

Rodeo Valley Watershed Water Quality Assessment



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Most content in the student packet was adapted for YMCA Point Bonita from the Earthforce Water Quality Monitoring Handbook (www.earthforce.org)

Graphics courtesy of the Headlands Institute

INTRODUCTION

Watersheds

Watersheds are defined as the total land area drained by a particular stream or river. Watersheds can be large or small, draining a single valley or the entire basin. On its way to the lowest point in the watershed, water can travel over the earth's surface and across farm fields, forestland, suburban lawns, or city streets. It can also seep into the soil and travel as ground water. A healthy watershed not only stores but also filters water for a river or stream, keeping the water system "healthy."

Both pollutants and nutrients found within a watershed will eventually make their way into the streams and rivers of that watershed, and become part of the water cycle. The growth of human populations can result in the diversion of the water from naturally flowing streams and rivers as the need for water and hydroelectric power rises. This disrupts the water cycle, and adds certain pollutants and nutrients to the watershed.

Fertilizers and pesticides are major sources of contamination for watersheds. Most often the wildlife within a watershed suffers the most from water contamination. Contamination causes slight changes in the chemical and physical properties of water, which can upset the natural balance of the aquatic life. Most plants and organisms require a specific set of conditions in order to live; if that range is exceeded, the plants and organisms may die. Because of these changes in water quality, food chains can be altered and drinking water may become contaminated. However, as mentioned above, nature does have a system of removing pollutants from watersheds. As water percolates through soil into the water table, soil, rocks, and sand filter out many of the impurities carried by the water.

It is important to realize all of us live within a watershed and that the way we live can affect the water we drink as well as the animals and plants that live in our area, including us humans. We all influence what happens in our local watersheds by how we treat the natural resources contained therein - the soil, water, air, plants, and animals. It is our responsibility to keep local watersheds healthy; it is also our responsibility to monitor the water in our area and take action if our watersheds become unhealthy or off-balance.

BACKGROUND OF THE WATER QUALITY MONITORING PROJECT

Study Location: Rodeo Valley Watershed

The Rodeo Valley is located within the Gerbode Basin, about ten miles north of San Francisco in a former U.S. military base now part of the Golden Gate Recreation Area in Marin (GGNRA). Rodeo Valley has historically been used for agriculture, cattle grazing, and various military purposes. Possible pollution sources include military wastes, the presence of cattle farms, and remnants of old roads that have contributed to runoff and erosion.

Your Role

The Water Quality Monitoring Project offers area high school students the opportunity to experience the scientific process firsthand. You will be the scientists that perform the monitoring assessments, collect data, and analyze your results.

This study will be conducted within two aquatic habitats in the watershed: Rodeo Lagoon and Pond. Rodeo lagoon is a unique water body as it contains *brackish* water - a mixture of salty and fresh water. In this study, you will assess the diversity of aquatic macroinvertebrates and determine the levels of: pH, nitrates, phosphates, turbidity, dissolved oxygen, and temperature. By collecting data on the biotic and abiotic components of the watershed, you will be contributing to a long-term scientific monitoring of these unique and important ecosystems. Aquatic biologists to monitor the health of the local watershed use the results in this study. This long-term dataset helps biologists identify areas of focus for restorations projects in order to maintain a healthy watershed in Rodeo Valley.

This project is part of a curriculum that educates San Francisco Bay Area high school students about the local ecosystem. If you would like more information on this program, please contact YMCA Point Bonita at (415) 331-9622.

WATER QUALITY MONITORING

(Adapted from the Earthforce Water Quality Monitoring Project (earthforce.org); Edited by Rudd)

Purpose

We need to monitor aquatic ecosystems in our local watershed in order to understand the health of our waters. Can we safely swim in them? Can animals and plants survive in them? Can we drink from them? Furthermore, it is important to track the status of the bodies of water over time and respond to changes in water quality.

Analysts determine water quality by testing for specific chemicals and physical states. Water quality testing involves measuring certain *abiotic* (*nonliving*) factors that affect water quality: dissolved oxygen, pH, temperature, nitrates, phosphates, and turbidity.

When analysts study *macroinvertebrates* (an invertebrate you don't need a microscope to see) and an area's *riparian zone*, they study the *biotic* (*living*) factors that help indicate water quality. The presence, condition, and number of fish, insects, algae, plants and other aquatic life can provide information about the health of specific water.

The primary use of these water quality assessment tools is to characterize current status of a watershed. Furthermore, these data can be used to track or predict significant change in the water system and identify major ecosystem stress.

Macroinvertebrates as Biological Indicators

Macroinvertebrates are a critical link in the aquatic food chain. In most bodies of water, the energy stored by plants is available to animal life either in the form of leaves that fall in the water or in the form of algae that grows on the stream bottom. The algae and leaves are eaten by macroinvertebrates. In turn, the macroinvertebrates become a source of energy for larger animals such as fish, which serve as a source of energy for birds, raccoons, water snakes, and even fishermen.

Aquatic macroinvertebrates differ in their sensitivity to water pollution. Some macroinvertebrates cannot survive in polluted water while others can survive or even thrive in polluted water. In a healthy body of water, the aquatic community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy body of water, there may be only a few types of non-sensitive macroinvertebrates present.

The diversity and abundance of aquatic macroinvertebrates provides information about the health of a body of water over a long time period. The data obtained by this macroinvertebrate sampling study can complement physical and chemical water quality assessments and provide a comprehensive picture of the health of a watershed. In this study, we will conduct a *qualitative* study of the aquatic macroinvertebrates in two water bodies of the Rodeo Valley watershed.

