# CHAPTER 6

# Chemical Assessment

## Introduction

Water chemistry is perhaps the most complicated and least understood characteristic of streams, rivers and lakes. While some chemicals are absolutely necessary for life (such as nutrients), they can be harmful to the waterbody in large quantities. Other chemicals provide no benefit when found in water and are harmful to the system (such as pesticides). Some chemicals may not directly impact human health, while others (such as nitrate) can have harmful effects in our drinking water.

As you explore your stream's water chemistry, it is important to understand that water chemistry is very complex, and that extreme natural variation in some chemicals is not unusual but actually the norm. Some of these natural variations will be addressed in the following sections in this chapter.

The following are just a few examples of how environmental conditions can influence water chemistry (see the IOWATER chapter on data interpretation as well):

- Season of year – In late spring, nitrate and phosphate levels in streams may rise in response to bare soil, heavy rains, increased tilling, and chemical application to row crops and urban lawns.
- Time of day – Dissolved oxygen levels rise during sunlight hours due to increased photosynthesis in aquatic plants and algae. They decrease overnight when photosynthesis is not occurring and plants and algae are using up dissolved oxygen.
- Weather – Runoff from heavy rains can transport pollutants to streams, thus having a strong impact on nonpoint source pollution.
- Physical influences – Decreased canopy cover from riparian zone removal results in solar warming of the water, which can decrease dissolved oxygen levels.
- Land use – Increased development throughout a watershed can result in more curb-and-gutter storm sewer runoff.

IOWATER testing includes those chemicals of concern that can be effectively and feasibly assessed. These and many more complex chemical tests are being done on Iowa's streams, rivers, and lakes by other professional agencies, such as the Iowa DNR, the U.S. Geological Survey, and local drinking water supply agencies. These additional tests may include **alkalinity**, conductivity, dissolved solids, hardness, chlorophyll, metals (e.g., chromium, copper, iron, lead, zinc), and organic compounds (e.g., pesticides and petroleum compounds).

IOWATER chemical tests you will be doing include pH, dissolved oxygen, nitrate-/nitrate-N, phosphorus, and chloride. You will be measuring the **concentration** of each of these parameters in the water. All parameters but pH are measured in units of concentration called milligrams per liter (mg/L).

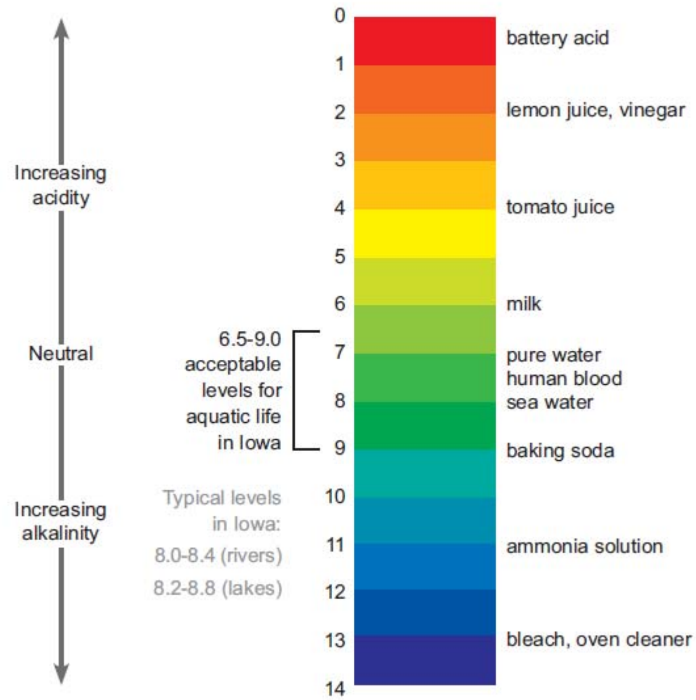
So how much is a mg/L. The University of Minnesota's ***Water on the Web*** (http://WaterOntheWeb.org) provides several analogies for what a mg/L represents. One mg/L is equivalent to:

- One inch in 16 miles
- One minute in two years
- One ounce in 32 tons
- One cent in $10,000
- One car in bumper-to-bumper traffic from Cleveland to San Francisco

## pH

**pH** is a measure of a water's acid/base content and is measured in pH units on a scale of zero to 14. A pH of seven is neutral (distilled water), while a pH greater than seven is basic/alkaline and a pH less than seven is acidic.

