# Water Chemistry Analysis Handbook

First Edition: Shayne Fuller (2000)
Second Edition: Shara Cohn (2002)
Third Edition: Joanne Lee (2003)
Fourth Edition: David Kuperstein, Spencer Orey (2004)
Fifth Edition: Kelly Nissen, Jon Spaulding (2005)
Sixth Edition: Alex Chang, Beth Griffiths (2006)
Seventh Edition: Annie Tsay, Gopal Lalchandani (2008)
Eighth Edition: Michael Brandt, Preeti Talwai, Jonathan Wong (2009)
Ninth Edition: Edward Lee, Ada Lin, Daniel Fuad (2010)
Tenth Edition: Isra Syed, Ruth Rosenthal, Kevin Sung (2011)
Eleventh Edition: Katherine Lee, Gregory Pon, Eli Rosenthal (2012)
Twelfth Edition: Nikhil Kotha, Alvin Lau (2013)
Thirteenth Edition: Hoon Min, Ariana Tang (2014)
Fourteenth Edition: Jonathan Kung, Muskaan Aggarwal, Steven Li (2016)

**Objective:**
The objective of Water Chemistry Analysis is to collect biweekly samples from both a riffle and a pool within the boundaries of each site at Arcade Creek and to test those samples for the presence of various chemicals. Ideally, monthly samples must be collected at the same times, locations, and depths. This data can be used to assess creek health and anthropogenic threats to the creek. These results help to illustrate the ability of the creek to support life and maintain a healthy ecosystem.

**General Terminology:**
Cultural Eutrophication: Human-caused enrichment of the water with nutrients, usually phosphorous, sometimes nitrates

Eddy: A current of water moving in an opposite direction of the main current that generally goes in a circular motion

Harmful Algal Bloom (HAB): Excessive algal bloom that occurs due to an excess amount of nitrates or phosphates in the creek water.

Human Disturbance: Human disturbance can be trash, waste from Haggin Oaks Golf Course (such as the lawn preparation of the Haggin Oaks Golf Course), etc.

Inorganic pollutants: Suspended and dissolved solids that are usually natural in origin

Non-point source pollution: Exact origin of pollution cannot be determined

Organic pollutants: Come from decomposition of living organisms and their byproducts. They release both nutrients and toxins into the water.

Pollution: Anything that affects the condition of the water. This is not limited to toxic waste. It can include soil erosion, flooding, etc.

Point source pollution: Pollution traced to a single origin

Pool: An area of the creek where the water is not moving or breaking the surface and is at least two feet deep
Reach: A section of the creek composed of a pool, a riffle, and a run

Riffle: An area of the creek where the water is running and breaking the surface

Run: A stretch of straight stream

Thermal pollutants: A change in average temperature caused by human influence. Change in water temperature can have drastic effects on aquatic life.

Trihalomethane (THM): an organic molecule in which hydrogen is replaced by elements from the electronegative Halogen family, usually chlorine and bromine

Toxic pollutants: Heavy metals and lethal chemicals (usually dumped by industry).

Transect: 1/10 of the length of a site. Will be marked by tags.

**Creek Protocol:**
The leader of each group must contact his/her group members at least two days before the testing date to make sure all members will be present. The leader must also coordinate with the other leaders because there are a limited number of kits. Before actually leaving Mira Loma, make sure you have signed out all equipment. Remember to clear all equipment with the equipment manager before taking them from the creek room.

*Materials to bring to the creek:*

- Waders
- 2 containers for water samples per site (one for pool, one for riffle)
- Dissolved Oxygen (DO) kit with 2 DO bottles
- Record sheet
- Gloves
- Trash Bags

*Creek Methodology:*

- ONLY VISIT THE CREEK IN GROUPS OF FOUR OR MORE!!! If a group is found to have sampled with fewer than three people, there will be severe consequences.
- If someone is injured at the creek, two members of the group should leave to find assistance while one person stays behind with the injured individual. - Keep all emergency numbers with you at all times.
- Do not sample if water conditions are too extreme, and remember to put safety first.
- All groups must sample on the second week of the month before Wednesday.
- Record the weather, temperature, time, and any other observations such as unusual changes. - Before you leave for your site, ensure that your DO kits are stocked with reagents, bottles, clippers, and a thermometer.
- Find the markers for the site. It may be helpful to go with a long mapper first to locate your site - Sample from a riffle and pool within the site. Leaders will show you where they are located. If possible, sample from the same riffle and pool every time. Consistent sampling is important to obtain an accurate representation of the creek's health. - Collect water at a depth of at least two feet.

