



Bridging the Watershed
An Outreach Program of the Alice Ferguson Foundation
in Partnership with the National Park Service and Area Schools



URBAN POOLS

An Exploration of the Management of the Abiotic, Biotic, and Cultural Components of Urban Pools

National Mall and Memorial Parks



Reflecting Pool



Constitution Gardens



Simon Bolivar Pool

NPS RANGER FIELD STUDY GUIDE

Bridging the Watershed

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National Mall Interpretive Program

Themes	
Green Team	<i>Urban Pools Module</i>
American history and culture are forever shaping and being shaped by this country's natural resources.	The use and management of water in the parks in the District of Columbia are reflections of the enduring and evolving relationship between humans and nature.

Goals	
Green Team	<i>Urban Pools Module</i>
The historical and cultural stories of the National Mall are incomplete without the natural story. The goal of the Green Team is to uncover these interconnected stories and provide opportunities for visitors to examine each individual's place in the natural world—not only within the biologically, ecologically, or geologically spectacular "natural gems" of the National Park Service. Through the interpretation of the Mall's unique urban natural resources, visitors may be inspired and provoked to connect to and examine their roles and responsibilities in various natural cycles, both within the National Park Service and in their home communities.	Students will come to a deeper understanding of our human connection to water, not only through the study of three urban pools in Washington, D.C., but also through the study of how water has been used and managed throughout history in several different cultures.

Objectives
Students will collect water quality data from at least two of the Mall's urban pools and compare that data with current management plans.

Universal Concepts	Tangibles	Intangibles
life death beauty human relationship with nature control intentions adaptability limits inspiration timelessness change	water pools plants animals granite marble concrete inscriptions (on Signers' Island)	reflection stress relief aesthetics development management natural cycles food webs sounds and smells

URBAN POOLS CURRICULUM DESIGN				
Title	Lesson 1	Lesson 2	National Mall	Lesson 4
	Urban Pools in History	Freshwater Ponds as Homes	Field Study	Designing a New Urban Pool
Enduring Understandings	<p>Water is a natural resource that humans incorporate into their personal lives and communities.</p> <p>Humans have the ability to manipulate the inputs to achieve aesthetic qualities in urban pools.</p>	<p>A pond is in balance when its biotic needs are met by the pond's abiotic conditions.</p> <p>Humans can correct an out-of-balance pond using a combination of natural and/or artificial corrective measures.</p>	<p>National parks preserve natural and cultural resources.</p>	<p>Urban pools require considerations of aesthetic desires, abiotic/biotic realities, and human resources.</p>
Essential Questions	<p>How has water been used and managed throughout history in different cultures?</p>	<p>What kinds of plants, animals and inputs are required to maintain balance in a pond?</p> <p>What can humans do to help correct a pond's balance?</p>	<p>How does the use and management of urban pools affect the relationship between humans and the environment?</p>	<p>What considerations are necessary to create and maintain desired water quality?</p>
Performance Tasks Students will:	<p>Complete a graphic organizer describing the characteristics and vital data for four urban pools throughout history.</p> <p>Brief Constructed Response (BCR): Compare and contrast the A, B, Cs of the four urban pools discussed in the readings.</p>	<p>Identify abiotic and biotic characteristics of freshwater ponds that create in- or out-of-balance conditions.</p>	<p>Collect water quality data at two or three urban pools.</p> <p>Compare water quality data collected with management plans described by NPS rangers.</p>	<p>Design and draw a fictitious memorial and pool for the National Mall.</p> <p>Determine water quality necessary to maintain aesthetic features.</p> <p>Outline management plan to maintain desired water quality.</p>


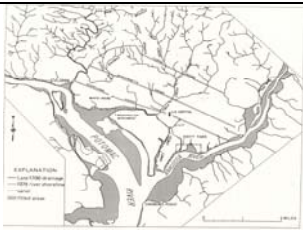

Urban Pools: Field Study at the National Mall

Objectives

Students will:

- collect weather data for day of the field study.
- record latitude and longitude at each site using a handheld GPS unit.
- collect observational data about each site.
- conduct water quality testing at each site.
- compare their water quality data to ideal data and current management.

