Water Education For All
Lesson: Watersheds and Pollution
Middle and High School

Time: 3-4 hours (plus additional time for student research and sampling as needed)

Objectives:
- Define common water quality monitoring parameters
- Collect water samples from a body of water in students' watershed
- Analyze data to communicate the significance of water quality results
- Describe the connections between results, possible sources of pollution, and pollution reduction methods

Driving questions:
- Who is responsible for clean water?
- How do human activities affect water quality?
- How can humans monitor and minimize water pollution?
- How does water quality impact ecosystems?

Standards alignment:

NGSS Standards: Middle School (6-8)
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. (MS-ESS3-3)

ESS3.C: Human Impacts on Earth Systems. Human activities have significantly altered the biosphere. Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

NGSS Standards: High School (9-12)
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. (HS-ESS3-4)

Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (HS-ESS3-6)

ESS3.C: Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Science Words:

average
anoxic
bioassessment
coliform
dissolved oxygen
drought
E. coli
ecosystem
eutrophication
monitoring
nonpoint pollution
nutrients
ocean acidification
parameters
pathogens
pH
point source pollution
pollution
runoff
sediments
stormwater
turbidity
water quality

Materials:

- Computers with Internet access
- Water quality monitoring test kits- see references to learn where you can order kits & more information
- Water quality monitoring test probes, if available
- Copies of the water quality students worksheets (one per group)
- Other materials as instructed if students are completing extension activities

ENGAGE

Teachers can use the following information to spark students' interest in water quality and its implications for the natural world. Water quality can impact careers, recreational activities, health, and other aspects of our life.

Dirty Water Affects Everyone

All living things need water to survive. When the physical, chemical, and biological components of the water are altered, it may cause ecosystems to become unhealthy. Water quality monitoring is a tool people can use to investigate different environmental parameters in water. Using data collected during the water quality monitoring process, we can learn what is causing an unhealthy ecosystem. For example, high levels of nutrients (i.e. lawn fertilizers that are washed into rivers and streams with the rain) can cause an algal bloom, leading to low dissolved oxygen levels that make it impossible for aquatic plants and fish to survive. Everything in an ecosystem is connected; if one component is disrupted, there may be lasting effects for the whole system.

The presence or absence of certain creatures can also give you insight about the water quality in their habitat. Scientists have identified certain bacteria as indicators of water pollution. If these bacteria are present in a body of water, chances are that water may be polluted. For example, coliform bacteria are used as an indicator that human or animal feces are present in the water. This water quality monitoring approach is called bioassessment.

Water pollution can cause detrimental effects to human health. For example, storm drains, unlike sewers, send water to the ocean without treatment. Runoff-- water that runs off the land when it rains, carrying our pollutants with it-- is the number one water quality threat in San Diego. Runoff pollution in the ocean leads to increased risk of viral infections, sinus and ear problems, fever, flu, skin rashes, and viral diseases (such as hepatitis) for those who swim in the ocean close to storm drain outfalls. These risks are only magnified following a rainstorm, when litter and contaminants from the streets are flushed through the storm drain system and into the ocean. This is why San Diego residents are advised not to swim in the ocean for the first 72 hours (3 days) after it rains.

Laws to Protect Our Water

Clean water is a human right. In the United States, there are several laws that protect water from pollution.

The **Clean Water Act (CWA)** is the primary federal law in the United States governing water pollution. Passed in 1972, the objective of the Federal Water Pollution Control Act-- commonly referred to as the Clean Water Act (CWA)-- is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This is accomplished by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works (POTW) for the improvement of wastewater treatment, and maintaining the integrity of wetlands. The Congress passed the Clean Water Act to protect all “navigable waters of the United States.” To this day, the Clean Water Act remains the primary tool used to protect our nation’s waters.

San Diego Watersheds

A watershed is an area of land where all the water drains to the same place. Water from rainfall, snowmelt, or urban runoff travels from the top of our mountains, through cities, and eventually into larger bodies of water downhill and downstream. A watershed’s boundaries are defined by natural topographic features, like mountains and valleys, rather than man-made features.