- When wading in the creek, move upstream, so as to not create bubbles or stir up other chemicals in the creek. Take the water sample upstream of your location.
- Avoid taking samples promptly after other groups have been trampling around your sampling site.
- Remember to collect an extra pool sample for Bio Assay.
- Run the DO tests on-site.

DO TESTING STEPS

1. Collect water sample in the largest, glass DO bottle
2. Put the two DO reagents in the water sample, place the cap (make sure no air bubbles are present) and shake for 30 seconds until orange-brown floc precipitate clearly forms
3. Set the bottle on a flat surface and wait for roughly 2 minutes so the floc can settle at the bottom of the bottle
4. Use nail clippers to open the pillow packet and put the reagent into the bottle, forming a yellow solution.
5. Pour the solution into the measuring tube and place the rectangular bottle over the top of the tube
6. Invert the tube and the rectangular bottle so that the solution falls down into the bottle
7. Use the dropper to drop the chemical into the bottle. Swirl the bottle between drops, and count the number of drops until the solution is clear. Remember and record this value.

- You may run into some unexpected difficulties during your fieldwork. For example, during the rainy season, there may be no riffle. If such is the case, record and elaborate as much as possible in the comments box. Do your best to collect whatever data possible. Doing so will make your contribution to this project much more effective.
- Wear appropriate apparel (i.e. close toed shoes, long sleeves, or long pants if necessary) - For humans the water is considered to be unsafe for contact at 200 colonies per 100 milliliters of water. Arcade Creek has considerably higher levels than this, so try to limit your time playing in the water!

Once you return to Mira Loma, make sure you check all equipment back into the Creek Room. Do not take anything home, and clean out your DO kits. Fill out the log sheet along with the data table each time your group conducts tests on the creek, and remember to turn in the data sheets. NOTIFY LEADERS/MANAGERS IF THE KITS NEED REPLACEMENTS.

**Lab Protocol:**

*Lab Materials:*

Samples from the pool and riffle
All the kits (Hardness, Chlorine, Phosphate, Ammonia, Alkalinity, Nitrates)
Pipettes
Droppers
Calculator
Goggles
Aprons
Gloves
Distilled Water
Record Sheets
Probes

*Lab Methodology:*

- The tests you will be conducting are standardized tests of the Water Quality Index (WQI). - Perform the low range tests first. If the sample yields a high value for the low range test, then proceed with the high range test.
- Test the water sample for Total Chlorine <u>before</u> testing for Free Chlorine because Total Chlorine already accounts for the amount of Free Chlorine in the sample.

- Clean all glassware and work stations. Remember that the lab is a classroom during the day. - Wash your hands thoroughly and any other part of your body that came into contact with the creek water or the chemicals we work with.
- There should be no eating while in the lab.
- Wear appropriate apparel (aprons, goggles, and closed toed shoes) and tie long hair back - Help maintain the re-order list as the year progresses (things that have been broken or used up).
- QAQC (Quality Assurance/Quality Control) each other. It helps ensure that the data is accurate. Run the test first yourself, and then have your partner run it without previously telling him/her your result. Compare and discuss your results. Hopefully they will be the same.
- **Do not make up data.** Run all possible tests and record all tests that could not be performed and why. Inform your leaders and managers when this happens. When you falsify data you undermine everything this project stands for.

