RiverWatch Water Quality Volunteer Monitoring Manual

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Introduction to the RiverWatch Program

The Ipswich River Watershed Association (IRWA) is a non-profit organization incorporated in 1977. The goal of the organization is to protect and restore the Ipswich River and its watershed primarily in the 21 communities that are located in or draw water from the watershed. One focus of the organization has been to identifying the causes, environmental impacts, and potential solutions of severe low-flow problems associated with the Ipswich River through monitoring, outreach and advocacy. IRWA also provides capacity building and technical support for river restoration initiatives including dam removal investigations at high priority sites in the watershed. IRWA also administers the Parker, Ipswich, Essex Rivers Restoration Partnership (PIE-Rivers) with the goal of coordinating monitoring and restoration efforts among the three watersheds that surround the Great Marsh Area of Critical Environmental Concern (ACEC). The partnership includes the Parker River Clean Water Association PRCWA, an all-volunteer non-profit organization founded in 1997 and the Chebacco Lake and Watershed Association (CLWA) also an all-volunteer organization founded in 1985 to protect Chebacco Lake and its surroundings. IRWA has maintained a consistent monitoring program since 1997 focused on surface water indicators such as dissolved oxygen, temperature, conductivity, chloride and most recently, *E. coli*. The PRCWA maintained a monitoring program from 2008-2014 for temperature, dissolved oxygen, nitrate, phosphate, and *E. coli*. The CLWA collects samples for bacteria testing on Chebacco Lake.

A significant component of this monitoring effort is the RiverWatch program, a water monitoring program that depends on volunteers to collect data on weather, depth, velocity, dissolved oxygen, temperature, conductivity, chloride, nitrate, phosphate and bacteria (*E. coli* and *enterococci*. By collecting this periodic information, IRWA has established a baseline for the typical water quality conditions of the Ipswich River and major tributaries. Having this baseline data enables us to more intensively monitor areas of concern and share this data with the appropriate organizations to affect change for the River.

Strategy and Logistics

In order to gain an accurate picture of water quality in the region we will monitor a combination of constituents at 34 sites in the Ipswich River watershed (12 tributary sites and 22 mainstem sites), 6 sites in the Parker River watershed (3 tributary sites and 3 mainstem sites). We will also monitor 3 stream sites in the Essex River watershed and 2 sites on Chebacco Lake. Monitoring will take place monthly from March-December for dissolved oxygen, temperature, conductivity and chloride. Bi-weekly monitoring for nitrate, phosphate and bacteria will take place from April-October. Monthly sampling of Chebacco Lake for total phosphorus and chlorophyll a will take place from April-October. Streamflow will be monitored at 3 sites in the Ipswich watershed (1 mainstem site and 2 tributary sites). Continuous data loggers for temperature will be used at 7 sites in the Ipswich watershed (4 mainstem sites and 3 tributary sites), 4 sites in the Parker watershed (2 mainstem and 2 tributary sites) and 1 site in the Essex watershed. Continuous loggers for dissolved oxygen and temperature will be used at 2 sites on the Ipswich River, 1 site in the Parker River and 1 site in the Essex watershed. See Table 1 for a list of parameters by site.

The purpose of regularly monitoring the Ipswich River and its tributaries includes:

- Defining the range of temperature, dissolved oxygen, conductivity, chloride, nitrate, phosphate and bacteria concentrations over the range of annual conditions in both mainstem and tributary locations.

- Determining the relative water level and flow at a variety of ungauged locations around the basin.
- Measure streamflow at established gages through the River Instream Flow Stewards (RIFLS) program.
- Monitor surface waters for levels of E. coli in class B waters and enterococci in class SA waters according to recreational use standards.
- Document the presence and severity of bacteria pathogen indicators.

In defining the range of temperature, dissolved oxygen, conductivity, chloride, nitrate, phosphate, bacteria, flow and dissolved oxygen, IRWA will be able to better define changes in the River over time to determine the success of restoration efforts and any further degradation of the system.

Volunteer monitors are responsible for monthly monitoring which takes place in the morning of the last Sunday of each month from March through December unless the date conflicts with a holiday. If there is a conflict, the previous or next Sunday will be chosen. Volunteer monitoring in January and February is performed for conductivity and chloride if not prevented by snow and ice. Sampling for nitrate, phosphate and bacteria will take place biweekly from April-October.

All samples must be collected between 8 am and 12:30 pm, except for the tidal locations, which are sampled within 1 hour of low tide closest to the 8 am to 12:30 pm time span. Sampling in the morning is extremely important because the lowest dissolved oxygen values are generally observed in the early morning. We want to record these low values because they have the most potential to affect the organisms living in the Ipswich River. Sampling in January and February is optional. Historically volunteers sampled during these months, but the River was often frozen and the data collected during these months was generally not used in management decisions.

Data sheets are retained and entered electronically by volunteers within 2 weeks of sampling (see the Appendix A for data sheets). Data sheets are subsequently collected and stored at IRWA headquarters. An annual report containing all the monitoring data for the year is compiled IRWA.

Once a year, an IRWA volunteer or staff member will conduct a site audit of each monitoring site. The volunteer or staff member will observe each volunteer monitor to ensure they are completing the monitoring procedure correctly.

Safety Procedures and Emergency Information
IRWA volunteer and staff safety is ***the highest priority***. Please read the following safety precautions carefully.

Automobiles and Roadways
Many sampling sites are located on bridges which are not commonly used by pedestrians and your presence may be a surprise to motorists. Monitors must observe the following precautions:

- Wear high-visibility clothing
- Warn approaching traffic of your presence by parking your vehicle down the street on the same side.
- Use extreme caution when crossing the street.

Bridges
Always use extreme caution at the edge of a bridge. Test railings before leaning against them. **Do not climb** onto to railing or bridge abutments.

Wading
At a few sites wading is necessary. Wading should only be done when the water is less than knee-deep and not fast-moving. **Do not wade alone.**

Weather Considerations
The monthly monitoring program requires that you be outside in cold and/or rainy conditions. Monitors should expect to be at their site for up to 60 minutes and should dress appropriately. If there is lightning in the area, stay out of contact with the water, avoid contact with metal on bridges and stay away from all tall trees.

Emergency Information
In case of an **emergency** during monitoring, call 911.

After the emergency has been taken care of please notify the IRWA Office at 978.412.8200. Non-emergency problems should be reported to IRWA as soon as possible.