San Diego County has 11 coastal-draining watersheds:

1. San Juan
2. Santa Margarita
3. San Luis Rey
4. Carlsbad
5. San Dieguito
6. Penasquitos
7. San Diego River
8. Pueblo
9. Sweetwater
10. Otay
11. Tijuana

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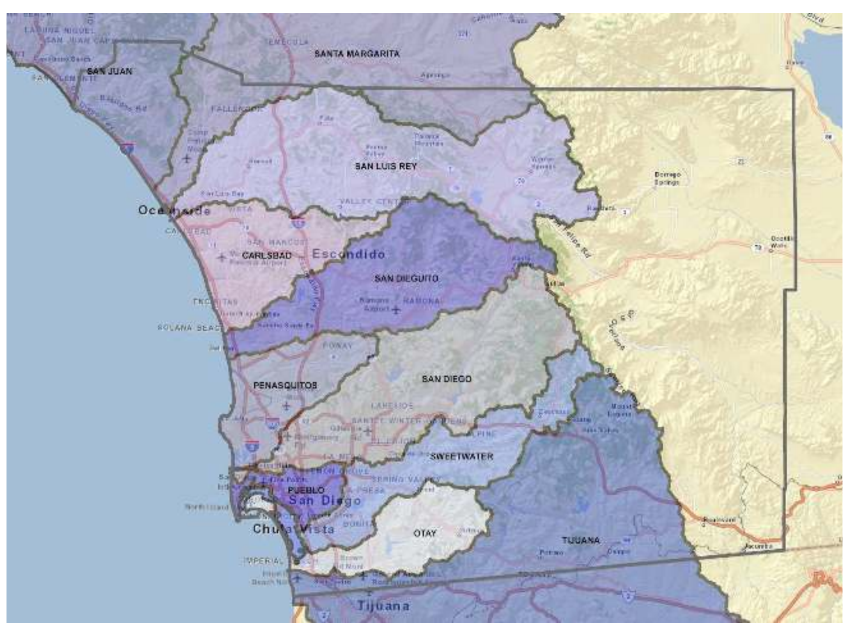

Pollution Sources

In San Diego, urban runoff pollution is the biggest threat to water quality. When it rains, high concentrations of pollution are collected by rainwater, travel into storm drains, and flow untreated into the ocean. Due to the pollutants contained in urban runoff, San Diego beachgoers are advised to avoid swimming in the ocean for the first 72 hours (3 days) after it rains. Sometimes it is difficult to determine the origin of pollution, which is considered nonpoint pollution. This cannot be traced back to a single point of origin. Examples of nonpoint pollution include car oil, pet waste, car soap, fertilizers, pesticides, trash, sediments, etc.

Sometimes, water is polluted by businesses or sewage spills, which have more clearly identifiable origins. This type of pollution is known as point source pollution. Since point source pollution is easier to trace, it is easier to enforce laws to make the responsible parties stop pollution.

Regardless of where we live, our daily activities can carry pollutants from our homes, businesses, and schools into our storm drain system and, eventually, our ocean. Some pollution happens unintentionally, while other times, people and businesses are aware that they are disposing of trash or chemicals illegally. Everyone lives in a watershed; therefore, human activities will always impact our bodies of water. Although humans will impact our environment in some way, we can also take actions to reduce that impact and help keep our water clean.

YouTube video: “The Scoop on Stormwater” by the U.S. EPA

Water Quality Monitoring

According to the U.S. Environmental Protection Agency (EPA), *human health ambient water quality criteria* are numeric values that limit the amount of chemicals that should be present in our nation's waters. These criteria are described in Section 304(a) of the Clean Water Act of 1972.

Water quality criteria are developed by assessing the relationship between pollutants and their effect on human health and the environment. These criteria are used by states and Native American nations to establish water quality standards and ultimately provide a basis for controlling discharge of pollutants.

Water Quality Monitoring at San Diego Coastkeeper

From 2008 to 2018, San Diego Coastkeeper ran the largest volunteer-based freshwater water quality monitoring program in the state of California. Coastkeeper’s Water Quality Monitoring Program trained hundreds of San Diegans in watershed health, sample collection, and laboratory analysis. Every month, these volunteers visited 34 sampling sites across 9 of San Diego’s watersheds, generating thousands of data points over the course of the program. At these sites, volunteers took readings, made observations, and collected water samples that were then analyzed in Coastkeeper's water quality laboratory.

During its 10 year tenure, the Water Quality Monitoring Program created a pathway for interested residents to understand their local watersheds. The data told the story of each sampling location to help residents understand the health of their local waters. The dataset also served as a powerful tool to track sources of pollution, and to address gaps in monitoring caused by limited government resources.