Posters Needed

		
Satellite Photo of Chesapeake Bay Watershed	Former Potomac Shoreline and Filled Areas	Map of National Mall or Mall Brochure

Student Materials Needed

Student Field Study Guides

Clipboards

GPS units

Thermometers (to measure air and water temperature)

Water quality test kits for

- dissolved oxygen (DO)
- nitrates (NO₃)
- orthophosphates (PO₄)
- turbidity

Waste-water container

Distilled water

Outline of Field Study Activities

1. Greeting and Important Administrative
2. Introduction to Field Study
3. Gather General Information
4. Site 1: Reflecting Pool
5. Site 2: Constitution Gardens Lake
6. Site 3: Simon Bolivar Memorial Pond (if time permits)
7. Data Comparison and Reflection
8. New (student-designed) Memorial

continued on next page

Urban Pools: Field Study at the National Mall, *continued*

Greeting

Bus will drop students off behind the Lincoln Memorial on Daniel French Drive. Meet bus and confirm with teacher and bus driver departure time and location. The bus may spend the duration of the field study parked along Virginia Avenue between 17th and 18th Streets NW. When appropriate, students can retrieve their lunches from the bus.

Provide time for students to use restroom facilities and gather on steps of the Lincoln Memorial.

Personalize the experience as much as possible. Introduce BTW/NPS staff and ask everyone's name, even though you may not remember all of them. Ask if there are any questions before the field study begins.

Discuss safety issues and give students an idea about field study time frame and WHEN THEY CAN EXPECT TO EAT LUNCH.

Introduction To Field Study

The introduction will require some forethought and time to create. It is a weaving of:

- the cultural/historical interpretation of D.C. and the National Mall,
- how urban pools, in general, relate to the Potomac watershed,
- assessment of students' background knowledge, and
- expectations during the field study.

It is also important to determine amount of time spent on each activity, and adjust accordingly if bus arrives late or students need to leave earlier than expected.

Interpretive points for this introduction can be found in the "Background Information" section at the end of this guide. These are only suggestions, but they provide some of the important points that can be woven into the introduction.

This field study is a core component of the *Urban Pools* curriculum module. It puts scientific concepts learned in the classroom into context by applying concepts to the real-world and collecting and analyzing meaningful data.

Posing questions to students will help to assess students' background knowledge. This will help you adjust your facilitation to meet student understanding.

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Urban Pools: Field Study at the National Mall, *continued*

Introduction To Field Study (continued)

The “Chesapeake Bay from Space” poster can help students put their classroom lessons in context and find their location in the watershed.

Possible outline and questions for students:

1. Ask students what the colors indicate on poster, and ask students to locate the Potomac River.

2. What body of water does the Potomac River flow into? *Chesapeake Bay*

3. What is a watershed?
See “Background Information” for detailed explanation.

4. Tell students that the “Chesapeake Bay from Space” poster represents the Chesapeake Bay watershed and within that watershed is the Potomac watershed.

Potomac River is 382 miles long, its watershed is 14,670 sq miles, average flow into the Chesapeake Bay is 4,000,000,000 gallons/day, and over 5,000,000 people live in the Potomac watershed.

5. Point out the brown portion in the Potomac River on the poster and ask students what they think it is and how it occurred.

The brown color in the water is suspended sediment caused by runoff from rain that occurred closer to the river’s source. It’s a good example of runoff and sedimentation

6. How difficult would it be to control what flows into the Potomac River?

The question is intended to get students to ponder the bigger picture. Use it to segue to human-made urban pools. They will have an opportunity to see how difficult it is to manage urban pools. Ask them to think about the entire Potomac watershed and how each and everyone living in it affects its health.