*Lab Efficiency:*

- While accuracy should not be sacrificed for efficiency on data collection days, efficiency during data collection days is still a major concern. Using the following format, it is possible to be done with testing in about thirty minutes.
- Each of the seven sites will be assigned to do one of the chemical tests during each lab session. Site test assignments shall rotate among the different groups. The members of a particular site are then responsible for carrying out the specific test for the pool and riffle samples of each site, following the HACH (This is a company, pronounced hawk) test instructions in the kits and recording the data on the designated data sheets.
- If a certain site finishes their tests early, they should assist other sites completing longer tests to maximize the collective efficiency of the group. **ALL MEMBERS OF THE STUDY are required to carry out their tests and work during lab testing sessions.**

**Data Protocol**

*Data Methodology*: One of the most significant parts of the Chemistry Analysis is the recording and tracking of accurate data. Without this, the tests performed and the time put into the study are meaningless. Thus it is very important that a set protocol is followed for both data recording and data analysis.

<u>1. Data Recording</u>:

- Record appropriate data in the sheets provided to you at each data collection meeting - Ensure that you convert all units properly. The instructions for the tests will specify what calculations to make.
- The managers will then copy each site's data into a comprehensive spreadsheet which will contain a running account of all of the data for the year.
- **NO FALSIFICATION OF DATA WILL BE TOLERATED.** Our data is used by outside agencies and must be accurate. Please uphold the integrity of the Arcade Creek Project.
- Every month, this revised spreadsheet , will be put onto the data flash drive for electronic storage.
- A hard copy of the data should be put into the chemistry binder.

<u>2. Data Analysis:</u>

- Data analysis will be done every few months, provided that there is enough data.
- Data analysis can be done in many different ways. The creek's health can be studied as a whole over a certain amount of years, the progression of data collected from one or several tests can be analyzed, or chemistry data can be compared to data from other studies. These are just a few possibilities.

- Make sure that you check with your leader and the managers before analyzing data. If a set of data has already been analyzed in the exact way that you want to do it, then it is of little use to redo what has already been done.
- On the document containing your analysis, record exactly what analysis you are doing (tests, studies, years, etc.)
- Proper data analysis should have a graph or graphs followed by a paragraph explaining the information presented in the graphs. Not only should the progression be explained, but the significance of the trends should be explained as well. To evaluate the health of the creek, the levels of the chemicals found should be compared to public, accepted standards. There should also be a clear conclusion to the analysis.
- Cite all outside sources used in your analysis.
- Email a copy of your analysis to ALL the managers and your site leader. THIS IS MANDATORY for you to get hours for your analysis, because it is necessary to ensure quality of work as well as proper distribution of the analysis. Please make sure to put your name(s) on the analysis. - An electronic copy of the analysis will be saved on the data flash drive and a hard copy will be put in the chemistry binder.

**Test Information:**

*Dissolved Oxygen (DO):* Atmospheric $O_2$ mixed in the water available for biological consumption
- an indicator of the water's ability to support life
- DO is attributed to photosynthesis and direct mixing of atmospheric $O_2$ with the water surface. Direct mixing requires a rough substrate, bottom, and a quick current velocity. Arcade Creek rarely exhibits these tow properties, so its primary source of $O_2$ is photosynthesis.
- Photosynthesis is dependent on sunlight. There will be fluctuations of dissolved oxygen content throughout a 24-hour period, with more in the day and less at night.
- DO usually reaches its peak at 4 P.M., decreasing to as low as 4 mg/L before dawn. - DO values may change while in the sample bottle because of algae that are continuing photosynthesis, air bubbles, and microorganisms that are using oxygen. It is best to perform the DO on site.
- DO is dependent on temperature, location (depth), and flow.
- When taking samples, record the appearance and flow of the water, weather, and temperature. A high temperature results in less oxygen.
- Changes in dissolved oxygen are attributed mainly to the build up of organic wastes. Aerobic organisms must consume oxygen to decompose organic matter.
- Biochemical Oxygen Demand (BOD) is the oxygen required to decompose organic matter and sustain the aerobic organisms living in the water. It is inversely related to DO.
- Temperature and oxygen content are inversely related.
- Healthy DO: saturation greater than ninety percent, approximately 9.5 mg/L

*Free and Total Chlorine:* When in contact with water, small amounts of hypochlorous acid (HClO) and hydrochloric acid (HCl) form.
- Hypochlorous acid: Agent responsible for puncturing the cell walls of bacteria and other organisms. It can break down further into its respective ions of $H^+$ and $ClO^-$ - HClO and ClO- are the molecules measured as free chlorine.