Water Quality Parameters

The following are some parameters to test water quality:

1. **pH-** Measures how acidic or basic a liquid is. Levels around 6 or 7 are considered normal for freshwater; when pH levels are too acidic or too basic, the ecosystem is affected and may suffer serious damage.
2. **Conductivity-** How well the water conducts electricity is an important indicator of salts dissolved in the water. Clear water indicates low levels of dissolved solids and generally does not conduct electricity. Murky water typically has a higher concentration of dissolved solids and conducts electricity.
3. **Dissolved oxygen (DO)-** Measures how much oxygen is dissolved in the water; this is what fish breathe with their gills. A normal level of dissolved oxygen is around 8 or 9. When the dissolved oxygen levels are below 5, the oxygen is too low, resulting in an unhealthy watershed. Low dissolved oxygen levels are often caused by algal blooms, which may be the result of excess nutrients (eutrophication) in bodies of water. Eutrophication occurs when an area's runoff contains lots of fertilizers, which is an especially large problem in areas with lots of agriculture.
4. **Water temperature-** Temperatures too high or too low can cause stress for aquatic organisms. In cases where temperature changes are severe or long-lasting, some organisms may not be able to survive. Such events can cause major disruptions of the food chain in an area. Temperature also directly affects other variables, such as dissolved oxygen.
5. **Turbidity-** Measures the cloudiness or haziness of the water. High turbidity is usually caused by an excess of particles in the water. Turbidity may also indicate the presence of other pollutants, acting as an indirect water quality indicator. For example, high turbidity levels may indicate some of the following water quality issues:
    - algal blooms- generally lead to low levels of dissolved oxygen (DO) and in extreme cases, dead zones
    - excess sediments- sand, silt, or soil suspended in the water (which might originate from erosion or dredging)
    - waste discharge and/or urban runoff

Turbidity also affects light penetration, presenting problems for plants and algae that photosynthesize. Since aquatic plants depend on sunlight to produce their own food, high turbidity can limit their growth. In turn, this affects the animals that eat and live on the plants.

Additional in-lab testing required for:

1. **Nutrients**- high levels of nitrate, ammonia and phosphorus can be detrimental to water quality. Excess nutrients can come from agricultural fertilizer or manure, runoff, sewage spills, pet waste, detergents, soap, and fossil fuels. High levels of nutrients can cause detrimental effects in aquatic life. While nutrients are important in ecosystem functioning, an excess can cause rapid growth of algae (algal blooms), massive algal die-offs, and then a reduction in dissolved oxygen levels. Without oxygen, fish and other wildlife cannot survive.

2. **Bacteria-** the concentration of specific bacteria in the water can indicate if a sample has been contaminated with fecal matter. Two of the more common methods detect the presence of ***E. coli*** and *Enterococcus* bacteria, which come from warm-blooded animals. We use two tests for indicator bacteria:

    - *Colisure,* designed to test for the presence of *E. coli.*
    - *Enterolert,* designed to test for *Enterococcus*.

    E. coli is the preferred indicator for freshwater ecosystems, whereas *Enterococcus* is the preferred indicator for saltwater ecosystems. These bacteria serve as **indicator bacteria**, so they serve as proxies for pollutants like feces or toxic chemicals. If exposed to water with these bacteria, swimmers can develop infections and become sick.

    For both tests, the samples are given growth media. The growth medium consists of a mixture of nutrients to help bacterial samples grow and a chemical that reacts with bacterial metabolites. This reaction is what scientists look for to determine the presence or absence of indicator bacteria.

    Assessing the results of the two tests requires different methods. The colisure test will display a bright purple color and fluoresce under UV light if there is *E. coli* present. The enterolert test will glow under UV light if *Enterococcus* is present. See the pictures below for examples of positive colisure and enterolert tests.

EXPLORE

Options for exploration activities:

- If water quality test kits are available, students may collect samples from a nearby waterway. Teachers may also choose to collect samples for testing later that day. The **Water Quality Sampling** activity below gives some outlines for how to do this. This activity is not required, but highly recommended. To learn more about borrowing free student water quality test kits from San Diego Coastkeeper, contact education staff at https://www.sdcoastkeeper.org/contact.
- If students are not able to collect samples directly, they may use water from their classroom tap. Alternatively, they can use the **Water Quality Data Analysis** activity below to analyze San Diego Coastkeeper water quality data from freshwater sources.
- In place of sampling directly, students can use online resources or data sets to research the water quality of their watershed.