Chesapeake Bay Watershed

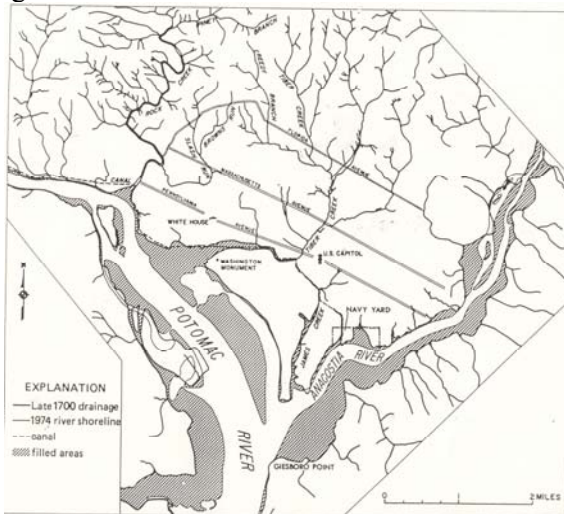


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Urban Pools: Field Study at the National Mall, *continued*

Introduction To Field Study (*continued*)

7. The map of the Former Potomac Shoreline and Filled Areas (below) will help students understand how water shaped and influenced the city. Help orient students to the map and ask them if they would have been standing on land 200 years ago.



Former Potomac River Shoreline and Filled Areas

8. At this point, an interpretation of the reclamation project that extended Pierre L'Enfant's 1791 original plan for Washington D.C. is appropriate (i.e., interpretative points can be found in the "Background Information" section at the end of this guide). Conclude with a brief summary of the purpose and symbolism of the memorials that were built on this reclaimed land and the landscape designs that surround them. This will set the stage for the post-field study classroom lesson in which students will choose an event or person they think worthy of a new memorial and then design a memorial and urban pool.
9. Use a large map of the park or hand out park brochures as you orient students to the park. Show them the sites they will study.
10. Form groups and distribute materials. (Group size is dependent on number of students and equipment.)
11. Begin site study and data collection. Be aware of time and always tell students how much time is allotted for each activity.

continued on next page

Urban Pools: Field Study at the National Mall, *continued*

Gather General Information

On page 2 of the Student Guide is a chart to record general information and weather data. It should take about 10 minutes to complete. Some instruction may be necessary to use the GPS unit. The latitude and longitude should not change for field studies, and, if time is a factor, coordinates can be given to students.

Thermometers are part of the water quality testing equipment; use them to find air temperature. To determine cloud cover, circle the percent of the sky that is covered with clouds.

Site 1: Reflecting General Information

To engage students and refresh their memories, ask questions about the Reflecting Pool. Students (should) have completed Lesson 1 of the curriculum module and; therefore, have prior knowledge about the Reflecting Pool. Also, descriptions of the three urban pools they will study are in the Student Field Study Guide.

Gathering “Observational Data” can be done as a group with ranger guiding questions. It might be worthwhile to spend some time beforehand talking with other park staff to become acquainted with current conditions of three pools students will study.

Next, student groups should collect abiotic data (e.g., temperature, DO, NO₃, PO₄, and Turbidity). It is helpful to periodically tell students amount of time left to complete testing.

When students finish, group should compare results. Determine an average for each parameter and compare student data to ideal conditions and actual management values. (Note: Management procedures may change. Check with Natural Resource Manager for current management.)

Proceed to Site 2: Constitution Gardens Lake

continued on next page

Urban Pools: Field Study at the National Mall, *continued*

Site 2: Constitution Gardens Lake

Follow the same basic procedure completed at the Reflecting Pool. The following information is provided to supplement background information.

The bacterial and chemical algal controls used in the Reflecting Pool are used here as well. There was an attempt to take natural “muck” from Kenilworth Aquatic Gardens and use it to cover the bottom of Constitution Gardens Lake in the hopes that the muck would contain algae-eating zooplankton. The attempt was not a failure, but it had minimal impact. The water in the lake is D.C. drinking water that is chemically treated to remove additives harmful to fish. Bubblers add oxygen to the water. This water does not drain directly into D.C. storm sewer drains.

The purpose of Constitution Gardens was to create a peaceful, natural space in the heart of the city and to produce additional water surface for the reflection of the Washington Monument. The curving lines of Constitution Gardens Lake and planter boxes, that extend from the island and are filled with cattails, contribute to the natural appearance and attract various wildlife species. Creating a more natural pond should reduce management costs.

Site 3: Simon Bolivar Memorial Pond

The Simon Bolivar Memorial Pond will be used as a check for understanding. If time permits, ask students to predict the results of their chemical data before data collection at Bolivar’s pond begins. Students can use data they collected at the Reflecting Pool and Constitution Gardens Lake as a basis for their predictions.