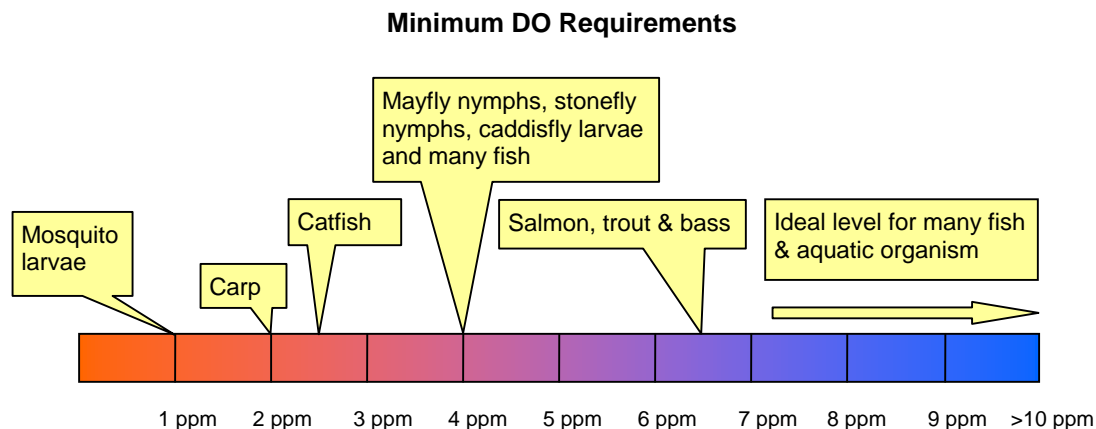
Physical and Chemical Water Quality Analysis

There are six crucial quantitative measures used to assess water quality: dissolved oxygen, turbidity, temperature, nitrates, phosphates, and pH. Each of these measures does not exist in isolation with respect to the others; in fact, a change in one will most likely result in a change in the rest. For example, an increase in water turbidity will most likely result in a higher water temperature, which in turn will cause a change in the amount of dissolved oxygen in the water due to changing rates of photosynthesis. In short, all these measurable factors are connected with one another. You will discover this as you proceed with your investigation.

1. Dissolved Oxygen

Dissolved oxygen (DO) is oxygen that is dissolved in water. It gets there by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. Dissolved oxygen is essential for healthy lakes, ponds, lagoons, and rivers. It is important to note that dissolved oxygen does not refer to the oxygen (O) in the water molecule (H_2O).

The presence of oxygen in water is a positive sign, while the absence of oxygen is a signal of severe pollution. Waters can range from high to very low levels of DO in the water - so low, in some cases, that they are practically devoid of aquatic life. Most aquatic plants and animals need oxygen to survive. How much DO an aquatic organism needs varies by species, physical state, water temperature, pollutants present, and other factors.



Only green plants and some bacteria can produce oxygen through photosynthesis and similar processes; green plants manufacture virtually all the oxygen we breathe. However, much of the dissolved oxygen in water comes from the atmosphere. Waves on lakes, slow-moving rivers, and tumbling water on fast-moving rivers act to mix atmospheric oxygen with water. Algae and rooted aquatic plants also provide oxygen to the water through photosynthesis. Fish and aquatic animals cannot split oxygen from water (H_2O) or other oxygen-containing compounds.

Some aquatic organisms, like pike and trout, require medium-to-high levels of dissolved oxygen to live. Other animals, like carp and catfish, can tolerate low levels of dissolved

oxygen. Waters of consistently high levels of dissolved oxygen saturation, such as 90 percent or higher, are usually considered healthy and stable ecosystems, capable of supporting many different kinds of aquatic organisms. Waters below 90 percent saturation may have large amounts of oxygen-demanding materials, such as organic waste (feces, fertilizer, etc.).

Oxygen levels can be reduced in a number of ways. If water is too warm, there may not be enough oxygen in it. When there are too many bacteria or aquatic animals in the area, they may consume DO in great amounts, thereby lowering DO levels. DO can also be reduced by the presence of run-off from farm fields containing phosphates and nitrates (the ingredients in fertilizers).

2. Nitrates

Nitrogen is an element needed by all living plants and animals to build amino acids and, in turn, protein. In aquatic ecosystems, nitrogen is present in many forms. Blue-green algae are able to use nitrogen in its elemental form (N_2) and convert it into forms of nitrogen that plants can take up through their roots and use for growth: ammonia (NH_3) and nitrate (NO_3).

As aquatic plants and animals die, bacteria break down their large protein molecules into ammonia. Ammonia is then *oxidized (combined with oxygen)* by bacteria to form nitrites (NO_2) and nitrates (NO_3). Excretions by aquatic organisms are very rich in ammonia, although the amount of nitrogen they add to water is usually small. Ducks and geese, however, contribute nitrogen from their waste, and in areas where they are abundant this can be a problem. Through the decomposition of dead plants and animals and the excretions of living animals nitrogen that was previously "locked up" is released.

Because nitrogen (in the form of ammonia and nitrates) acts as a plant nutrient, it also causes eutrophication. *Eutrophication* is the enrichment of water with nutrients, usually phosphorous and nitrogen, which stimulates the growth of algal blooms and rooted aquatic vegetation. Eutrophication promotes more plant growth and decay, which in turn increases oxygen demand and lowers the total dissolved oxygen. Because of this process, nitrates in excess amounts can have a significant impact on water quality.