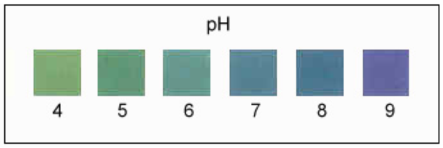
The pH level of surface water is influenced by the concentration of acids in rain and the types of soils and bedrock in an area. The typical pH of rainfall in the U.S. is slightly acidic, ranging from 5.0 to 5.6. As rainwater falls, it dissolves carbon dioxide from the atmosphere, thus forming a weak carbonic acid and lowering the pH of the precipitation. Low pH levels (acidic) can have a harmful impact on the health of aquatic communities. Very acidic water or **acid rain** can directly harm aquatic life and can also allow toxic substances, such as ammonia and heavy metals, to leach from our soils and possibly be taken up by aquatic plants and animals (**bioaccumulation**).




Even with the natural inputs of acidic water, the pH of Iowa surface waters generally range from 8.0 to 8.4. The presence of alkaline (basic) soils and limestone bedrock in many areas of the state help neutralize the effect acidic precipitation might have on Iowa's streams and lakes. This is quite fortunate for Iowa since pH can influence many chemical and biological processes. Most aquatic organisms require habitats with a pH of 6.5 to 9.0.

Extremely high or low pH values are rare in Iowa. Most values that exceed 9.0 (basic) are caused by excessive algal growth, a sign of nutrient enrichment. Very low (acidic) pH readings are generally near point sources of pollution.

Typical range for pH = 8.0 to 8.4 (rivers); 8.2 to 8.8 (lakes)
Iowa average = 8.2 (rivers); 8.5 (lakes)
Iowa's water quality standard - pH shall not be less than 6.5 nor greater than 9.0
** Based on 2000 through 2009 data collected by the Iowa DNR*




***pH scale on the test strip vial***

***Reporting Technique:*** For use with Hach® pH test strips

1. Check the expiration date on the bottom of the bottle. If expired, **DO NOT USE**.
2. Facing upstream, in the area along your *transect* with the greatest flow, dip the test strip in the water and remove immediately. Hold strip level for **15 seconds**. **DO NOT SHAKE** excess water from the test strip.
3. Estimate pH by comparing test pad to color chart on test strip bottle. Remove sunglasses before reading the strip. ***The pad will continue to change color, so make a determination immediately after 15 seconds.***
4. Record results on the IOWATER Chemical / Physical Stream Assessment field form.
5. Dispose of test strip in waste container, which can be emptied into your household trash.