Monthly Monitoring Equipment and Procedures

All monitors share with their partners one complete Water Monitoring Kit, which includes the following:

Equipment Check-List

_____datasheet
_____pencil
_____bucket
_____thermometer
_____Dissolved Oxygen kit
_____orange
_____depth line

Procedure Check-List

_____Weather Observation
_____Water Temperature
_____Dissolved oxygen (in River if possible, or else in bucket)
_____Color, Clarity, and Odor
_____Velocity 1, 2, and 3 times
_____Depth

Detailed Equipment List

- bucket with rope attached to handle
- thermometer
- Field data forms
- dissolved oxygen test kit or DO meter or multi-parameter unit
- Conductivity meter and calibration solutions (for selected sites)
- Chloride test kit (for selected sites)
- depth measuring tape 50' and marked in tenths of feet with weight attached
- field notebook
- pen/pencil
- procedure checklist
- Safety vest and safety cones (optional)
- Nitrile gloves (for chloride testing)

Monitors are asked to bring their own orange peels for velocity measuring

Preparations on the Night Before Monitoring:

1. **Notification**
   Be sure to notify someone (friend or family member) of your plans to be out monitoring the next day.

2. **Paperwork**
   Fill out as much of your data form as possible. The more you fill out before the easier your task will be in the morning.

3. **Equipment Check**
   Check through your equipment to be sure everything is there and in good working order. Double check the dissolved oxygen test kit to make sure you have all the necessary chemicals and reagents. Put all your equipment together and ready for the next day.

Monthly Monitoring Procedures

Data Recording

All data should be recorded on the field data sheet (see Appendix A). All information on the data sheet must be filled out. Please write clearly in ink and never erase what you think might be an error. Instead, cross out the errors neatly with a single line and write the correct entry next to or above it. Send IRWA the completed monitoring sheet after each monthly monitoring event.

If you are entering the data into the monitoring spreadsheet please email a copy of the spreadsheet to IRWA after each monthly monitoring event as well as giving the completed paper monitoring sheet to IRWA.

Site ID, Observers, Date, Time and Tide

Fill in the appropriate information.
Site ID #: Site ID code (i.e.: FB-WA)
Site location: Physical location of your monitoring site (i.e.: Fish Bk. at Washington St. Boxford)
Observer(s): Monitors names
Date and time: Date and time of sampling
Tide: If the site is tidal, record the time of the low tide closest to your monitoring time

Weather

Circle the term on the data sheet that best describes the current weather conditions (Clear, Partly cloudy, Cloudy, Overcast, Drizzle, Rain, Snow, Fog, Sleet or Other).

Rain in last 48 hours

Circle the description on the data sheet that best describes the amount of rain in the previous 48 hours (Heavy, Light or None).

River Status

If the River is frozen or dry (no water present) check the appropriate box under River Status.

Collecting a Grab Sample

If you are at a bridge site, the first thing to do once you are ready to start sampling the water is to collect a grab sample using your bucket. Follow the directions below:

1. Empty bucket.
2. Throw bucket over bridge railing.
3. Swing bucket back and forth like a pendulum about 2 feet above the water.
4. At apex of arc, drop bucket into water.
5. Pull bucket up - it should be about 1/2 full with water.
6. Swish water around to rinse the inside of the bucket.
7. Pour water out either on the road, or downstream of sampling spot

8. Repeat steps 2-5

Be gentle with the bucket the last time you pull it up so that the water is not sloshed around and aerated. Sloshing the water around will cause air in the atmosphere to be introduced into the water sample. If the water has a low dissolved oxygen concentration it could be increased so the results of the dissolved oxygen analysis would not be accurate.

If you are not at a bridge site you can either collect a sample using the bucket by wading out into the stream and looking upstream. Rinse the bucket and pour the rinse water downstream. Then collect a sample carefully upstream of your position and wade back to shore. Otherwise, you can collect your temperature, dissolved oxygen and chloride samples directly from the River (not using the bucket).

Water Temperature

Once you have obtained a sample in your bucket, submerge entire thermometer in the water and leave it there while you are sampling the bucket for dissolved oxygen. Collect your dissolved oxygen sample, and then after you have "fixed" the dissolved oxygen sample check the thermometer. The thermometer should be in the water for approximately 3 – 5 minutes before reading the value. Record the temperature to the nearest 1/2 degree Celsius. Note the thermometer number on the data sheet. It is important to obtain the water temperature reading very soon after collecting the water sample because the water sample temperature may change rapidly if it is very different from air temperature.

Dissolved Oxygen

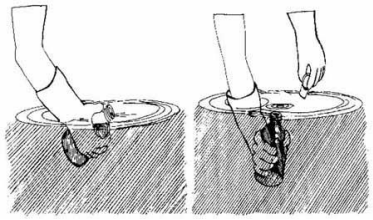
Dissolved oxygen testing is completed using the LaMotte Test Kit. The most important thing about dissolved oxygen sampling is not to introduce oxygen from the atmosphere into the sample. River water samples may contain from 0 to 12 mg/L of dissolved oxygen, but the air we breathe contains about 210,000 mg/L of oxygen!

Remember that the chemicals in the test kit should be kept of the reach of children. Also, read the safety information on the chemical reagents found in the kit. If you get any of the chemicals on your skin, rinse it off right away. It's always a good idea to bring some paper towels with you when you are sampling, to clean up any spills.

1. Take the sample bottle out of the dissolved oxygen test kit and remove the bottle cap.

2. To avoid contamination, thoroughly rinse the Water Sampling Bottle with sample water, if it needs it. You should have rinsed it out with tap water after your last monthly sampling.

3. Angle the bottle approximately 45 degrees.
   a. If you are sampling from a bridge and using a bucket, place the bottle into the water until the lower lip of the bottle is just underwater. Allow the water to gently flow into the bottle.
   b. If you are sampling in a tributary or the Ipswich River, point the bottle downstream and lower the bottle until the lower lip of the bottle is just underwater. Allow the water to gently flow into the bottle. Remember not to stand directly upstream of where you are collecting the water sample. If you stand facing the stream bank while you are sampling, then your body will not be upstream of the sample.