The following information is provided to supplement background information. The six jets no longer spray. Instead, the pool has been filled with planter boxes of emergent aquatic vegetation and inhabited by red-winged blackbirds. In addition, students will most likely see ducks and fish.

The idea to manage an urban pool in a more natural manner started here. A man named John Hoke made a big push in the 1970s to take the forlorn, trash-filled Bolivar pond and fill it with lily pads and turtles. It was a big hit, and the same technique was used at Constitution Gardens Lake. It seems that the koi are a fairly recent addition—an idea that is going out of favor with the new push towards encouraging native species and removing exotic ones.

Since cost of maintenance is an important consideration, the cost of conversion to a more natural state reduced the cost of maintenance from \$4,000 to \$1,500 per year.

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Urban Pools: Field Study at the National Mall, *continued*

Data Comparison and Reflection

During the walk to Constitution Gardens Plaza for reflection, point out the Old Lockkeeper's House on Constitution and 17th Street to remind students of Washington, D.C.'s watery past. Tiber Creek once flowed freely to this point, where it met the original shoreline of the Potomac River. In the 1800s, Tiber Creek was canalized. The Washington Canal connected the S.W. Waterfront, the Capitol, and the White House and ultimately connected with the first lock of the C&O Canal in Georgetown. The Washington Canal was eventually paved over to make Constitution Avenue. Water still runs beneath Constitution Avenue today.

An easy way to compare data is to have a poster-sized dry-erase board or writing tablet. If time is an issue, ask students to write their data on the table during lunch.

During the discussion, ask a member of each group to use their data to describe one of the urban pools they examined. When all of the groups have finished, or even throughout their descriptions, pose the first primary question:

- 1. Are there measurable differences in the water quality between the two/three pools?**
- 2. How does student data compare to ideal and actual management values?**
Ideal values for abiotic parameters can be found in the "Background Information" section.
- 2. Does the current NPS management support the intended purpose of each pool?**

Members of each group may have conflicting opinions, which is fine, but as they answer the question, encourage them to use the concepts learned in the pre-field study lessons to support their arguments. Encourage this by asking questions like, "How do you know that?" or "Why does that kind of input have that result?" The goal for this discussion (and the field study) is that students will develop a conclusion about the park and its resources using both the data they have gathered today and the background knowledge they learned in the classroom. Help students understand the historical, cultural, political, and/or managerial reasons for certain practices. Science is not the only consideration.

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Urban Pools: Field Study at the National Mall, continued

New Student- Designed Memorial

Finally, the post-field study classroom activity is introduced. Students will design the water element to be included in a fictional new memorial commemorating a person or event of their choice. The space should not be larger than 20 ft X 40 ft.

This activity will be completed in the classroom; however, students are encouraged to observe the surroundings and make any notes that they think may help later in their design.



*Aerial Photo of National Mall near Constitution Gardens
Area of Proposed New Memorial in White Block*

If there is extra time, students may want to explore the use of water in the WWII Memorial, adjacent to the Constitution Gardens Plaza.

*Students depart the park.
Bus pick-up on Constitution Avenue and 17th Street N.W.*