Water Quality Sampling (optional)

Note: Student Field Data Sheet for water quality testing is available at the end of the lesson.

Before Sampling

Prior to visiting the site, the teacher should:

- Check the weather and tide conditions (if applicable).
- ALWAYS visit the area BEFORE taking your class to make sure it is safe and that the water body is accessible for testing.
- Evaluate potential hazards such as steep terrain, slippery areas, and trash.
- Make sure you have enough copies of the student field data sheet (one per group plus extras), water quality kits, and/or other equipment for each group.
- Read through all test procedures and, if time permits, pilot each test with tap water. This will allow time to work through any confusing instructions and work out timing or equipment needs before your sampling day.
- Bring a resealable container to store your water samples and chemicals. Do not leave the water samples in the field; many of the samples have special disposal procedures.
- Bring supplies to clean up trash (if possible): gloves, trash bags, and trash grabbers. This is a great opportunity to engage students in direct stewardship of their waterways by cleaning up litter!

The day before the field trip, share with your students the following safety tips:

- Wear closed toe shoes, a hat, sunscreen, and sunglasses.
- Work with your team (safety in numbers). Be respectful and clear in your communication; this is important when collecting data because you want to record correct data.
- Look out for safety issues (i.e. glass or rusty debris, slippery or steep terrain, dead animals, etc). Make others aware of any hazards present.
- READ the instructions of the equipment BEFORE using it.
- Don't leave trash behind.
- Don't drink/eat any of the chemicals you are using. Use protective gloves and goggles, and always wash hands before touching your face or eating.

* Don’t touch any sharp/unsafe objects.
* Clean up and dispose of your chemicals and/or water samples in the disposal container designated by your teacher. When you get back to school, dump the samples in a sink or toilet (unless otherwise instructed by the test kit manual). DON’T throw it in a body of water or storm drain!
* Make sure you bring all equipment, data sheets, and personal belongings with you after you finish testing. Leave the site cleaner than you found it.
* Make sure all team members are together before leaving the site.

Before the team begins collecting data, make sure each person on the team has a role. You can assign the following student roles:

1. Data collector: Completes the student field data sheet with the water quality data.
2. Water sample collector: Collects the water sample. If you are testing more than one site, you can assign more than one water collector per group.
3. Sampling lead: Helps keep team on track and task.
4. Time checker: Keeps time for each test according to instructions (e.g. DO will take about 9 minutes to shake the sample and wait for color development) while the others can rotate to take the water sample and add the test tablets for each test.
5. Field water quality technician: Tests a water quality parameter (e.g. air temperature, water temp, etc.). Students may rotate through this role for different water quality tests.
6. Field observer- Observes the conditions of the site. The field observer may take pictures or draw observations of the sampling site (e.g. green algae on water surface, storm drain runoff, etc.). If possible, this person should also identify and document any natural (e.g. erosion, low water level, low/high tide, etc.) and human impacts (e.g. animal/pet waste, factory outlet discharge, trash, etc.) to the site.

During the Activity

Students will work in teams of 4-5 to monitor water quality.

* Distribute materials- Give a clipboard, pencil, and a copy of the student field data sheet to each group. Be sure that you have all materials needed for the testing procedures. Consult the instruction manual of your test kits for directions and materials lists.
* Make observations- What are the conditions of the site? What temperature is it outside, and has it rained recently?
    * Take pictures or draw what you see (i.e. Green algae on the surface of the water, storm drain outfall nearby, etc).
    * What are the natural (erosion, low water level, low/high tide) and human impacts (animal/pet waste, storm drain outfall, trash) on this water body?
* Follow instructions from the water quality test kit manual to collect water and conduct tests.
* After testing, be sure to leave the site better than you found it. Take all trash with you and dispose of testing materials properly when back at school.

Water Quality Data Analysis

Download the San Diego Coastkeeper data set for the San Luis Rey and San Diego River watersheds. If you are unable to collect your own water samples in the field, you can use these data sets instead. You can also use this data set as a basis for comparing your own data collected from a local river or stream.