When it rains, varying nitrate amounts wash from farmland into nearby waterways. Nitrates also get into waterways from lawn fertilizer run-off, leaking septic tanks and cesspools, manure from farm livestock, animal wastes (including fish and birds), and discharges from car exhaust. In turn, nitrates stimulate the growth of plankton that provide food for many aquatic fish. This may increase the fish population beyond its *carrying capacity* (the total number of individuals of a species that a specific ecosystem can support). Also, if algae multiply rapidly, oxygen levels will be reduced and fish will die.

Nitrates can be reduced to toxic nitrites in the human intestine, and many babies have been seriously poisoned by well water containing high levels of nitrate-nitrogen. The U.S. Public Health Service has established 10 mg/L of nitrate-nitrogen as the maximum contamination level allowed in public drinking water.

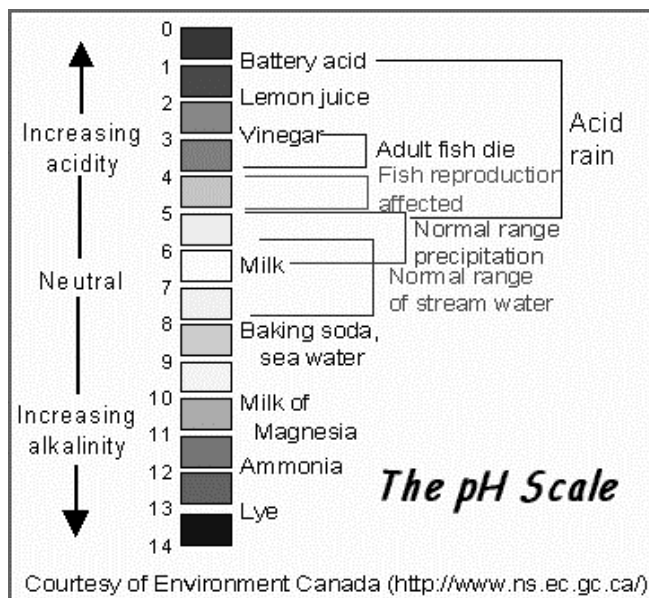
3. pH

Water (H₂O) is made of both H⁺ (hydrogen) ions and OH⁻ (hydroxyl) ions. The pH test measures the ratio of H⁺ ion concentration of liquids and substances. Each measured liquid or substance is given a pH value on a scale that ranges from 0 to 14.

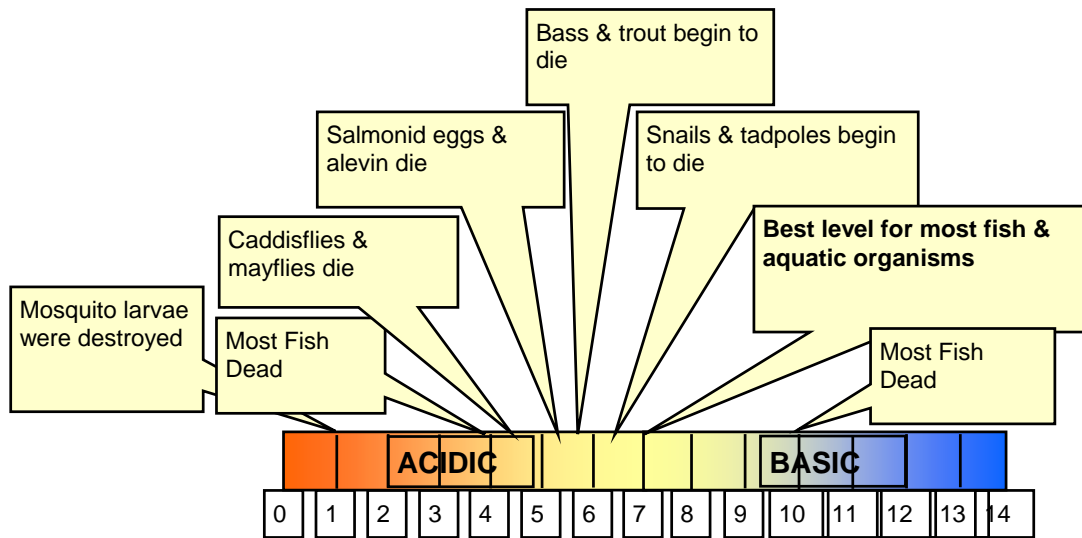
Pure deionized (distilled) water contains equal numbers of H⁺ and OH⁻ ions, and has a pH of 7. This is considered neutral, neither acidic nor basic. If a water sample has more H⁺ than OH⁻ ions, it is considered acidic and has a pH less than 7. If a sample contains more OH⁻ ions than H⁺ ions, it is considered basic or alkaline with a pH greater than 7.

It is important to remember that the pH scale is logarithmic, that is, for every one-unit change on the pH scale, there is a tenfold change in how acidic or basic the sample is. For example, lakes with a pH of 4 (acidic) are roughly 100 times more acidic than lakes with a pH of 6.

Changes in the pH of water are important to many organisms. Most organisms have adapted to life in water of a specific pH and may die if it changes even slightly. At extremely high or low pH values, the water becomes unsuitable for most organisms. For example, immature stages of aquatic insects and young fish are extremely sensitive to pH values below 5. Waters with high acidic values can also cause heavy metals, such as copper and aluminum, to be released into the water. Heavy metals can accumulate on the gills of fish or cause deformities in young fish, reducing their chance of survival.