Background Information

Introductory Cultural/ Historical Interpretative Points

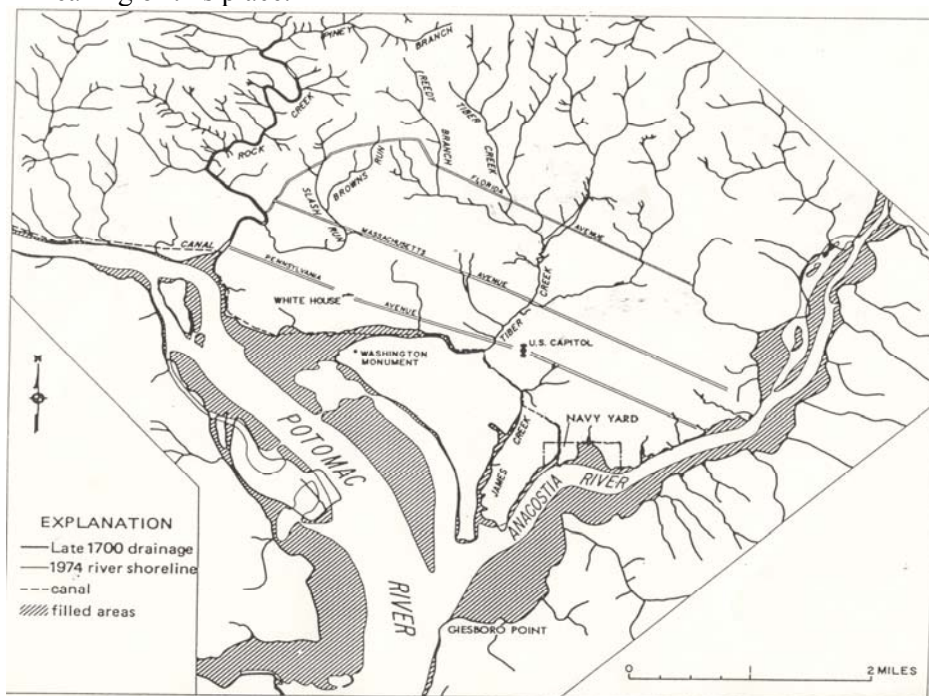
- 1 For purposes of transportation and survival, it was important for Washington, D.C. to be built along a river.
- 2 As President, George Washington was given the task to choose the exact location of the new seat of government. A political compromise between the North and the South determined that the South would assume the North's Revolutionary War debt if the new capital city was moved south from its northern placement in Philadelphia, Pennsylvania. The Potomac River was acceptable to both the Southern and Northern states. George Washington knew this particular stretch of the Potomac River quite well because his home (Mount Vernon) was only 14 miles downstream along the Potomac River shoreline.
- 3 The Chesapeake Bay provided shelter from the ocean, yet allowed ocean-going ships passage up the Potomac River to Washington, D.C. Also, the Potomac River was one of the only East coast rivers that had the potential to connect the Atlantic Ocean with the land west of the Appalachian Mountains. A series of canals were built with the intention to connect Washington, D.C., via the Potomac and Ohio Rivers, to the Mississippi River. Remnants of this Chesapeake and Ohio Canal (C & O Canal) that follow 185 miles of the Potomac River are preserved today by the National Park Service. Within the downtown D.C. area, Tiber Creek was transformed into the Washington City Canal, to connect the Washington waterfront to the Capitol to the first lock of the C & O Canal.
4. George Washington selected Pierre L'Enfant to design the layout of the city. L'Enfant used the area's geography to give prominence to the new capital's two most important buildings. The U.S. Capitol was built upon Jenkins Hill (now known as Capitol Hill), and the White House was built on a natural rise (an old river terrace deposit). The streets and avenues of Washington, D.C. radiate out from these two sites with an additional north-south grid pattern. Pierre L'Enfant called for a monument to George Washington along the shore of the Potomac River at the location where a line drawn south from the White House and west of the U.S. Capitol intersected. All additional space in that area would remain open as a national gathering place (the National Mall).

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Background Information, *continued*

Introductory Cultural/ Historical Interpretative Points (*continued*)

5. Increased sedimentation of the Potomac River (illustrated in the space poster) caused navigation problems. A reclamation project took sediment dredged from the river bottom and placed it along the already swampy shoreline. Sea walls held the sediment in place and extended 740 acres of land to Washington, D.C.,. It is on the reclaimed land that additional memorials have been built to capture the spirit of American history. Every conscious detail in the National Mall's art, architecture, design, and landscaping somehow contribute to the mood and meaning of this place.



Former Potomac River Shoreline and Fill Areas

6. Like other national parks, rangers at the National Mall protect the natural, historical, and cultural resources to preserve this space for the public's enjoyment and the enjoyment of future generations.