- Total chlorine measures the free chlorine and all the chlorine containing compounds. High amounts are considered harmful because they indicate the presence of carcinogenic byproducts, known as trihalomethanes or THM's.
- THM: an organic molecule where hydrogen is replaced by elements from the electronegative Halogen family, usually chlorine and bromine.
- Because chlorine is used as a disinfectant for sewage, it is usually present in the wastewater effluent, treated water that has been dumped back into the environment. No such effluent is pumped into Arcade creek so spikes in chlorine level could possibly be due to cultural eutrophication.
- This tests for the efficiency of the disinfecting process in wastewater treatment plants.
- A healthy range for drinking water is between 0.2-2.0 mg/L of $Cl_2$ of free chlorine

*Phosphates:* the most common form of phosphorous in natural waters
- Essential element for life, especially for plants
- Beneficial only when present in minute amounts
- In typical aquatic systems, plants grow until phosphates are used up. Thus, it is a limiting nutrient.
- Phosphates are fixed by algae and tied up in the sediment at the bottom on the creek. If the creek is stirred up too much, this can affect phosphate level. We only test for the ionic form ($PO_4^{3-}$).
- Scarcity is attributed to phosphorous' attraction to anionic soil particles and organic matter.
- Excessive phosphorous facilitates extensive algal growth called "harmful algal bloom" (HAB).
- Natural abundance of phosphorous is rare; it is usually caused by cultural eutrophication. - Human sources of phosphorous include inorganic detergents, fertilizers, human waste, industrial waste, and human disturbance of the land.
- Healthy levels are less than 0.1 mg/L

*Nitrates:* effects of nitrogen similar to phosphorous
- It is a plant nutrient.
- Excess amounts of nitrogen result in algal bloom.
- Nitrate has a negative charge ($NO_3^-$).
- Nitrates will leak into the water table and can contaminate drinking water.
- High amounts of nitrates do not affect aquatic organisms because phosphates limit their growth.
- Methemoglobinemia in infants prevents the baby's blood from carrying $O_2$. - Healthy levels are less than 10 mg/L.

*Ammonia:* breakdown creates nitrates and nitrogen
- Byproduct of decay and protein hydrolysis -

It is extremely toxic to gilled organisms.
- Added through cultural eutrophication, where the nitrogen cycle is disrupted - The toxicity is higher when pH is higher.
- The higher the temperature, the more ammonia can convert to its ionic form ($NH_3$- -> $NH_4^-$)
- Sources include fertilizer, cleaning agents, cow/horse excrement
- Perform test quickly after sampling
- Healthy levels are less than 0.05 mg/L

*Alkalinity:* the ability of water to resist acids that can cause drastic change in pH

- Created by buffers, it is measured as acid neutralizing capability in terms of calcium carbonate. - Fish and multicultural organisms are the most sensitive to fluctuations in pH because of their complexity, while bacteria and protozoa are the most tolerant.
- A higher alkalinity indicates healthy water and stable pH. Healthy levels are greater than 20 mg/L.

*Hardness:* a measure of the cations in the water, specifically the calcium ions

- It indicates the source of water and what it has been in contact with, including rocks and sediments.
- Soft water is less than 60 parts per million.
- Fluctuations in calcium hardness are a sign of human involvement. Ions naturally stay in a relatively stable state.
- It affects other ions and the toxicity of metal ion, especially copper. Copper kills aquatic mammals and is the most toxic element from storm water runoff.
- It is visually detected as competitive inhibition. Soap competes for dissociation with calcium and magnesium, which are less soluble.
- Magnesium and calcium compete with toxic metals for placement on gills.
- Moderately hard water is between 4.4-8.8 grains/gallon and hard water is between 8.8-17.5 grains/gallon