In the United States, the pH of natural water is usually between 6.5 and 8.5, although wide variations can occur. In many areas of the U.S., the type of rocks and minerals that are present determine the acidity of the local water. If limestone is present, the alkaline (basic) limestone neutralizes the effect the acids might have on lakes and streams. The areas hardest hit by acid rain and snow are downwind of urban/industrial areas and do not have any limestone to reduce the acidity of the water.



4. Phosphates

Phosphorous is usually present in natural waters as phosphate (PO_4^{-2}). Phosphorous is an essential element for life, an important nutrient for plants to grow and for energy use of plants and animals. Phosphate has two different forms in our environment: organic phosphate, which is a part of living plants and animals, their byproducts and their remains; and inorganic phosphate, which can be bound to soil particles or present in laundry detergents.

The number of aquatic plants growing in a particular area is dependent on the amount and type of phosphorous available. In an aquatic ecosystem, inorganic phosphate is rapidly taken up by algae and larger plants, resulting in algal blooms, causing significant impacts on water quality. Since phosphorous acts as a plant nutrient, it also causes eutrophication.

Phosphorous from natural resources, such as forest fires and fallout from volcanic eruptions, is insignificant when compared to human-caused enrichments of water from nutrients. Phosphorous is introduced into the environment from activities such as human and animal wastes, fertilizers, industrial wastes and human disturbance of the land and its vegetation. Phosphates in excess amounts can have a significant impact on water quality.

5. Temperature

Water temperature affects many other physical, biological and chemical properties of a body of water. For example, cool water can hold more dissolved oxygen (DO) than warm water because gases dissolve easier in cooler water. Like pH, temperature also has wide-ranging effects on aquatic ecosystems, and most aquatic organisms have adapted to survive within a range of water temperatures. Some organisms prefer cooler water, such as trout and stonefly nymphs, while others thrive under warmer conditions, such as carp and dragonfly nymphs. As the temperature of a river or lake increases, warm water organisms will replace cool water species. Few organisms can survive in temperatures of extreme heat or cold.

Temperature	Examples of Life
Greater than 20°C (warm water)	Much plant life, bass, bluegill, carp, catfish, leeches, caddisfly
Middle range (12-20°C)	Some plant life, trout, stonefly, mayfly, caddisfly, water beetles
Low range Less than 12°C	Trout, caddisfly, stonefly, mayflies all thrive

Changes in water temperature can also affect the rate of photosynthesis and plant growth (and decay). As plants die, they are decomposed by bacteria that consume oxygen, increasing the biochemical oxygen demand in the water. The metabolic rate of organisms also rises with increasing water temperatures, resulting in an even greater oxygen demand.

One way that the temperature of water can increase in a river or lake is from thermal pollution. Thermal pollution is an increase in water temperature caused by adding relatively warm water. Industries, such as nuclear power plants, may cause thermal pollution by discharging warmer water from their plant that was used to cool machinery. Thermal pollution may also come from storm water running off warmed urban surfaces, such as streets, sidewalks and parking lots.

6. Turbidity

Turbidity measures the cloudiness of a body of water. You can think of turbid water as the opposite of clear water. Soil particles carried by runoff cause rivers to turn brown after a heavy rain. High amounts of soil in the water will block sunlight from reaching the bottom of a river or a lake in shallow water. Higher turbidity can be caused by human activity like cutting trees and removing vegetation next to a body of water.

When water is turbid, floating particles absorb heat from the sun and cause the water temperature to rise. Higher temperatures cause oxygen levels in the water to fall, limiting the ability of fish and insects to survive there. Floating particles may clog fish gills. When these particles sink, they can smother and kill fish and aquatic insect eggs that lay on the bottom. Turbidity can also limit plant growth by inhibiting sunlight from penetrating into deeper waters. Higher turbidity can lead a combination of warmer water, less light and oxygen depletion, making it impossible for some forms of aquatic life to survive.

MATERIALS LIST

The following is a list of materials needed by each four-person group. Multiply the materials list below by the number of groups that will be taking data.

Students must bring the following with them on the day of the study:

- Student Packet with data sheets
- Pen or Pencil
- Clothing and personal items (as specified below)

The following will be provided by the YMCA for each study group:

- Pond study kits, including materials for all tests

STUDENTS: You may get wet during monitoring. You will want to dress appropriately. Cotton, when it gets wet, will make you very cold! Make efforts to wear clothes that are not made of cotton. Wool or synthetic material such as fleece or polypropylene is great. Also, do not wear expensive jewelry, bring expensive electronics such as cell phones or music players, or wear clothes you don't want to get dirty. The following is a suggested list of clothing you should wear.

- Warm, wind-resistant layer of clothing, sweater or jacket, NOT cotton
- Quick-drying, wind-resistant pants or shorts, NOT cotton
- Hat with brim
- Wool or synthetic socks, NOT cotton
- Waterproof or rubber boots, if you have them
- Water Bottle
- Sunscreen

Biological Indicators of Water Quality: Studying Aquatic Invertebrates

One quick way to determine the relative health of a body of water is to examine the living things living in it. It seems reasonable to infer that the more species that are able to live in the water, the less polluted the water is. This investigation will give us a general idea of the health of the water sources in the Marin Headlands by seeing which organisms are able to live in the water here. You will gather and identify as many specimens of freshwater invertebrates as you can in order to make this initial determination.

It should be noted that this is a *qualitative* investigation, and not meant to provide numerical answers as to the water quality. The results you obtain in this investigation will serve to guide your hypotheses for the second half of the water quality assessment, which involves *quantitative* data collection.