Step 3 – filling the bottle

Step 4 – Pushing the bottle underwater to completely fill the bottle

From: EPA Monitoring and Assessing Water Quality www.epa.gov

4. When the bottle is almost full, rotate so that the bottle is straight up and down, and push it under the water.
5. Once the bottle is full, tap the sides of the submerged bottle gently and put the cap on under water.
6. Retrieve bottle and examine it carefully to make sure that no air bubbles are trapped inside. If there are air bubbles in the sample, dump the sample out and collect another sample.
7. Once a satisfactory sample has been collected, immediately "fix" the sample.
8. To fix the sample, carefully remove the bottle cap and add 8 drops of Manganous Sulfate Solution and 8 drops of Alkaline Potassium Iodide Azide. Replace the cap and mix by inverting the sample bottle several times.
    a. **NOTE:** Be careful not to introduce air into the sample while adding the reagents. Simply drop the reagents into sample. Cap carefully, and mix gently.
9. During mixing a precipitate will form. **Allow the precipitate to settle below the shoulder of the bottle before proceeding.**
10. **Once the precipitate has settled below the shoulder of the bottle, mix the sample again and allow it to settle below the shoulder of the bottle a second time.**
11. Once the precipitate has settled below the shoulder of the bottle the second time, add 8 drops of Sulfuric Acid 1:1 to the bottle. Cap and gently mix by inverting the bottle until the reagent and the precipitate have dissolved. A clear-yellow to brown-orange color will develop, depending on the oxygen content of the sample.
    a. **Once this step has been completed the sample is "fixed". This means that contact of the sample with the air will not increase the sample oxygen value.** Once the sample has been "fixed", it is not necessary to perform the actual test procedure immediately. Thus, you can complete the rest of your observations and finish the dissolved oxygen test somewhere inside if it is cold.
12. Fill the titration tube to the 20 mL line with the "fixed" sample and cap.
13. Fill the Direct Reading Titrator with Sodium Thiosulfate, 0.025N.
    a. This is competed by pushing in the plunger of the titrator to expel any air and then putting the tip of the titrator into the hole in the top of the titrating solution. Turn the bottle of titrating solution upside down and slowly pull back the syringe plunger until the tip of the bottom of the plunger is past the zero mark on the titrator scale.

b. Turn everything right side up and slow push the plunger until it is reading “zero”. Remove the titrator from the standard solution.

14. Insert the titrator into the center hole of the titration tube cap. While gently swirling the tube, slowly press the plunger to titrate until the yellow-brown color is reduced to a very faint yellow. If the color of the “fixed” sample is already a very faint yellow, skip to step 15.
15. Remove the titrator and cap. Be careful not to disturb the titrator plunger, as the titration begun in Step 14 will be continued in Step 16. Add 8 drops of Starch Indicator Solution. Sample should turn blue.
16. Replace the cap and titrator. Continue titrating slowly until the blue color just disappears. Read the test result where the plunger tip meets the scale. Record as mg/L dissolved oxygen. (**NOTE**: Each minor division on the Titrator scale equals 0.2 mg/L of dissolved oxygen. 1 mg/L = 1 ppm)
17. If the plunger tip reaches the bottom line on the titrator scale (10 mg/L) before the endpoint color change occurs, refill the titrator and continue the titration. When recording the test result, be sure to include the value of the original amount of reagent dispensed (10 mg/L).
18. Dispose of solutions in sink at home, with the water running. Rinse out your syringe and sample bottle, allow to air dry on a paper towel. You can repeat entire procedure for accuracy.

Duplicate dissolved oxygen sample
Each year during the July monitoring event, every monitor will take an additional dissolved oxygen sample at each site using the bucket or wading into the River. This sample will then be analyzed for dissolved oxygen and the value reported. This way we have one date where everyone has collected two samples, or a duplicate sample. The difference between the samples should be less than 1 mg/L. This procedure provides assurance that everyone is properly collecting and analyzing the samples. Additional information regarding the dissolved oxygen procedure is attached in Appendix B.

Water Color
Circle most accurate description (Clear, Very light tea, Light tea, Tea, Dark Tea, or Other).

Water Clarity
Circle most accurate description (Clear, Slightly Turbid, Moderately Turbid, Highly Turbid/Murky).

Water Odor
Circle most accurate description (None, Rotten eggs, Musky, Fishy, Oily, Ammonia or Other).

Velocity Measurement

Velocity Measurement from a Bridge
1. Throw orange peel into water on the upstream side of the bridge.
2. Record the amount of time (in seconds) it takes the peel to travel beneath the bridge (from upstream to downstream).
3. Repeat for a total of 3 times and record measurements. If times are drastically different, repeat 3 more times.

4. Record the 3 times and calculate their average. For data entry onto spreadsheet, enter each time into the individual cells and the spreadsheet will calculate the average and, using the distance, will also calculate the velocity.
5. Divide the given distance of your bridge (in feet) by the average time (in seconds) to get the velocity. Multiply the result by a correction factor of 0.85.

Velocity Measurement from Water's Edge

1. Mark off 15 to 30 feet on shoreline, from upstream to downstream. Measure distance (in feet). Select upstream and downstream locations that can be easily identified (i.e. where a large rock or tree is present) or mark the locations.
2. Throw orange peel into the water at the upstream location.
3. Record the amount of time (in seconds) it takes the peel to travel between the two marks (from upstream to downstream).
4. Repeat for a total of 3 times and record measurements. If times are drastically different, repeat 3 more times.
5. Record the 3 times and their average.
6. Divide the given distance (in feet) by the average time (in seconds) to get the velocity. Multiply the result by a correction factor of 0.85.

Depth Measurements

Depth Measurement from a Bridge

1. Depth should be measured as close to the center of the River a possible, away from abutments and other obstructions to flow. Always measure River depth at the same location every month.
2. Holding the weight and line over the edge of the bridge, measure the distance from a fixed point to the bottom of the stream bed. Be aware the tapes are in tenths of feet, not inches. Record the distance on your data sheet.
3. Measure the distance from that same fixed point to the top of the water. Record the distance on your data sheet. Remember it's tenths of feet.
4. Subtract these two readings to calculate depth of water. Record the depth of water on your data sheet.

Depth Measurement taken in the River directly

If your site is not a bridge, then obtain your depth measurement from the middle of the River using a marked yard stick. For cross-section measurements, refer to Appendix E of this manual for instructions.

Conductivity
Conductivity will be measured at selected sites. Volunteers at these sites will be given the necessary materials to take this measurement.

Conductivity is a measure of the ability of water to conduct an electrical current. This is affected by the amount of dissolved ions in the water and is affected by geology and discharge into streams containing inorganic solids such as chloride, sodium, phosphates and nitrates that raise conductivity or organic runoff such as oil from a spill that can lower conductivity. Conductivity is measured in micro Siemens per centimeter (µs/cm). In general, conductivity can range from 50-1500 µs/cm, but streams supporting healthy aquatic habitats should be in the range of 150-500 µs/cm.