**STORE AT ROOM TEMPERATURE**

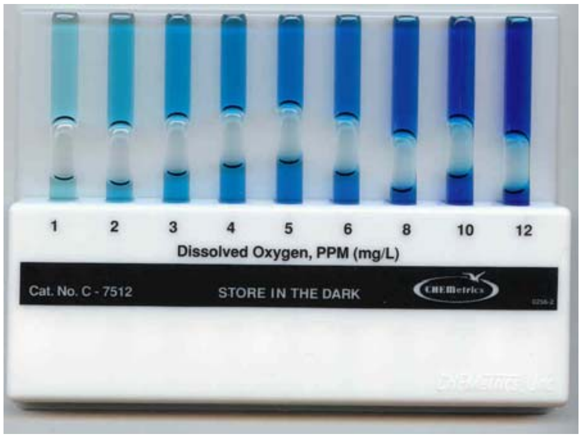
## Dissolved Oxygen

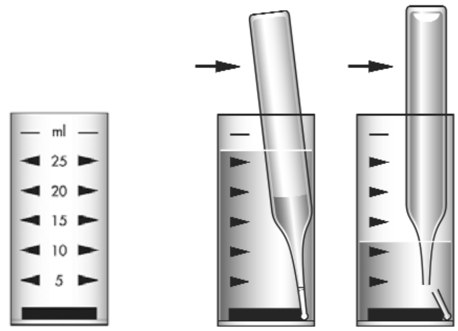
**Dissolved oxygen** (DO) is necessary for nearly all aquatic life to survive. Certain processes add oxygen to a waterbody, while others remove or consume oxygen. Oxygen is added to a stream or lake from the atmosphere through mixing in turbulent areas. Plants also contribute oxygen through photosynthesis. Oxygen is removed in surface water by decomposition or organic material, respiration, and chemical processes. DO in waterbodies can be affected by:

- Water Temperature – Cold water holds more oxygen than warm water.
- Season – DO levels are higher in winter than in summer.
- Time of Day – On a sunny day, DO levels rise from morning through the afternoon as a result of photosynthesis, reach a maximum in late afternoon, and steadily fall during the night, reaching their lowest point before dawn.
- Stream Flow – DO will vary with the volume and **velocity** of water in a stream; faster moving water mixes readily with atmospheric oxygen, thus increasing DO.
- Aquatic Plants – Plant and algae growth in a stream will affect the oxygen contributed by photosynthesis during the day and depleted by plant **respiration** at night.
- Dissolved or Suspended Solids – Oxygen dissolves more readily in water that does not contain high amounts of salts, minerals, or other solids.
- Human Impacts – Lower DO levels may result from human impacts including organic enrichment, urban stormwater runoff, riparian corridor removal, stream channelization, and dams.

Dissolved oxygen is measured in milligrams per liter of water (mg/L). Iowa standards, which are set to protect aquatic life, call for a minimum of 5 mg/L of DO in warm water streams and 7 mg/L in coldwater streams.

Typical range for dissolved oxygen = 8.7 to 12.9 mg/L (rivers); 7.4 to 10.4 mg/L (lakes)
Iowa average = 10.5 mg/L (rivers); 8.7 mg/L (lakes)
Iowa's water quality standard – 5 mg/L for warm water streams and 7 mg/L for cold water streams
** Based on 2000 through 2009 data collected by the Iowa DNR*




***Reporting Technique***: For use with the Chemetrics® dissolved oxygen test kit

1. Check the expiration date on the back of the color comparator. The ampoules do not expire as long as they are kept in the dark at room temperature. If your equipment is expired, **DO NOT USE**.
2. Remove the 25 ml sample cup from the kit and rinse it **<u>three times</u>** with stream water.
3. Facing upstream, in the area along your *transect* with the greatest flow, fill the sample cup to 25 ml mark, mixing the water and air as little as possible.
   - Lower the sample cup down to wrist depth while holding it upside down. Turn the opening downstream so that the cup backfills with water, then turn the cup upstream and carefully remove cup and water sample from stream.
   - ***GENTLY*** tip the sample cup to pour off excess water.
4. Place the ampoule in the sample cup, tilting it so the tip is wedged in one of the spaces along the side of the sample cup.
5. Snap off the tip of the ampoule by pressing it against the side of the cup, allowing it to fill with water.
6. Remove the ampoule from the cup and mix the water by inverting the ampoule slowly several times. Be careful not to touch the broken end as it will be sharp.
7. **Two minutes** after you break off the ampoule tip, compare the ampoule to the color standards provided in the kit. ***Read the ampoule right at two minutes as the ampoule will continue to change color.*** Remove your sunglasses before making a determination.
8. Hold the comparator nearly flat while standing directly beneath a bright source of light. Place your ampoule between the color standards moving it from left to right until the best color match is found. Record your result on the IOWATER field form.