Materials (per study group):

- Water collection device (pan or Frisbee)
- Small mesh net
- Field microscope or magnifier
- Field guides to freshwater invertebrates
- Spoon
- Data collection sheet
- Pen or pencil

Field Procedure:

1. Break into study groups. Groups should be 2-4 people.
2. Gather all materials, place other equipment out of the way.
3. Collect a sample of water and sediment from the water source you are investigating. Do this by submerging the water collection device and/or using the mesh net. Carefully bring the sample to a picnic table or other place where you are conducting your study.
4. Allow 30-60 seconds for observation of the sample. Carefully use the spoon to sift through your water sample, look for movement. If you do not observe organisms in your sample, return the sample to the water source from which it came and gather another sample.
5. If you observe organisms in your sample, place them in the field microscope using a spoon or use a magnifier to observe it more closely. Be sure to put adequate water into the magnifier; the organism should be completely submerged. Use your field guides and other reference materials to identify the organism you have found.
6. Once you have identified the organism in your magnifier, mark it on your data collection sheet. Then return the organism to the sample, and return the sample to the water source from which it came.
7. Repeat steps 3-6 for 30 minutes, taking a new water sample every 5 minutes, or until your teacher or naturalist tells you that time is up. Your goal is to try to identify as many organisms as you can in the time allotted.
8. Be sure to clean up any materials at the end of the study.

Data Sheet: Aquatic Invertebrates

The freshwater invertebrates are grouped below by their relative sensitivity to pollution. When you identify an organism, place a tally mark next to its name. (*NOTE: some organisms you find may not appear on the list below. Check with your teacher or naturalist to determine which of the three categories they belong in.*)

1. POLLUTION-SENSITIVE

Caddisfly Larva		}	TOTAL: _____
Mayfly Larva/Nymph			
Riffle Beetle			
Stonefly Larva			
Dobsonfly (Hellgrammite)			
Gilled (water-breathing) snail			
Water Penny			

2. MODERATELY POLLUTION-TOLERANT

Water Scavenger Beetle		}	TOTAL: _____
Predacious Diving Beetle			
Whirligig Beetle			
Waterboatman			
Backswimmer			
Giant Water Bug			
Water Scorpion			
Water Strider			
Crayfish			
Aquatic Snowbug			
Crane fly Larva			
Blackfly			
Horsefly Larva			
Damselfly Larva			
Fishfly Larva			
Nematode Worm			
Dragonfly Nymph			
Amphipod (Scud)			
Springtail			
Alderfly Larva			
Clam (or other bivalve)			
Water Flea			
Copepod			

3. POLLUTION-TOLERANT

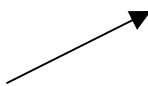
Air-breathing snail		}	TOTAL: _____
Clam or Seed Shrimp			
Mothfly Larva			
Blackfly Larva			
Leech			
Midge Larva			
Red-Tailed Maggot			
Mosquito Larva or Pupa			
Planarian			
Aquatic Earthworm			
Horsehair Worm			
Water Mite			

Data Analysis:

Count how many different species (NOT how many individuals!) in each category that have been identified during your study. Then perform the following calculations to obtain an assessment score. Use the guide below to interpret your assessment score.

	(# of species)		(sub-score)
Pollution-Sensitive	_____	x3 =	_____
Moderately Tolerant	_____	x2 =	_____
Tolerant	_____	x1 =	_____
Add up the subtotals above for your			
ASSESSMENT SCORE:			_____

<p><i>Water Quality Index</i></p> <p><i>0-10: Poor</i></p> <p><i>11-16: Fair</i></p> <p><i>17-22: Good</i></p> <p><i>23+ : Excellent</i></p>



Discussion Questions

- What do your results tell you? What can you say about the quality of the body of water you sampled?
- Is this a good way to determine water quality? Why or why not?
- Are there any ways to improve the design of this study?
- What other questions does this study raise? If you were able to conduct a follow up study to answer those questions, what would you do?

Name: _____

Date: _____

Water Quality Assessment: Dissolved Oxygen

(adapted from the LaMotte water monitoring kit, www.earthforce.org/green/do)

INTRODUCTION:

Dissolved Oxygen (DO) is important to the health of aquatic ecosystems. All animals need oxygen to survive, even those that live underwater. Natural waters with high DO levels are most likely stable and healthy environments, and are capable of supporting a diversity of organisms. Natural and human-induced changes to the aquatic environment can affect the availability of DO.

You will be measuring the DO % saturation, which can change with the temperature of the water. Colder water can hold more DO than warmer water. Additionally, high levels of bacteria or rotting organic matter may cause the % saturation to decrease. This can result large fluctuations in DO levels through out the day and year.

QUESTION:

What is the DO % saturation of the water sample you are investigating?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

1 small test tube with threaded cap

Dissolved Oxygen TesTab (up to six)

Colored DO chart

Watch

Data sheet with % saturation table

Pen or Pencil

PROCEDURE:

1. Obtain the current water temperature from the group conducting temperature readings. Record the temperature on your data sheet.
2. Submerge the small test tube into the water sample. Carefully remove the tube from the water sample, keeping the tube full to the top.
3. Drop **two** DO TesTabs into the tube. Water will overflow when tablets are added. Then screw the cap onto the tube. Make sure no air bubbles are present in the tube.
4. Mix by inverting the test tube until the tablet has disintegrated. There is no need to shake the test tube. Bits of material may remain in the sample. This may take up to 5 minutes.
5. Wait 5 more minutes for a color to appear.
6. Compare the color of the sample to the DO color chart. Record the result (0ppm, 4ppm, 8ppm)*. Then consult the table on the back of this sheet to determine % saturation.