Oakton ECTestr for low (0-1990 µs/cm)

Calibration

1. Open the battery compartment lid. The two white buttons are increment (INC) and decrement (DEC) calibration keys (figure 1).
2. Rinse the electrode in deionized or distilled water, then rinse it in calibration standard, then dip it into a container of calibration standard.
3. Switch the unit on. Wait several minutes for the display to stabilize.
4. Press the INC or DEC keys to adjust reading to match the calibration standard value.
5. After 3 seconds without a key press, the display flashes 3 times, and then shows “ENT”. The tester accepts calibration value; returns to measurement mode.
6. Replace the battery cap.

Measurement

1. Remove electrode cap. Switch unit on.
2. Dip electrode into test solution. Make sure sensor is fully covered.
3. Wait for reading to stabilize. Note reading.
4. Turn tester off and replace electrode cap.

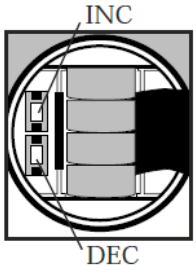


Figure 1. Increase and decrease keys in Oakton EC Testr battery compartment.

Oakton ECO Testr EC Low (0-1990 µs/cm)

Calibration

1. Press power button to turn on tester
2. Dip sensor into calibration solution and wait for the value to stabilize.
3. Press the “cal” button to begin the calibration. Display shows CAL momentarily and blinks the default reading.
4. Press the “hold/ent” button until the blinking value matches the value of your calibration standard at 25º C. Note: To set a calibration standard that is lower than the blinking value, continue to press “hold/ent” past the maximum value to continue with the lowest adjustable value.
5. Release “hold/ent” to accept the calibration value. After a few seconds, (Ent) is shown and measurement is resumed.
6. To abort calibration, press “cal” to escape (ESC).

Measurement

1. Remove cap and press power button to turn on tester.
2. Dip sensor into test solution.
3. Stir once and let reading stabilize. Note measured value.
4. To hold reading, press “hold/ent”. Screen flashes H0 once, and then displays measurement with blinking unit (µS) to indicate that tester is in the hold mode. Press “hold/ent” again to cancel hold mode (HC).
5. Press power button to shut the tester off. Note: tester automatically shuts off after 8.5 min. of non-use to conserve batteries.

Oakton ECO Testr CTS (Conductivity, turbidity, Salinity)

1. Remove the cap and press the power button to turn on.
2. The meter will begin in the measurement mode that was used when it was last powered off.
3. To change the measurement mode, press the menu button, the letters PArA will display
4. Press the left arrow button and the letters PArA Cond will display.
5. Press the left arrow button to accept and the display will read donE.
6. Dip the sensor in at least 30 mm of calibration standard.
7. Stir gently and press the cal/esc button
8. The display will show CAL followed by the default value
9. An icon in the image of a clock timer will stop blinking when the reading is stable and a check mark icon will display.
10. Press the menu button to manually adjust the reading to the desired value. The adjustment will decrease only, however the adjustment will eventually cycle back to the highest value.
11. Press the left arrow button to accept the desired calibration value when finished. The display will show donE to confirm the manual calibration.

Oakton ECO Testr CTS1 (Conductivity, total dissolved solids, Salinity)

Calibration

1. Short press the top button to turn on.
2. Conductivity mode should appear. Press the CAL/MODE button to switch to conductivity mode if needed.
3. Remove sensor cap. Rinse probe in distilled water and shake off excess.
4. Long press the CAL/MODE button to enter calibration mode.
5. Dip the probe into 1413 µS/cm calibration solution. Stir gently, leave it to stand. Wait for the measurement stability icon (☺) to appear and stay on the display, then short press the CAL/MODE button to complete the calibration. Tester returns to measurement mode and calibration icon "**M**" appears on the bottom left side of the display.

Measurement

1. Stir the probe in the sample solution gently, leave it to stand. Wait for the stability icon (☺) to stay on screen, then take the reading.
2. Rinse off the probe thoroughly in distilled water.

Chloride Measurement

LaMotte chloride test kit

1. Fill test tube to 15 mL line with sample water.
2. Add one drop of *Phenolphthalein Indicator, 1%. If solution remains colorless, proceed to Step 3. If solution turns a pink color, add Sulfuric Acid, 0.5N one drop at a time, mixing after each drop, until pink color disappears.
3. Add three drops of Chloride Reagent #1. Cap and swirl to mix. Solution will turn yellow.
4. Fill Direct Reading Titrator with Chloride Reagent #2. Insert Titrator in center hole of test tube cap.
5. While gently swirling tube, slowly press plunger to add Chloride Reagent #2, one drop at a time, until yellow color changes to orange-brown (right).
6. Read test result directly from the scale where the large ring on the Titrator meets the Titrator barrel. Record as ppm Chloride. EXAMPLE: Plunger tip is 3 minor division below line 100. Test result is 100 plus (3 division x 4) equals 112 ppm.
7. If plunger tip reaches bottom line on Titrator scale (200 ppm) before endpoint color change occurs, refill Titrator and continue titration. When recording test result, be sure to include the original amount of reagent dispensed (200 ppm).

HIGH CHLORIDE & SALINITY READINGS

For high chloride and salinity readings the sample must be diluted to bring it within a practicable range for titration. Dilutions of 1 to 20 or 1 to 100 are recommended. For example: 1 mL of sample water is diluted to a total of 20 mL with distilled water. This is a 1 to 20 dilution. Fill the Titrator to the 15 mL line with the diluted sample. Proceed with Steps 2 -7 above. Multiply result by conversion factor below:

1 - 20 DILUTION

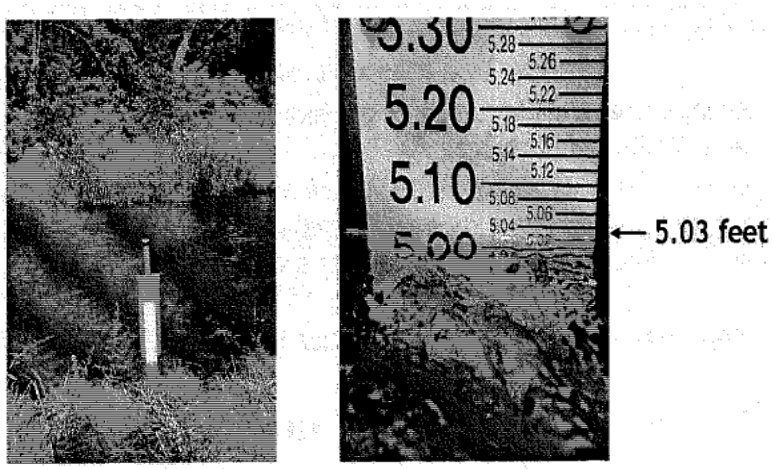
mg/L (ppm) Chloride = Titrator Reading x 20

Reading a RIFLS Staff Gauge

If you would like to participate in the RIFLS staff gauge monitoring program, please contact the IRWA Program Coordinator for information on how to get started.