Data Sets

- What: Data collected from San Diego Coastkeeper's water quality monitoring program.
- Where: Two stations (sites) per watershed where water samples were collected.
- When: Two seasons (wet/dry).
- How: Each value is an **average** among 3 water samples collected at the same site and time.

About the Basin Plan

The Water Quality Control Plan for the San Diego Basin (Basin Plan) was created by the San Diego Regional Water Quality Control Board. The Basin Plan, which went into effect in 2016, established guidelines that waterways should meet to be considered healthy. Collecting samples is an important step to see if our waterways are adhering to or exceeding these guidelines. If our waters continually fail to meet these guidelines, this is a clue that pollution is affecting the ecosystem.

What does the water quality data tell us? Find out using the following guiding questions:

1. In the San Diego Coastkeeper data set, find the values that exceeded the Basin Plan guidelines (cells shaded red). Find the times of the year that correspond with the abnormal values.

    a. Why do you think these values were so abnormal during this time of year? What were the conditions like during sampling (e.g. weather or runoff events)? Is there a correlation between the time of year, weather, and the abnormal values?

    b. If you collected your own samples, compare the results to the normal values (Basin Plan guideline values) using the table below. Identify any parameters that exceeded the guidelines.

Water Parameter	**Basin Plan Guideline Value** *(healthy waters should be...)*
Dissolved Oxygen (DO)	≥ 5.0 mg/L
pH	6.5 - 8.5
Turbidity	≤ 5 units
Nitrates	≤ 1 mg/L
Ammonia	≤ 0.025 mg/L
Total Phosphorus	≤ 0.1 mg/L
E. coli	≤ 406 MPN/100mL*
Enterococcus	≤ 108 MPN/100mL*

**MPN, or Most Probable Number, refers to the concentration of bacteria in a given quantity of water (here, 100mL).*

2. The table below contains dissolved oxygen (DO) data from one sampling site in the San Diego watershed, collected twice a year from 2010-2015 (starting in the 2nd half of 2010).
    a. Tip: In the "season" column, a value of 1 denotes a sample taken during the wet season, and 2 denotes a sample taken during the dry season. The alternating 1s and 2s mean that samples were taken twice a year-- one during the wet season (winter) of 2011, the next during the dry season (summer) of 2011, the next taken during the wet season of 2012, etc.
    b. Tip: The cells shaded in red fall outside the Basin Plan guideline values for dissolved oxygen. Why do you think some of the cells in the table are shaded darker red than others? Refer to the Basin Plan guidelines table (above) and compare the values of both tables to see if you can understand the reason behind the color.
3. Use the table to create a bar or line graph of DO values at this site over time. Set up the graph so that the x-axis represents time and the y-axis represents DO values.

Site	Year	Season (1= wet, 2=dry)	Dissolved Oxygen
SDG-010	2010	2	5.19
SDG-010	2011	1	6.54
SDG-010	2011	2	2.84
SDG-010	2012	1	5.34
SDG-010	2012	2	3.55
SDG-010	2013	1	5.88
SDG-010	2013	2	4.72
SDG-010	2014	1	2.80
SDG-010	2014	2	0.37
SDG-010	2015	1	2.70
SDG-010	2015	2	3.30

4. Of these two variables (time and DO), which is the dependent variable and which is the independent variable? Why?

5. Using the table above, find the average for the dissolved oxygen values taken during (1) wet seasons and (2) dry seasons.
   a. Are the averages different between the wet and dry season? If so, why might there be a difference?
   b. You can use Excel or Google Sheets to calculate averages. In an open cell, write the "average" formula:
      = AVERAGE(cell 1, cell 2, cell 3)
   c. When you have included all the values you would like to calculate the average of, close the parentheses in your formula and click enter.
      =AVERAGE(D32,D34,D36)
   d. If you don't have access to a computer, you can easily use a calculator to find the average. Simply add all the values and divide by the total number of values.

6. When looking at the dataset as a whole, do you see any correlations among variables (i.e. dissolved oxygen and temperature)? Do any of the variables seem to increase or decrease together?
   a. Think about the reason that multiple parameters may increase at the same time. What could be causing this? If we know there is a relationship between two or more water quality parameters, how could that affect our approach to prevent pollution?