**ppm stands for "parts per million"*

DATA/RESULTS:

Current water temperature: _____ What is the DO level you recorded? _____

Using the table to the right, what is the % saturation you recorded? _____

Additional observations:

Record anything that you think might affect the results: foreign objects in the sample, location the sample was taken, etc.

		Dissolved Oxygen		
		0 ppm	4 ppm	8ppm
Temperature (degrees Celsius)	2	0	29	58
	4	0	31	61
	6	0	44	64
	8	0	78	68
	10	0	38	71
	12	0	37	74
	14	0	39	78
	16	0	41	81
	18	0	42	84
	20	0	44	88
	22	0	46	92
	24	0	48	95
	26	0	49	99
	28	0	51	102
30	0	53	106	

DISCUSSION:

Considering the factors that affect DO % saturation mentioned in the introduction, how can you explain your results? What specific conditions in the surrounding watershed do you think affected your data?

Compare your findings to your conclusions from the aquatic invertebrates assessment. Are they consistent? Why or why not?

What are some factors that might affect DO % saturation (besides those mentioned in the introduction)?

Name: _____

Date: _____

Water Quality Assessment: Nitrates

(adapted from the LaMotte water monitoring kit, www.earthforce.org/green/nitrate)

INTRODUCTION:

Nitrate (NO_3^-) is needed by all aquatic plants and animals to build protein. The decomposition of dead organic matter and the waste products of living animals release NO_3^- into the environment. Excess NO_3^- increases plant growth and decay, promotes bacterial decomposition, and therefore decreases the amount of oxygen available in the water. Sewage, excess fertilizers, and agricultural runoff can all increase the level of NO_3^- .

Drinking water that contains high levels of NO_3^- can affect the ability of blood to carry oxygen. This can be especially true for infants who drink formula made with water high in NO_3^- .

QUESTION:

What is the Nitrate concentration of the water sample you are investigating?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

1 Test Tube with 5 ml calibration and cap

Nitrate Wide Range CTA TesTab #1 (up to three)

Nitrate Wide Range CTA TesTab #2 (up to three)

Colored nitrate chart

Watch

Data sheet

Pen or Pencil

PROCEDURE:

1. Fill the test tube to the 5 ml mark with the water sample.
2. Add one Nitrate TesTab #1 to the test tube, then put the cap firmly in place.
3. Mix by inverting the test tube until the tablet has disintegrated. There is no need to shake the test tube. Bits of material may remain in the sample.
4. Add one Nitrate TesTab #2 to the water sample. Mix by inverting the test tube as you did in step 3.
5. Wait 5 minutes for a red color to appear.
6. Compare the color of the sample to the nitrate color chart. Record the result (5ppm, 20ppm, 40ppm)*.
7. If supplies and time allows, repeat steps 1-5 two more times.

DATA/RESULTS:

Observed nitrate level of the sample: _____

Additional observations:

Record anything that you think might affect the results: foreign objects in the sample, location the sample was taken, etc.

DISCUSSION:

What do your data show? What can you conclude about the nitrate levels of the water in Rodeo Valley?

Thinking about the specific environment you are studying, what do you think contributed to the NO_3^- levels of the samples you took?

(if you measured the NO_3^- more than once:) Was your measurement consistent? If not, why not?

Name: _____

Date: _____

Water Quality Assessment: pH

(adapted from the LaMotte water monitoring kit, www.earthforce.org/green/ph)

INTRODUCTION:

pH is a measurement of the acidic or basic quality of water. The pH scale ranges from 0 (very acidic) to 14 (vary basic or alkaline), with 7 being neutral. The pH of distilled water is 7.0, but the pH of naturally occurring water varies, usually between 6 and 8.5. Most aquatic organisms are adapted to a specific pH level and may die if the pH of the water changes even slightly. The pH of a natural water supply can change from introduction of waste and pollution, agricultural runoff, local geology, and a host of other factors. Extreme high and low water pH levels can likely exceed the tolerances of the plants and animals living in that water.

The pH scale literally refers to the relative concentration of H⁺ and OH⁻ ions. The scale is logarithmic, that is, each whole number on the scale represents a tenfold increase or decrease in the concentration of H⁺ ions.

QUESTION:

What is the pH of the water sample you are investigating?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

1 Test Tube with 10 ml calibration and cap

pH Wide Range TesTab (up to three)

Colored pH chart

Data sheet

Pen or Pencil

PROCEDURE:

1. Fill the test tube to the 10 ml mark with the water sample.
2. Add one pH Wide Range TesTab to the test tube, then put the cap firmly in place.
3. Mix by inverting the test tube until the tablet has disintegrated. This may take up to 2 minutes. There is no need to shake the test tube. Bits of material may remain in the sample.
4. Compare the color of the sample to the pH color chart. Record the result.
5. If supplies and time allows, repeat steps 1-4 two more times.

DATA/RESULTS:

Observed pH of the sample: _____

Additional observations:

Record anything that you think might affect the results: foreign objects in the sample, location the sample was taken, etc.

DISCUSSION:

Is your water sample acidic (below 7) or basic (above 7)?

If the pH of distilled (pure) water is 7.0, what might account for the difference in pH for naturally occurring water in general?

What do you think contributed to the pH of the samples you took? Consider what you know about the Rodeo Valley watershed in your answer.