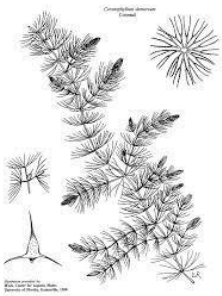
1. Staff gauges are located on Martin's Brook at Park St. in North Reading, on the Ipswich River at Haverhill St. in North Reading and on Boston Brook at Peabody St. in Middleton. The staff gauge on Martin's Brook is a former USGS gauging station.
2. Staff gauges are marked in feet, tenths of feet and hundredths of feet (not inches).
3. Determine the water level to the nearest hundredth of a foot. The gauges are labeled every two hundredths of a foot, so you will have to estimate when the water level is between two marks. If the water level upstream and downstream of the gauge differs, record the average.
4. Record your observations in the same place every time (e.g., a field notebook).
5. Note the time and date of your reading.
6. Note the weather conditions or other relevant information.
7. Take a photograph of the site from the same location at least 4 times per year to document different water levels, seasons and/or unusual conditions or events.

8. Enter data on the RIFLS website (www.rifls.org) according to instructions from the IRWA program coordinator.



Invasive Aquatic Plants
Invasive aquatic plants are widespread across the region and have caused infestations in several bodies of water. For example, Martins Pond in North Reading, Field Pond and Bracket Ponds in Andover have all had problems with Eurasian milfoil and fanwort. Hood Pond in Topsfield has had problems with variable milfoil and water chestnut. These plants can overtake a pond and crowd out native aquatic plants and limit habitat for fish and wildlife, as well as recreational use. RiverWatch monitors can help detect potential invaders in and around the river through passive observations while monitoring. Perhaps you may see an unusual plant fragment in the bucket or notice a plant growing that you might not have seen during prior outings. Here is what to look for:

Variable Milfoil
Variable milfoil is a non-native submerged plant with a “raccoon-tail” appearance. This is a hardy species that tolerates a variety of aquatic conditions, can grow in over 10 feet of water, and produces
dense mats of vegetation. This species spreads very rapidly from fragments.



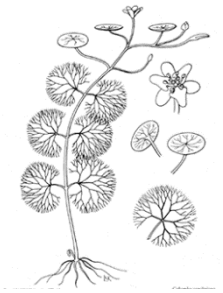
Key Identifying Features
The feathered submerged leaves are 2" long and 1" wide with rounded tips. Leaves are arranged in closely spaced whorls of four to six on a thick reddish stem, giving the plant a shaggy appearance. The
rigid emergent bract that forms in late summer has variable (serrated and smooth) leaf types.

Eurasian Milfoil

Eurasian Milfoil is an aggressive exotic plant that is common in the alkaline waters of western Massachusetts and is occasionally found in eastern waterbodies. Eurasian Milfoil spreads rapidly
via fragmentation and can form dense monocultures in the waterbody.

Key Identifying Features
The olive green feathered leaves are less than 2" long with leaf tips that appear blunt. Leaves occasionally have a reddish tint. Leaves are arranged in whorls of four (occasionally 3-6)
around the stem and the whorls are spaced approximately 3/8" apart. The stems are red/brown or white/pink in color and reach 20 feet. Reddish flowers form during July and August in whorls of four on an 8" emergent bract (protruding above the water surface).

Fanwort



Fanwort is native to the southern United States and is a very persistent species. Fanwort was likely introduced to New England via the aquarium trade and has been established in the acidic waterbodies of Massachusetts for over fifty years. The species is a popular aquarium plant due to its decorative bright green fan-shaped leaves. Like many other exotic species, Fanwort can re-grow from fragments.

Key Identifying Features
The bright green fan-shaped leaves are arranged in opposite pairs on the stem. In late summer the plant produces tiny white/cream flowers and small oval and diamond shaped floating leaves.

Water Chestnut

Native to Eurasia, this species was intentionally introduced in 1877. Since its introduction it has become a nuisance in the Concord and Charles river systems and continues to spread across the state. Friends of Hood Pond has been managing water chestnut through annual hand pulling. Water Chestnut does not spread from fragments, but produces nuts that sink and remain viable in the sediment for over seven years.

Key Identifying Features
The floating diamond shaped leaves have deep leaf margins and form rosettes. The upper side of the leaf is shiny and the underside is covered with fine hairs. Submerged leaves are feather-like and whorled around the stem. A 1" fruit (chestnut) with four shard barbs may be attached. When present, flowers are white with four petals

Appendix A: Monitoring Data Sheet

RiverWatch Monthly Monitoring Data Sheet

SITE ID#	LOCATION	
OBSERVER(S)		
DATE	TIME	TIDE

WEATHER (circle one)

Clear Partly Cloudy Cloudy Overcast Drizzle
Rain Snow Fog Sleet Other

RAIN IN THE LAST 48 HOURS (circle one)

Heavy Light None

RIVER STATUS (check appropriate boxes, if necessary)

☐ River is frozen ☐ River is dry

WATER COLOR (circle one)

Clear Very light tea Light tea Tea Dark Tea

WATER CLARITY (circle one)

Clear Slightly turbid Moderately turbid Highly turbid/murky

WATER ODOR (circle one)

None Rotten eggs Musky Fishy Oily Ammonia Other

WATER QUALITY				
Parameter	**Calibration standard**	**Calibration standard reading**	**Sample measurement**	**Calibration standard reading following sample measurement**
Water temperature			°C	
Dissolved oxygen			mg/L	
Conductivity	µS/cm	µS/cm	µS/cm	µS/cm
Chloride	mg/L	mg/L	mg/L	

VELOCITY			
DISTANCE	**TIME 1**	**TIME 2**	**TIME3**
ft	Seconds	Seconds	Seconds

DEPTH					
Depth (from bridge)					**Depth (in stream – if station isn't at a bridge)**
Railing to bottom	**-**	**Railing to surface**	**=**	**Depth (surface to bottom)**	**Water Depth**
ft		ft		ft	ft

WILDLIFE/COMMENTS, INVASIVE SPECIES (i.e. variable milfoil, water chestnut):

Please return to: IRWA, PO Box 576, Ipswich, MA 01938 Email: irwainfo@ipswichriver.org

Appendix B: Auditing Form for RiverWatch Volunteers:

Date: _____Time: _____ Site: _____

Monitors Present: _____

Parameters Done, comments on by auditor:

Parameter	**Monitor(s) Measurement**	**Auditor Measurement**
Dissolved Oxygen (mg/L)		
Temperature (°C)		
Conductivity (µS/cm)		
Chloride (mg/L)		

Water Temperature: _____

Dissolved Oxygen: _____

Conductivity: _____

Depth: _____

Velocity: _____

Weather: _____

Habitat/Wildlife: _____

Filling out Form: _____

Comments of auditor for things to change: _____

_____

Comments of auditor on data reliability / necessity of flagging data for QA/QC issues:

_____

Signatures: Monitors:_____

Auditor:_____

Appendix F: Thermo Scientific Conductivity/DO Meter Instructions

Conductivity Calibration

One to five conductivity standards can be used for calibration. Always use fresh standards and select standards that are near the sample conductivity. Prepare the conductivity cell according to the instructions in the conductivity cell use guide. Connect the conductivity cell and any other electrodes to be used to the meter.

Power on the meter and set the measurement mode to conductivity.

Note: *For an automatic calibration, the nominal cell constant of the conductivity cell must be entered in the*
setup menu before the calibration is performed and Thermo Scientific Orion 100 µS/cm, 1413 µS/cm and/or
12.9 mS/cm conductivity standards must be used.

Automatic and Direct Calibration

1. In the measurement mode, press ***f1 (cal)***. Press the arrow keys to highlight *Conductivity-Channel* and press ***f2 (select)***.
2. Rinse the conductivity cell and any other electrodes in use with distilled water, blot dry with a lint-free tissue and place into the standard.
3. When the conductivity cell and standard are ready, press ***f3 (start)***.
4. Wait for the conductivity value on the meter to stabilize and stop flashing and perform one of thefollowing actions:
    i. Press ***f2 (accept)*** to accept the displayed conductivity value.
    ii. Press ***f3 (edit)*** to access the numeric entry screen and edit the conductivity standard value.
    iii. Press the arrow keys to highlight a number or decimal point, press ***f3 (enter)*** to select the highlighted item and repeat until the standard value at the measured temperature is shown.
    iv. Press ***f2 (done)*** to exit the numeric entry screen.
    v. Press ***f2 (accept)*** to accept the entered conductivity value.
5. Press ***f2 (next)*** to proceed to the next standard and repeat steps 2 through 4 or press ***f3 (cal done)*** to save and end the calibration. If five standards are used, the calibration will save and end once the fifth conductivity standard value is accepted.
6. The meter will display the calibration summary including the average calculated cell constant. Press ***f1 (meas)*** to export the data to the calibration log or press ***f2 (print)*** to export the data to the calibration log and a printer or computer. The meter will automatically proceed to the measurement mode.

RDO/DO Calibration

Air Calibration

1. In the measurement mode, press ***f1 (cal)***. Press or to highlight *DO-Channel* and
2. press ***f2 (select)***.
3. Press or to highlight *Air* and press ***f3 (select)***.
4. Rinse the RDO optical DO probe or polarographic DO probe with distilled water, blot dry with a lint-free tissue and place into the prepared calibration sleeve or BOD bottle. Allow the probe and water-saturated air to reach equilibrium.
5. When the probe and water-saturated air are ready, press ***f3 (start)***.

6. Wait for the dissolved oxygen reading on the meter to stabilize and stop flashing. Once the reading is
7. stable, the meter will display *Accepting Auto % Sat. Calibration* and *100.0 %* if using an RDO optical
8. DO probe or *102.3 %* if using a polarographic DO probe.
9. Press ***f3 (cal done)*** to export the data to the calibration log or press ***f2 (print)*** to export the data to the
10. calibration log and a printer or computer. The meter will proceed to the measurement mode.

Set Zero Calibration

A zero point calibration is performed in an oxygen-free solution. A zero-point calibration is not generally required unless measurements will be taken below 10% saturation or 1 mg/L. Perform an air or water calibration before performing a zero-point calibration.

1. In the measurement mode, press ***f1 (cal)***. Press the arrow keys to highlight *DO-Channel* and
2. press ***f2 (select)***.
3. Press the arrow keys to highlight *Set Zero* and press ***f3 (select)***.
4. Rinse the RDO optical DO probe or polarographic DO probe and any other electrodes in use with distilled water, blot dry with a lint-free tissue and place into the prepared zero oxygen standard. Allow the probe and standard to reach equilibrium.
5. When the probe and zero oxygen standard are ready, press ***f3 (start)***.
6. Wait for the dissolved oxygen reading on the meter to stabilize and stop flashing. Once the reading is stable, the meter will display *Accepting Auto % Sat. Calibration* and *0.00*.
7. Press ***f3 (cal done)*** to export the data to the calibration log or press ***f2 (print)*** to export the data to the calibration log and a printer or computer. The meter will proceed to the measurement mode.

Measurement

In the measurement mode, press ***f3 (channel)*** to scroll through and select the channel displaying Cond (conductivity) and DO – mg/L (dissolved oxygen in milligrams per liter).

Note: *It is highly recommended that any unused channels not be shown on the meter display while taking measurements, since the meter waits for all displayed channels to stabilize before logging the measurement data.*

Press the left arrow while taking a measurement in the continuous measurement mode to freeze the display and press the left arrow a second time to unfreeze the display and continue the measurement. Press the down arrow while taking a measurement to manually export the measurement to the data log, if the data log is enabled in the setup menu.

1. Rinse the conductivity cell, RDO optical dissolved oxygen probe with distilled water, blot dry with a lint-free tissue and place into the sample.
2. Start the measurement and wait for it to stabilize.
    a. If the meter is in **AUTO-READ** mode (default setting), press the Measure button to start the measurement. When the icon stops flashing, record the applicable measurement parameters and temperature of the sample. Press Measure again to start a new measurement.
    b. If the meter is in continuous mode, the meter will immediately start taking a measurement and update the display whenever the measurement changes. Wait for

the display to show **ready** and record the applicable measurement parameters and temperature of the sample.

c. If the meter is in timed mode, the meter will log measurements at the preselected time interval, regardless of the measurement stability. The meter will update the display whenever the measurement changes, so the applicable measurement parameters and temperature of the sample can be recorded when the display shows **ready**.

3. Remove the electrodes from the sample, rinse with distilled water, blot dry and place into the next sample.
4. Repeat steps 2 and 3 for all samples.
5. When all samples have been measured, store the electrodes according to their user guides.