Note for educators: The darker red a cell is shaded, the more severely it fails to meet the guidelines of the Basin Plan. The severity of runoff pollution is higher in the wet season. With the more frequent rains of the wet season, pollution from the land is flushed through the watersheds and into our bodies of water, resulting in higher pollution levels. *Try to guide the students to this understanding rather than giving them the answer. They should try to figure out reasons for this correlation themselves first, and then you can help them if they're stumped.*

EXPLAIN

After students complete their data collection and analysis, they will examine correlations between water quality parameters as well as possible causes and solutions. Students will use their results and the following questions to (1) make a claim about what happened to the watershed they studied, and (2) pose a possible solution to minimize the problem. If the water body they tested had good water quality, they could discuss ways to prevent future pollution.

Group discussion example.
Our results showed the following:

- Algal blooms + low DO + high temperature.

Guiding questions

- Can you identify the probable source of pollution? What type of pollution is it: point or nonpoint?
- How could you reduce the impact of the pollution?
- Is there a government agency, university, or environmental nonprofit organization that could help you take action to solve the problem?
- Can you help educate the people in the community on how they can reduce pollution? What about industries or private companies?
- What new technologies could you implement to reduce pollution in this water body? (Example: treating polluted stormwater that discharges into the river.)
- Develop a cost-benefit analysis of a watershed with excellent water quality versus a watershed with poor water quality. Is the human activity causing more economic loss than benefits? What about the ecological cost? Explain.

Science Communication

After scientists collect data, they need to communicate their findings with the scientific community. They use a specific writing style and format to publish their results in science journals.

You can discuss your results using graphics and/or a table like the one below. Reference scientific journal articles or other reliable sources to write a conclusion explaining your results and what they mean about the water quality of your study site. If available, use other studies on the same topic or geographic area to compare your findings.

Water quality parameter	Observation in the field	Sources of pollution
Turbidity	amount of particles suspended in water how clear or cloudy the water appears	Sediments from construction sites Erosion or other causes that lead to high levels of particulate matter
Nutrients	High or low nitrate, ammonia, and/or phosphorus levels	Fertilizers- nitrates and ammonia Phosphates- soaps and detergents
Dissolved Oxygen (DO)	High or low DO levels	Agricultural runoff can cause algal blooms, oxygen depletion
Temperature	High or low temperature	Warm or cold water from nearby urban runoff, storm drains (i.e. water running off of a hot parking lot)
pH	High or low pH values	Chemicals in agricultural or industrial runoff, discharge of polluted stormwater or wastewater
Bacteria	High levels of fecal indicators	Pet waste that is not cleaned up Human waste- contamination of stormwater by faulty pipes or sewage spills

ELABORATE

The following activities can be assigned to small teams of 4-5 students to explore individual water quality issues in more depth.

Using evidence to support their claim, students will discuss possible reasons the water quality parameters are exceeding normal values. Students should also consider the best method(s) of monitoring and possible solutions to the pollution problems.

Scenario 1: Low pH
Students will develop a few pH experiments to understand the difference between acidic vs basic, its effects in water quality, and the impacts of ocean acidification.

1. Add a cup of vinegar in water, measure pH. Test the pH. Is this acidic or basic?

2. Add a tablespoon of baking soda to a cup of vinegar. Measure the pH. Did it change?

Your stream has a pH of 4.

- What will happen to the wildlife? What will be the challenge for plants or animals in an acidic environment?
- What could have caused the pH to drop?
- Can you give an example of how pH affects the life in a pond, river, and/or ocean habitat?
- What's the correlation between pH and CO_2? How does this relate to ocean acidification?

Scenario 2: High Nitrates

- What are some possible causes of high nitrate levels?
- What happens when we observe high levels of nutrients in the water? Is there any correlation between nutrients and other water quality parameters?
- Can you make a claim about how life is going to be affected by high levels of nutrients in a pond, river, and/or ocean?

Scenario 3: Low Dissolved Oxygen

- What could have caused low oxygen levels?
- How does the combination of low precipitation and high temperatures (e.g. drought) affect dissolved oxygen levels?
- How does eutrophication affect dissolved oxygen levels?
- Warmer water holds less dissolved oxygen. How might global warming affect dissolved oxygen in lakes, streams, and/or the ocean?
- What would happen to the wildlife in an anoxic (low oxygen) environment?

Scenario 5: Fecal Coliform Bacteria

- After it rains, how do the levels of coliform bacteria change in a stream? What could explain this change?
- How does fecal coliform bacteria present a health threat to the ecosystem and people?