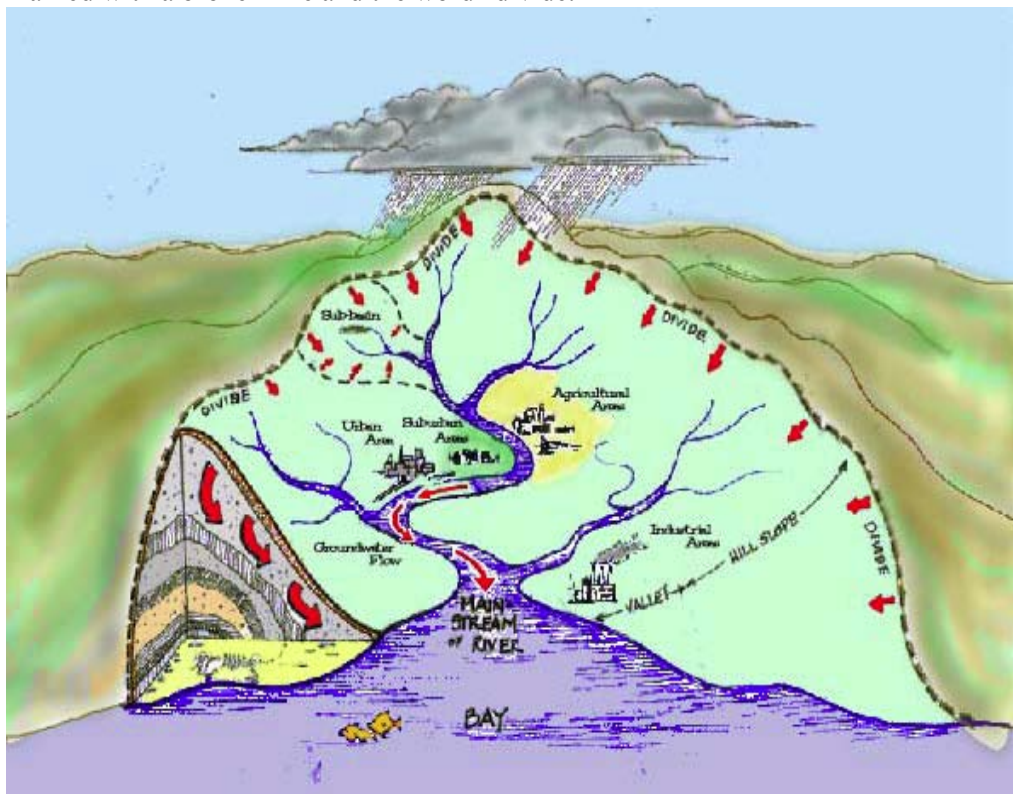
Stated goal for students: Be a responsible citizen by following all NPS rangers' lead and take care not to litter, do not trample protected areas, etc.

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Background Information, *continued*

What Impacts a Watershed?

A watershed is an area of land from which runoff drains into a stream, river, lake, or other bodies of water. Streams and rivers drain water from the land as they flow from higher to lower elevations. You can identify the boundary of a watershed by locating the highest points of land around it. On the cross-section (below), the boundary is marked with a broken line and the word “divide.”



Cross-section of a watershed

Human activities impact a watershed. A healthy stream is a busy place, teeming with many forms of life. Plants grow along the sides and in the stream, protecting the aquatic environment. Bank vegetation shades the stream, slows water flow in rainstorms, and filters out some pollutants before they enter the stream. When humans “develop” land with such activities as constructing buildings or laying pavement for roads and parking lots, this developed land becomes more impervious, causing the amount and the speed of the runoff to increase. Water unable to penetrate the hard surfaces runs over the land into storm drains or causes flooding that strips soil from the land. Most of this water, along with sediment it carries, empties into natural waterways. Once suspended in the water, sediments may have adverse effects on aquatic organisms such as reducing the light available for plants to use in photosynthesis and making it more difficult for aquatic animals to find food, see predators, or get oxygen. These sediments may also bury the eggs of certain animals and bottom-dwelling organisms. Human activities (e.g., farming, mining, logging, and raising livestock) add to both the sediment load and the pollutants that can be carried by these sediments.