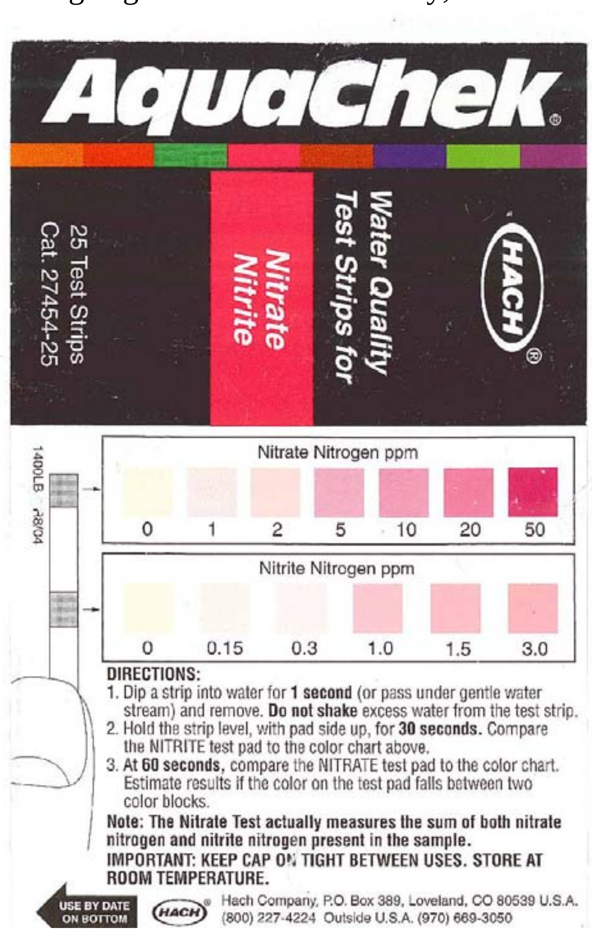
**<u>Note</u>**: The ampoule and ampoule tip may be disposed of in your household trash – be careful of the broken glass. Avoid breaking the ampoule open, as the contents may be mild skin and/or eye irritants. ***Keep color comparator and unused ampoules away from direct sunlight***, as they will change to a blue color and are no longer usable. **STORE IN THE DARK AT ROOM TEMPERATURE.**

## Nitrate-N / Nitrite-N

Nitrogen is an essential plant nutrient, but excess nitrogen can cause water quality problems. Too much nitrogen and phosphorus in surface waters causes nutrient enrichment, increasing aquatic plant growth and changing the types of plants and animals that live in a waterbody. This process, called **eutrophication,** can also affect other water quality parameters such as pH and dissolved oxygen.

| |
|---|
| Typical range for Nitrate + Nitrite-N = 3 to 8.5 mg/L (rivers); 0.05 to 0.94 mg/L (lakes)<br>Iowa average = 5.8 mg/L (rivers); 0.07 mg/L (lakes)<br>Iowa's drinking water quality standard – 10 mg/L<br>** Based on 2000 through 2009 data collected by the Iowa DNR* |

**Nitrate** and **nitrite** are two forms of nitrogen. Nitrate is very easily dissolved in water and is more common in streams. Sources of nitrate include soil organic matter, animal wastes, decomposing plants, sewage, and fertilizers. Because nitrate is very soluble in water it can move readily into streams. Nitrite is another form of nitrogen that is rare because it is quickly converted to nitrate or returned back to the atmosphere as nitrogen gas. Due to its instability, detectable levels of nitrite in streams and lakes are uncommon. Detectable nitrite levels in streams and lakes may indicate a relatively fresh source of ammonia.




***Note finger holding the test strip to illustrate the two pads and how each relates to its corresponding color scale to the right.***

The amount of nitrate or nitrite dissolved in water is reported as nitrate-N (nitrate expressed as the element nitrogen) or nitrite-N in milligrams per liter of water (mg/L). Iowa's drinking water standard for nitrate is 10 mg/L as nitrate-N. The concentration of nitrate-N in water may vary greatly depending on season and rainfall, fertilizer application rates, tillage methods, land use practices, soil types, and drainage systems. Consistently high nitrate readings (over 10 mg/L) may be cause for concern and warrant further investigation.

