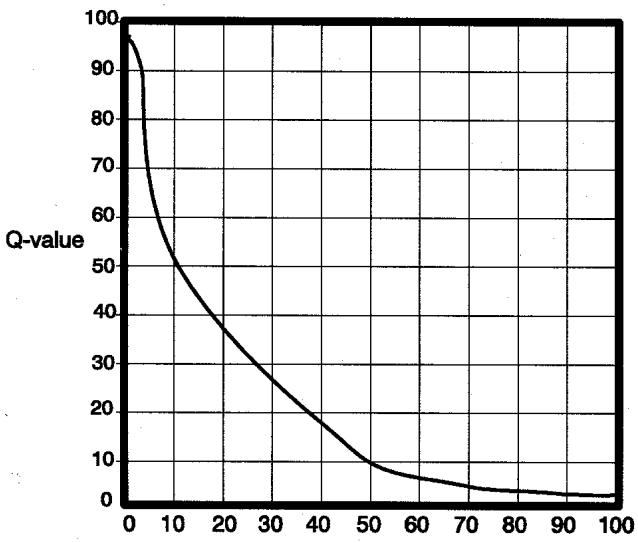
pH: units
Note: Q = 0.0 if pH < 2.0 or if pH > 12.0

Orthophosphates



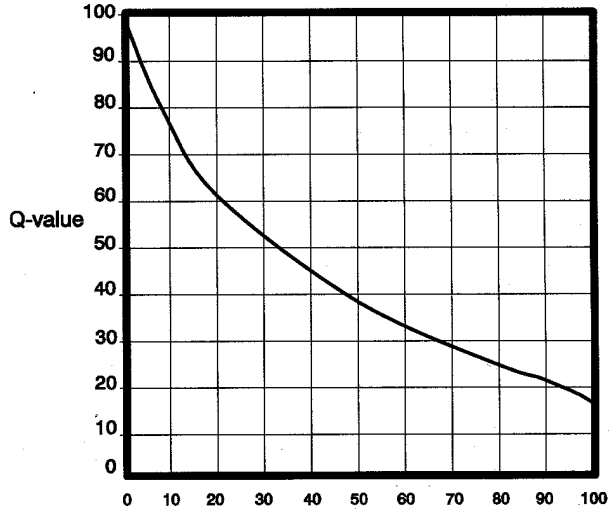
Orthophosphate: mg/L
Note: Q = 2.0 if orthophosphate > 10.0

Nitrates



Nitrate: mg/L
Note: Q = 1.0 if Nitrate > 100.0

Turbidity



Turbidity: JTU
Note: Q = 5.0 if Turbidity > 100.0