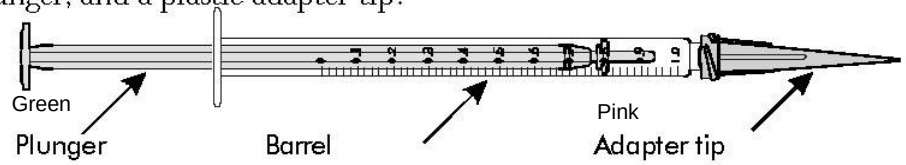
Appendix C: Additional information on dissolved oxygen sampling

Reference: University of Rhode Island Watershed Watch SOP 010 – Dissolved Oxygen Monitoring March 2005, Revision 1.

LaMotte **Product Upgrade Notice**

Direct Reading Titrator
General Instructions **Code 1649**

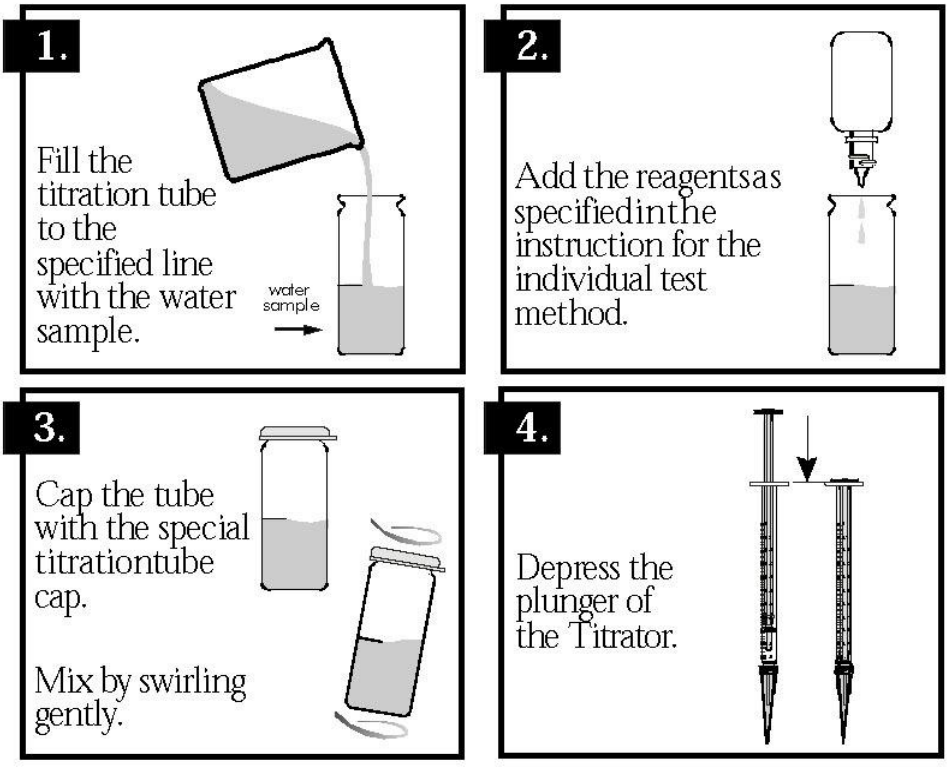
The new Direct Reading Titrator consists of a plastic barrel, a plastic plunger, and a plastic adapter tip.



The adapter tip reduces the size of the drops that are dispensed and increases the precision of the test results. DO NOT REMOVE THE ADAPTER TIP.

Instructions

These are general instructions for the use of the Direct Reading Titrator. The titrator in the illustrations is an example. Refer to individual test kit instructions for test procedures and the actual range and increment values.

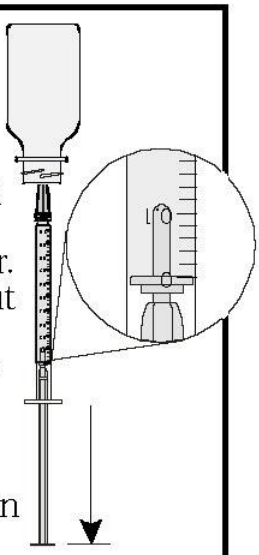


5.

Insert the adapter tip into the special plastic plug in the titrating solution bottle.

6.

Invert the bottle. Hold the bottle and the Titrator firmly together. Slowly pull out the plunger until the large ring on the plunger is opposite the zero (0) line on the scale.

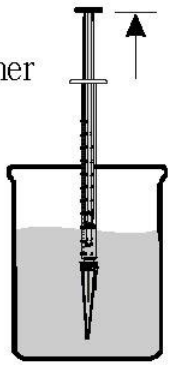


7.

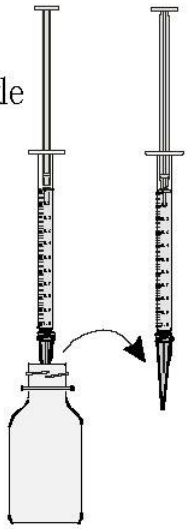
If an air bubble appears in the Titrator barrel or the adapter tip, partially fill the barrel and pump the titration solution back into the inverted reagent bottle to expel the bubble.

NOTE:

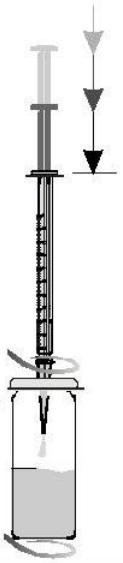
When filling the Titrator from a container without a special plug, submerge the adapter tip below the surface of the solution and pull out the plunger.



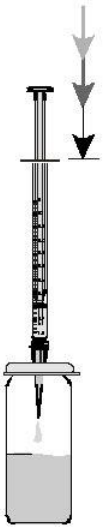
8. Turn the bottle right side up and remove the Titrator.



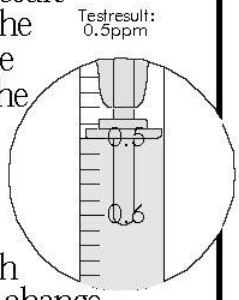
9. Insert the adapter tip into the opening in the titrator tube cap. Slowly depress the plunger to dispense the titrating solution. Gently swirl the tube to mix the solution.



10. Continue adding the titrating solution until the specified color change occurs. If the color change does not occur when the large ring on the plunger reaches the bottom of the scale, refill the Titrator to the zero line. Continue the titration until the color change occurs.



11. Read the test result directly from the scale where the large ring on the Titrator meets the Titrator barrel. If the Titrator was refilled to reach the final color change, add the total amounts of titrant used to determine the final test result.