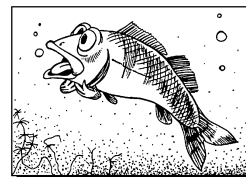
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Background Information, *continued*

Chemical Parameters (DO)

DISSOLVED OXYGEN (DO)

In order to support organisms such as fish, invertebrates, plants, and aerobic bacteria, a body of water must have enough dissolved oxygen (DO). All aquatic plants and animals require oxygen for cellular respiration.



Sources of Dissolved Oxygen

Much of the DO in water comes from the atmosphere when gaseous oxygen dissolves at the surface where air and water meet. Disturbance of the surface by rainfall, wind, or movement over rocks (such as rapids and riffles) causes more oxygen to dissolve. The more the water churns and bubbles, the more oxygen gets mixed with the water and dissolves in it. Another source of DO is the oxygen that aquatic plants and phytoplankton (including algae) produce during photosynthesis.

Physical Influences on Dissolved Oxygen

DO levels rise and fall with the season as well as with the time of day. In general, warm water holds less oxygen than cold water. Water also holds less oxygen at higher altitudes; a lake at the top of a mountain would contain less oxygen than a similar lake at the bottom of the same mountain. Aquatic plants need light to produce oxygen, so DO levels are usually low whenever light is low. This includes nights, cloudy days, and whenever dense algal growth blocks sunlight. Dissolved oxygen is decreased whenever humans do anything that causes water to be warmer than normal. Water is often used to cool machinery in a factory or power plant and then returned to a waterway. The water that is returned is warm because of the heat it absorbed from the hot machinery; therefore, it can't hold as much oxygen. This produces "thermal pollution," a problem causing major changes in aquatic ecosystems worldwide.

Units of Measurement for Dissolved Oxygen

DO is expressed in milligrams of oxygen per liter of water (mg/L) or in parts per million (ppm). The amount of DO can be converted to percent (%) saturation.

How Much Dissolved Oxygen is Enough?

Different aquatic species require different amounts of DO. Some species require different amounts at different life stages (e.g., tadpole, adult frog). In most cases, bodies of water with consistently high levels of DO (90% saturation or higher) are considered stable and capable of supporting many different kinds of aquatic life.

Dissolved Oxygen levels of: 5 – 6 mg/L are sufficient for most species.
< 3 mg/L are stressful to most aquatic species.
< 2 mg/L are fatal to most species.

If DO levels fall, organisms that can migrate (e.g., fish and some types of invertebrates) leave the low DO areas and congregate in areas with higher levels of DO. This temporary increase in population may deplete the food or oxygen in the new area, compounding the problem.

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Background Information, continued

Chemical Parameters (PO₄)

ORTHOPHOSPHATE (PO₄)

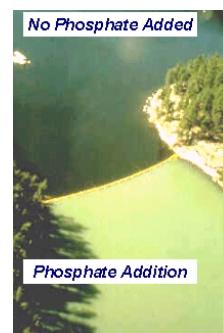
Phosphorus is essential for life. When phosphorus combines with four oxygen atoms, it forms a phosphate ion. Phosphate that is not combined in any molecules in plants or animals, making it available for reaction, is called “orthophosphate,” meaning “straight phosphate.” Algae and larger aquatic plants rapidly take up this ion because they need it for many metabolic reactions and for growth. Animals need it for similar reasons, and they get the phosphates they need from the food chain. Not only is orthophosphate the reactive form of phosphate, it is also much easier to test for this form than other phosphate forms. In most natural bodies of water, orthophosphate is present in very low concentrations. Though nitrogen is more important to plants, there is usually plenty of it available. The less available phosphorus acts as the “growth-limiting” factor for producers because plants compete for it, and plant growth and reproduction will be limited by the amount available.

Cultural Eutrophication

Algae are microscopic in size and require only small amounts of phosphates. When excess amounts of orthophosphates are available, algae reproduce rapidly in population explosions called algal blooms. The most common reasons for excess orthophosphates are fertilizers for lawns or crops, detergents with phosphate water softeners, and some industrial wastes. Many of these end up being washed into storm drains. When natural substances rich in phosphates (e.g., human or animal wastes) get into the water, algal blooms occur and are a clear indication of what is termed “cultural eutrophication” or human-induced enrichment of water with nutrients. The test for orthophosphates is a test for the uncombined or reaction-available form.