***Reporting Technique:*** For use with Hach® nitrate-N / nitrite-N test strips

1. Check the expiration date on the bottom of the Nitrite-N/Nitrate-N bottle. If expired, **DO NOT USE**.
2. Facing upstream, in the area along your *transect* with the greatest flow, dip the test strip into the water for one second and remove. **DO NOT SHAKE** excess water from the test strip.
3. Hold the strip level, with pad side up, for **30 seconds.**
4. Compare the NITR**I**TE (lower) test pad to the nitrite-nitrogen color chart on test strip bottle, estimate the nitrite concentration in mg/L, and

record your reading on the IOWATER field form (remove sunglasses before reading the strip). ***The pad will continue to change color, so make a determination immediately after 30 seconds***.

5. At **60 seconds** (or 30 seconds after estimating nitrite concentration), compare the NITRATE (upper) test pad to the nitrate-nitrogen color chart on test strip bottle, estimate the nitrate concentration in mg/L, and record your reading on the IOWATER field form (remove sunglasses before reading the strip). ***The pad will continue to change color, so make a determination immediately after 60 seconds***.
6. Dispose of test strip in waste container, which can be emptied into your household trash.

**STORE AT ROOM TEMPERATURE**

## Phosphate

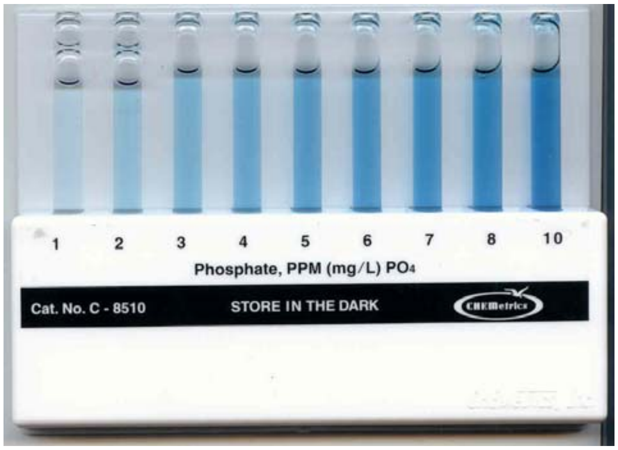
Phosphorus is an essential nutrient for plants and animals and is usually present in natural waters attached to sediment, in organic material, and dissolved in the water. Plant growth in surface waters is generally limited by the amount of orthophosphate, the dissolved form of phosphorus, present. It is the simplest form of phosphorus found in natural waters and is most available for plants to use. In most waters, orthophosphate is present in very low concentrations. The amount of phosphate dissolved in water is expressed in milligrams per liter of water (mg/L). The test kits IOWATER uses measure **orthophosphate**, which will be referred to as simply "phosphate."

There are natural sources of phosphorus, such as certain soils and rocks, but most elevated levels of phosphorus are caused by human activities. These include human, animal, and industrial wastes, as well as runoff from fertilized lawns and cropland. Excess phosphorus in water speeds up plant growth, causes algal blooms, and can result in low dissolved oxygen, or hypoxic, conditions that can lead to the death of certain fish, invertebrates, and other aquatic animals.

Typical range for total phosphorus = 0.11 to 0.34 mg/L (rivers); 0.05 to 0.13 mg/L (lakes)
Iowa average = 0.2 mg/L (streams); 0.08 mg/L (lakes)
** Based on 2000 through 2009 data collected by the Iowa DNR*

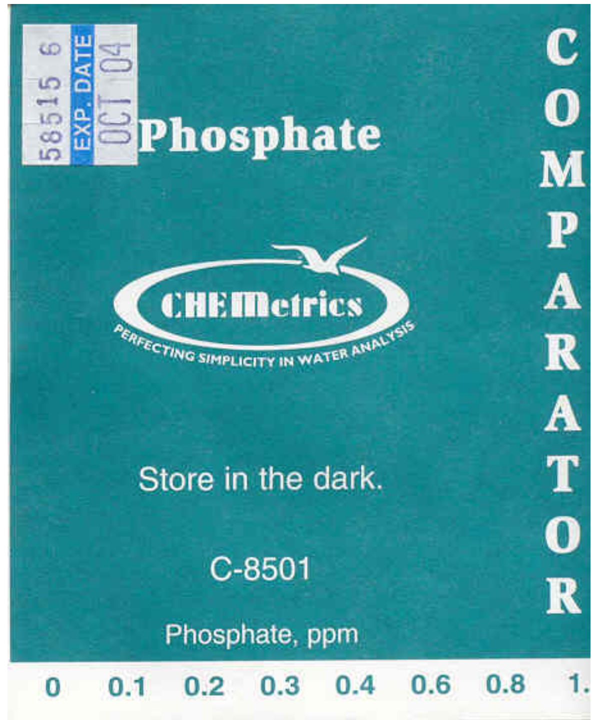
***Reporting Technique:*** For use with Chemetrics® phosphate test kit