Can you think of an example of an organism that is affected by changes in water pH?

(if you measured the pH more than once:) Was your pH measurement consistent? If not, why not?

Name: _____

Date: _____

Water Quality Assessment: Phosphates

(adapted from the LaMotte water monitoring kit, www.earthforce.org/green/phosphate)

INTRODUCTION:

Phosphate (PO_4^{-2}) is a nutrient needed for plant and animal growth and is also a fundamental molecule in metabolic reactions. High levels of phosphate can lead to an overgrowth of plants, increased bacterial activity, and decreased dissolved oxygen (DO) levels. Low phosphate levels conversely, can inhibit growth.

Phosphate comes from several sources, including human and animal waste, agricultural runoff, and industrial pollution.

QUESTION:

What is the phosphate (PO_4^{-2}) concentration of the water sample you are investigating?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

1 Test Tube with 5 ml calibration with cap

Phosphorus TesTab (up to three)

Colored phosphate chart

Watch

Data sheet

Pen or Pencil

PROCEDURE:

1. Fill the test tube to the 5 ml mark with the water sample.
2. Add one phosphorous TesTab to the test tube, then put the cap firmly in place.
3. Mix by inverting the test tube until the tablet has disintegrated. There is no need to shake the test tube. Bits of material may remain in the sample.
4. Wait 5 minutes for a blue color to appear.
5. Compare the color of the sample to the phosphate color chart. Record the result (1ppm, 2ppm, 4ppm)*.
6. If supplies and time allow, repeat steps 1-4 two more times.

**ppm stands for "parts per million"*

DATA/RESULTS:

Observed phosphate level of the sample: _____

Additional observations:

Record anything that you think might affect the results: foreign objects in the sample, location the sample was taken, etc.

DISCUSSION:

Thinking about the surrounding watershed, what do you think contributed to the PO_4^{-2} levels of the samples you took?

Do these findings support your findings in your study of aquatic invertebrates? Why or why not?

(if you measured the PO_4^{-2} more than once:) Was your measurement consistent? If not, why not?

Name: _____

Date: _____

Water Quality Assessment: Temperature

INTRODUCTION:

We have all measured the temperature of something: the air, a swimming pool, ourselves. The device used to measure temperature is a thermometer. Thermometers can vary as to quality and precision, so we must be careful as to use multiple data points when drawing conclusions. This test will measure both the air and water temperature.

Organisms are very sensitive to temperature changes. Most organisms need a specific temperature range in order to live; if the temperature moves out of that range the organisms could be seriously affected.

QUESTION:

What is the temperature of the air and water of the sample you are investigating? Will it change throughout the course of your test?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

2 Thermometers (Celsius)

2 pieces of string (about 2 meters each)

Watch

Data sheet

Pen or Pencil

PROCEDURE:

1. Attach the pieces of string to each thermometer. (NOTE: This may already be done for you)
2. Hang one thermometer from a nearby tree by tying the string around a tree branch. Place the other thermometer under the surface of the water; tie the string to a secure object above the water surface. Wait 2 minutes for the thermometers to adjust to the air and water temperatures.
3. Take a reading of each thermometer and record it in your data table.
4. Every one minute thereafter take a reading of each thermometer. Do this for 5 minutes (6 measurements total)
5. Calculate the average temperature for the entire test and write it on your data sheet.

DATA/RESULTS:

	Temperature in Degrees Celsius					
Thermometer	0 min	1 min	2 min	3 min	4 min	5 min
Water						
Air						

Average Air Temperature:

Average Water Temperature:

DISCUSSION:

Did the temperature of the air and water change throughout the course of the test? What might account for this?

Think about the location of the thermometer. Does it make a difference where the thermometer is placed? Why or why not?

Why is temperature an important factor in assessing water quality?

Name: _____

Date: _____

Water Quality Assessment: Turbidity

(adapted from the LaMotte water monitoring kit, www.earthforce.org/green/turbidity)

INTRODUCTION:

Turbidity is the measure of relative clarity of the water. Turbid water is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter, and microscopic organisms. Turbidity should not be confused with color, since darkly colored water can still be clear and free of sediment. Turbid water may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances which can be caused by boat traffic and abundant bottom feeders.

Remember that turbidity can affect measurable factors such as temperature and the rate of photosynthesis.

QUESTION:

What is the turbidity of the water sample you are investigating?

HYPOTHESIS:

(In formulating your hypothesis, draw on your results from the aquatic invertebrate study as well as your knowledge of the Rodeo Valley)

MATERIALS:

1 Secchi disk assembly

Metric measuring tape

1 Sampling jar with sticker

Turbidity comparison chart

Data sheet

Pen or Pencil

PROCEDURE:

1. Be sure the secchi disk sticker is fastened on the bottom of the sampling jar, slightly off-center.
2. Fill the jar with water from your source to the turbidity fill line indicated on the outside of the jar.
3. Hold the turbidity chart to the top edge of the jar. Looking down into the jar, compare the appearance of the secchi disk icon to the samples on the chart. Record the result as turbidity in JTU.

OPTIONAL PROCEDURE (if secchi disk assembly is available):

1. Be sure the secchi disk assembly is secure (the rope will not slip out from the disk).
2. Stand directly over the water to be tested. Be careful not to step on the bottom of the pond or otherwise disturb the water surface or bottom.
3. Carefully lower the secchi disk into the water, making sure that the rope is perpendicular to the water surface at all times.
4. Stop when the secchi disk is no longer visible to you.
5. Remove the secchi disk and measure the length of rope that got wet. If you could see the disk resting on the bottom of the pond, record "bottom."