12. If no additional tests are to be made, discard the remaining titrating solution in the Titrator. Do not return the titrating solution to the reagent bottle. Thoroughly rinse the titration tube and the Titrator. Do not remove the plunger or the adapter tip from the Titrator.

COMMON QUESTIONS ABOUT ANALYZING DISSOLVED OXYGEN

This assumes that you have collected your water sample(s) and have capped the bottle(s).

Should I pour off any of the water in my sample bottle before I add the reagents?
NO! If you pour off some water you are introducing air (and oxygen). When you cap the bottle and shake it this oxygen can cause erroneously high results. Put the bottle on a paper towel if necessary to catch any water that spills over when you add the reagents.

How should I hold the dropper bottles to dispense each reagent?
Hold the dropper bottles completely upside down. This ensures a uniform drop size. The liquid reagents won't come out until you squeeze the bottle.

Why must I shake the bottle and let the floc settle twice?
Doing this twice ensures that the chemical reactions are complete and that all the oxygen molecules have reacted with the chemical reagents.

Sometimes after I add the eight drops of sulfuric acid some brown particles remain. Is this OK?
The brown particles should be dissolved before you continue with your test. First, try shaking the sample bottle quite hard to see if they dissolve. If this doesn't work add one more drop of sulfuric acid (red capped bottle). Occasionally in water with an algae bloom there may be some organic matter present in you sample. This won't dissolve. You should be able to tell the difference between this and the chemical particles.

What does it mean by saying that the sample is "fixed"?
In a practical sense it means that contact with atmospheric oxygen will not affect your test results. Fixed samples may be stored up to eight hours, if kept refrigerated and in the dark. The chemical reactions that occur in this analysis are explained after these questions.

Okay, now I've got my syringe filled and through the hole in the cap on the titration vial. Sometimes the drops don't seem to fall right into the water sample. Why?
Each cap should have a tiny vent hole in it so that as the sodium thiosulfate is added to the fixed water sample the displaced air can escape. If you don't have this tiny hole, when you add the sodium thiosulfate instead of it dropping into the liquid it will run down the side of the bottle. This will also happen if a drop of liquid on top of the cap covers the vent hole. So, make sure that 1) your cap has a vent hole and 2) that is remains unobstructed during the titration. If your cap doesn't have a vent hole you can easily make one or enlarge an existing one by heating a pin and pushing it through the plastic.

The directions say to add sodium thiosulfate until the water samples turns a straw yellow. How much does the color matter? Why shouldn't I add the starch indicator all at once in the beginning?
I checked with Steve Wildberger of LaMotte Chemical Company about these questions. He feels that if you add the starch indicator all at once you will be likely to overshoot the end point. The color change from dark blue to colorless is much more abrupt than the more gradual change from brown to yellow. The pale yellow color in itself is an indicator that you are nearing the end point of the titration. He suggests that the yellow color you should be looking for when adding the indicator is "a manila folder yellow" rather than a straw yellow. I have also found that

in high oxygen water if you add the starch indicator in the beginning the dark blue color seems to coat the sides of the titration vial, which makes the visual determination of the endpoint more difficult.

My water sample is pale yellow right after it is fixed. Do I still have to see it get lighter before I add the starch indicator?
If your water sample is already a pale yellow after it is fixed, add the starch indicator before you begin your titration. If your sample is completely colorless after it is fixed and remains that way after you add the indicator this means that there is no dissolved oxygen in your sample. If this is the case, you might want to check the dissolved oxygen content of the 1 meter water just to make sure that the reagents in your kit are still functioning properly.

What should I do with any leftover sodium thiosulfate in the syringe?
Discard any remaining sodium thiosulfate into your titrator vial. Do not put it back into the bottle it came from. Then take apart your syringe and rinse it with tap water. Store it with the plunger backed off from the bottom of the syringe.

Chemical Reactions when Using the Azide Modification of the Winkler Method to Test for Dissolved Oxygen

(from: *Clean Water: A Guide to Water Quality Monitoring*, by E. Stancioff, University of Maine Cooperative Extension.)

The first step in a dissolved oxygen (DO) titration is the addition of manganous sulfate solution (4167) and alkaline potassium iodide azide (7166) to the water sample. These reagents react with each other to form a precipitate, or floc, of manganous hydroxide, $Mn(OH)_2$. Chemically the reaction is:

$$\mathbf{MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4}$$

manganous sulfate + potassium sulfate ⟶ manganous hydroxide + potassium sulfate

Immediately upon formation of the precipitate, the oxygen in the water oxidizes an equivalent amount of the manganous hydroxide to manganic hydroxide. In other words, for every molecule of oxygen in the water one molecule of manganous hydroxide is converted to manganic hydroxide. The reaction is:

$$\mathbf{2\,Mn(OH)_2 + O_2 + 2H_2O \longrightarrow 2Mn(OH)_4}$$

manganous hydroxide + oxygen + water ⟶ manganic hydroxide

After the precipitate is formed a strong acid, sulfuric acid 1:1 (6141WT) is added to the water sample. The acid converts the manganic hydroxide to manganic sulfate. At this point the sample is considered "fixed". Any concern for additional oxygen being introduced into the sample is reduced. The chemical reaction is:

$$\mathbf{2Mn(OH)_4 + 4H_2SO_4 \longrightarrow 2Mn(SO4)_2 + 8H_2O}$$

manganic hydroxide + sulfuric acid ⟶ manganic sulfate + water

Simultaneously, iodine from the potassium iodide in the alkaline potassium iodide azide solution is replaced by sulfate, releasing free iodine into the water. Since the sulfate for this reaction comes from the manganic sulfate which was formed from the reaction between the manganic hydroxide and oxygen; the amount of iodine released is directly proportional to the amount of oxygen present in the original sample. The release of free iodine is indicated by the sample turning a yellow-brown color. This chemical reaction is:

$$\mathbf{2Mn(SO_4)_2 + 4KI \longrightarrow 2Mn(SO_4) + 2K_2SO_4 + 2I_2}$$

manganic sulfate + potassium iodide ⟶ manganic sulfate + potassium sulfate + iodine

The final step in the Winkler titration is the addition of sodium thiosulfate. The sodium thiosulfate reacts with the free iodine to produce sodium iodide. When all the iodine had been converted the sample changes color from yellow-brown to colorless. Often a starch indicator is added to enhance the final endpoint. This chemical reaction is:

$$\mathbf{4NaS_2O_3 + 2I_2 \longrightarrow Na_2S_4O_6 + 4NaI}$$

sodium thiosulfate + iodine ⟶ sodium tetrathionate + sodium iodide