1. Check the expiration date on the back of the color comparator in the lid, on the round color comparator, and on the activator solution. The ampoules do not expire as long as they are kept in the dark and at room temperature. If your equipment is expired, **DO NOT USE**.
2. Remove the 25 ml sample cup and black lid from the kit and rinse them **<u>three times</u>** with stream water.
   a. Facing upstream, in the area along your *transect* with the greatest flow, fill the sample cup to 25 ml mark, mixing the water and air as little as possible.
   b. Lower the sample cup down to wrist depth while holding it upside down. Turn the opening downstream so that the cup backfills with water, then turn the cup



upstream and carefully remove cup and water sample from stream.

3. ***GENTLY*** tip the sample cup to pour off excess water.
4. Add 2 drops of A-8500 Activator Solution, place black cap on sample cup, and shake to mix the contents.
5. Place the ampoule in the sample cup, tilting it so the tip is wedged in one of the spaces along the side of the sample cup.
6. Snap off the tip of the ampoule by pressing it against the side of the cup, allowing it to fill with water.
7. Remove the ampoule from the cup and mix the water in the ampoule by inverting it slowly several times. Be careful not to touch the broken end as it will be sharp.
8. **Two minutes** after you break off the ampoule tip, compare the ampoule to the color standards provided in the kit. ***Read the ampoule right at two minutes as the ampoule will continue to change color.*** Remove your sunglasses before making a determination.




9. Based on the color of your ampoule, use the appropriate color comparator to estimate the orthophosphate concentration.
    a. The low-range circular comparator measures concentrations ranging from 0 to 1 mg/L. To use the circular comparator, place your ampoule, flat end downward, into the center tube. Direct the top of the comparator up toward a good light source while viewing from the bottom. Rotate the comparator to match your ampoule to the standards, and record your results on the IOWATER field form.
    OR
    b. The high-range comparator in the lid of the kit measures concentrations ranging from 1 to 10 mg/L. Hold the high range comparator nearly flat while standing directly beneath a bright source of light. Place your ampoule between the color standards moving it from left to right until the best color match is found. Record your result on the IOWATER field form.

**Note**: ***Keep color comparator and unused ampoules away from direct sunlight***, as they will change to a blue color and are no longer usable. The ampoule and ampoule tip may be disposed of in your household trash – be careful of the broken glass. Avoid breaking ampoule open, as contents can be mild skin and eye irritants. Sample water should be disposed of by pouring down household drain, not back into the stream. **STORE IN THE DARK AT ROOM TEMPERATURE**

If you notice that the ampoule color result is more green or brown than blue, and you have a difficult time matching it to the standards, please contact IOWATER for additional equipment to filter water samples to remove excess algae and/or sediment before running the test. Procedures for filtration will be sent with the filtering apparatus.