DATA/RESULTS:

What is the JTU rating you observed? _____

If you used the secchi disk assembly, at what depth was the disk last visible? _____

Additional observations:

Record anything that you think might affect the results: foreign objects in the sample, location the sample was taken, weather etc.

DISCUSSION:

Which factors do you think affect the turbidity of the water source you tested?

What are the effects of a high turbidity on plants and animals living in the water you tested?

What are some potential sources for experimental error in this test?

Water Quality Assessment: Master Data Sheet

After all groups complete all six tests as well as the aquatic invertebrates assessment, you will combine all data collected for your particular test site. You will do this in order to calculate averages for your data. Record your testing site's average scores for each measure in the data sheet below. Also, record any observations that you think might be important. This will help you think about the "health" of the water you tested.

Test	Average Measurement	Additional Notes
Freshwater Invertebrates	<i>Excellent</i> <i>Good</i> <i>Fair</i> <i>Poor</i>	
Temperature	Air: _____ °C Water: _____ °C	
pH	_____	
Phosphates	_____ ppm	
Nitrates	_____ ppm	
Dissolved Oxygen	_____ % sat.	
Turbidity	_____ JTU _____ cm (optional)	

DATA ANALYSIS

(Adapted from the Farallones Marine Sanctuary Association's Coastal Ecosystem Curriculum, 2002, www.farallones.org; Edited by Taus and Rudd)

Graphs

You will need to interpret the data you collect in order to characterize the water quality of the Rodeo Lagoon and Pond. The first steps towards successfully completing this process are to compile your school's data.

Organizing the *raw data* will allow you to identify any existing patterns, and to understand the relationship between current levels of water pollutants. To better visualize the data, you should begin by graphing the data. These graphs can be produced on the computers, but you may also make graphs manually using the data your class collected.

You can choose what your graph will depict. You might choose density of aquatic macroinvertebrates, pH levels, temperature versus dissolved oxygen, or other factors you measured and recorded.

Your teacher will direct you how graphs will be used in your analysis of the data you collected.

Statistics

A critical part of scientific investigation is statistical analysis. Statistical tests evaluate significant differences or similarities between data. They are used to draw conclusions about the patterns in the data with a higher level of confidence than using simple visual analysis. One can measure a phenomenon in nature, but the phenomenon can be due to chance variation, and not representative of actual conditions.

For example, if you flip a coin 10 times, your actual results can differ from the expected 5 heads and 5 tails. Likewise, when sampling a sand crab population, you could not be 100% certain of the actual conditions unless you were to census every crab. Statistical analysis allows us to estimate with 95% certainty ($P < 0.05$) what is happening in the natural environment. A common factor in statistical tests is to compare your results with the *null hypothesis*, which assumes there is no effect or difference due to the conditions in your study. Scientists look for a difference between their data and the null hypothesis, and represent that difference with statistical calculations such as *Chi Square*.

Your teacher will direct you if you are to perform statistical analysis on the data you collected.

General Discussion Questions

(Taus)

The discussion section of a professional lab report is where scientists begin to make inferences about what they observed and start to draw conclusions from those observations. Professional scientists normally start their formal discussions with a short summary of their findings. Then they draw inferences and interpret their results. In your discussions, you may include your interpretation of the data you helped to collect, as well as questions that came up during the experiment (even if you don't have answers to them) and commentary on the limitations or weak points in your experimental design. You can also suggest possible future avenues of research that might be able to clarify or build upon the findings in this study.

In most scientific studies, the discussion section is also the place to state whether a scientist has answered the scientific question, or hypothesis, set out at the beginning of the study. Because the water quality assessment at this stage is concerned with collecting observational data, and not as concerned with determining the effects of a single variable in a controlled experiment, this feature of the discussion is not as applicable.

The following are some possible points to address in your discussion of the water quality assessment you have completed:

- What can you safely conclude from the study? Do the data tell us something important about the water in Rodeo Valley?
- Overall, does the quantitative data you collected agree or disagree with the biological invertebrates assessment you conducted?
- How do the data compare between water sources upstream and downstream? Does the data differ between pond and lagoon habitats? If the data is not consistent with previously collected data, why do you think it is not consistent? If your data is different from data at different sites, why do you think it is different?
- From what you know of the history of Rodeo Valley, what factors do you think are most influential in determining the results of your assessment? In other words, can you identify possible sources of pollution that might affect the water's pH, temperature, turbidity, and NO_3 and PO_4 levels? Think about the following things:
 - History of land use
 - Presence of roads and buildings
 - Sewage treatment plants and septic systems, as well as the type of sewer system
 - Use of fertilizer in surrounding areas
 - Nearby barnyards and agricultural fields
 - Local geology
 - Presence of blue-green algae
 - Presence of vegetation in and around the water source
- What from this study can you apply to your own neighborhood? How would your own water quality compare to the water quality in Rodeo Valley?
- Are there limitations or weak points in the study? How would you improve your study's design?
- What might a scientist's next step be -- further research, different studies, or more questions?

Your teacher will direct you as to how you will present your discussions of the water quality assessment.

REFERENCES

Constantino, R. 2003. Gully Incision in Gerbode Creek, Rodeo Lagoon Watershed. Water Resource Center Archives, UC Berkeley, 1-24.

<http://www.earthforce.org>

<http://www.forks.wednet.edu/wvc/cadre/waterquality/waterLesson.htm>

<http://www.lamotte.com>