Scenario 4: High Turbidity

- What could have caused high turbidity in a water body?
- How does turbidity affect aquatic plants and animals?

Optional: Make your own Secchi disk to test turbidity (directions below).

Building the Secchi disk to test turbidity

In this activity, the students will build a Secchi disk - which will help them to understand **turbidity**, how scientists measure it, and why it is important for water quality measurements.

Materials:

- Plastic or cardboard circle (8 in / 20 cm diameter, white if possible)- can be cut from the bottom of a 2 gallon white plastic paint pail, a yogurt container lid, or scrap cardboard
- Ruler
- Scissors
- Permanent marker
- Nylon rope
- Metal washer
- Black and white paint
- Duct tape

Creating the Secchi disk:

1. If needed, cut your base material into a circle 8 inches/ 20 centimeters in diameter.
2. Using images of Secchi disks from the internet, replicate the pattern with paint. Make sure the 4 shapes are equal in size; print and trace a pattern from online if needed. Let the paint dry completely.
3. Use a ruler to mark a dot in the center of your circle. Punch a hole through the center of the disk.
4. Tie a metal washer to one end of the rope. This will serve as the weight to help the disk sink.
5. Put the other end of the rope through the hole that you made in the disk. The black and white pattern of the disk should be facing towards you (away from the washer).
6. Starting from the disk, measure and mark every meter of rope with a piece of tape. If you are sampling a shallower site, you may decide to mark a smaller interval (i.e. every 0.5m).

Using the Secchi disk:

1. Find a site to sample. The best sites are streams, creeks, rivers, or lakes with as little running water as possible.
2. Hold the end of the rope opposite the disk. Slowly lower your disk straight down into the water. Stop when you can't see it anymore. Record the depth by using your tape markings.
3. Raise the disk until you can see it again. Carefully measure the depth again. It should correspond to the place where the rope breaks the surface of the water.

4. Retrieve your Secchi disk.
5. Average the first and second depth measurement. This is your Secchi reading.

The disk can be used from piers and vessels, under any weather condition, as long as there is natural light. It is harder to use the disk during high wave or current action. Observe and record the water and weather conditions during your sampling.

EVALUATE

Students will present their results to the rest of the class and suggest possible solutions to pollution in their watershed. They can include graphics and/or infographics, use their own data and/or San Diego Coastkeeper's data, and outside water quality monitoring data (from media, government agencies, nonprofits, universities or other reliable sources) to support their evidence.

Students should address the following ideas:

- What water quality parameters did you test/analyze?
- What were your results? How did they compare to the Basin Plan values?
- What could have caused the levels of water quality you observed (types of pollution, sources, etc)?
- What impacts will this have on the ecosystem?
- Are there any other tests would you include in your monitoring program in the future? Discuss why.
- What is the economic, ecological, and social impact of poor water quality?
- Why is monitoring water quality important?

SAN DIEGO COASTKEEPER

Student Field Data Sheet

Name:

Date: Location:

Time: Air temperature:

Parameter	Site 1	Site 2	Site 3
Water Temperature			
DO			
pH			
Turbidity			
Nitrates			
Phosphates			
Ammonia			
Fecal coliform bacteria			

References

California State Water Resources Control Board (2004). pH Factsheet. Retrieved from http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/3140en.pdf

Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. (2013). Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems. *Nature Education Knowledge* *4*(4):10. Retrieved from https://www.nature.com/scitable/knowledge/library/eutrophication-causes-consequences-and-controls-in-aquatic-102364466

Environmental Protection Agency (2017). *Polluted Runoff: Nonpoint Source (NPS) Pollution*. Retrieved from https://www.epa.gov/nps

Environmental Protection Agency (2018). *Human health water quality criteria and methods for toxics*. Retrieved from http://water.epa.gov/scitech/swguidance/standards/criteria/health/

Environmental Protection Agency (2018). *Water quality criteria*. Retrieved from https://www.epa.gov/wqc

Marshack, J. B. (2012). *Water Boards Training Academy Course WQ120: Water Quality Goals* [PowerPoint presentation]. Retrieved from https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/training/class_slides.pdf

San Diego Coastkeeper (2018). Bioassessment: the bugs tell the story [Blog post]. Retrieved from http://www.sdcoastkeeper.org/blog/toxic-waters-in-san-diego/item/442-bioassessment-the-bugs-tell-the-story.html