## Chloride

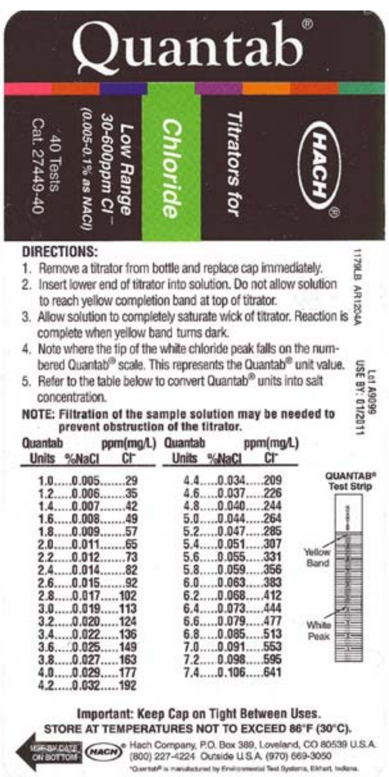

Chloride is a chemical found in salts, which tend to dissolve easily in water. In natural waters, elevated levels of chloride may indicate inputs of human or animal waste, or inputs from fertilizers, many of which contain salts. During winter months, elevated chloride levels in streams may occur as a result of road salt runoff to nearby streams. Chloride can be used as a "conservative" measure of water contamination since other natural processes, such as breakdown by bacteria, do not affect it.

The amount of chloride dissolved in water is expressed in milligrams per liter of water (mg/L). Average chloride concentrations for Iowa streams range from 16 to 29 mg/L.

> Typical range for chloride = 16 to 29 mg/L (rivers)
> Iowa average = 22 mg/L (rivers)
> *No data available for lakes*
> ** Based on 2000 through 2009 data collected by the Iowa DNR*

***Reporting Technique:*** For use with Hach® chloride titrators and sample cup from one of the Chemetrics® test kits.

1. Check the expiration date on the bottom of the chloride bottle. If your equipment is expired, **DO NOT USE**.
2. Rinse the 25 ml Chemetrics® test kit sample cup three times with stream water.
3. Facing upstream, in the area along your *transect* with the greatest flow, fill the sample cup up to the 25 ml mark with stream water.
4. Remove a titrator from bottle and replace cap immediately.Insert the lower end of titrator into sample cup. Do not allow the yellow completion string located at the top of the titrator to become submerged in the water sample.
5. Allow water sample to completely saturate the wick of the titrator. There is no time limit for this test – the reaction is complete when yellow string turns dark (this will take about 5-10 minutes).




6. Note where the tip of the white chloride peak falls on the numbered Quantab® scale. This represents the Quantab® unit value.
7. Refer to the table on the Quantab® test strip bottle to **convert the Quantab® units into a chloride concentration** and record results on the IOWATER field form.
8. If the Quantab® unit is below 1.0, report the chloride concentration as < (less than) the lowest concentration listed on the test strip vial (which for data submission purposes is 25 mg/L).
9. Quantab® test strips may be disposed of with household trash. Sample water can be disposed of in the field.


**STORE AT TEMPERATURES NOT TO EXCEED 86°F**

Chloride concentrations at some sites have exceeded the upper limits of this test (which can be recorded as >600 mg/L). To obtain high range chloride strips, with a range of 300-6,000 mg/L, contact IOWATER.

## Interrelationship among Chemical Parameters

The chemical parameters being measured as part of IOWATER are interrelated. See the IOWATER Data Interpretation Chapter for more information on how the chemical parameters, as well as the physical parameters, affect each other.

## Chemical Assessment Review Questions

**pH**

1. What is pH?
2. What can affect pH?
3. What are typical pH levels in Iowa waters (rivers, lakes)?
4. Once wet, how long do you wait before reading the pH test strip?

**Dissolved Oxygen**

1. What is dissolved oxygen?
2. What can affect dissolved oxygen in water?
3. Why is dissolved oxygen important in water?
4. What are Iowa's dissolved oxygen water quality standards?

**Nitrite/Nitrate-N**

1. What is nitrate-N and nitrite-N?
2. What are sources of nitrogen in water?
3. How long do you wait before reading the nitrite/nitrate-N test strip?
4. How does nitrate differ from phosphorus?

**Phosphorus**

1. What is phosphorus?
2. What are sources of phosphorus in water?
3. How do you use the two color comparators in the kit?
4. How do you dispose of the ampoule?

**Chloride**

1. What is chloride?
2. What are sources of chloride in water?
3. Why are typical concentrations of chloride in Iowa's streams?
4. Describe the procedure for using the chloride test strip.