Impacts of Cultural Eutrophication

Eutrophication is a natural cycle that is supposed to take thousands of years. *Cultural eutrophication* can occur in years or months, resulting in the death of an entire ecosystem. The first sign of cultural eutrophication is usually an algal bloom that makes the water “pea soup” green. Aquatic plants that normally grow in shallow waters become very dense. Swimming and boating may become impossible. While the nutrients last, rapid reproduction of algae and macroscopic plants continues. When the nutrients are used up, many of the excess plants and algae die.



Significant Levels

In natural bodies of water, an orthophosphate level of:

- 1 mg/L is considered excellent.
- 2-3 mg/L contribute to increased plant growth and algal blooms.
- ≥ 4 mg/L may temporarily stimulate plant growth enough to surpass natural eutrophication rates.

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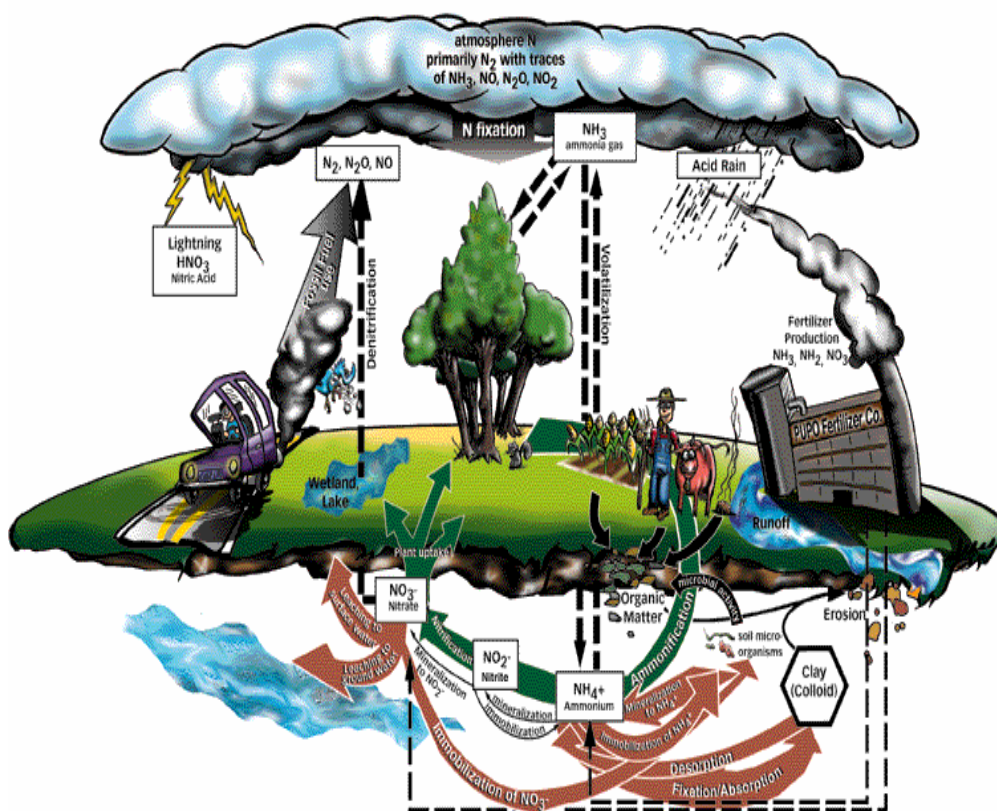
Background Information, *continued*

Chemical Parameters (NO_3)

NITRATES (NO_3)

Both plants and animals need nitrogen to build protein and nucleic acids. In nature, nitrogen is much more abundant than phosphorus and is most commonly found in its molecular form (N_2) in the atmosphere. In fact, nitrogen makes up about 79 % of the air we breathe, but this form of nitrogen is useless to both plants and animals.

A certain amount of nitrogen gets into water by natural processes. Some types of bacteria and some algae are able to convert N_2 into ammonia (NH_3) and nitrate (NO_3^-) that plants can use for growth. Animals acquire nitrogen by eating plants or other animals that feed on plants, both on land and in water. Waste from these animals decomposes, and the nitrates are recycled. When these organisms die, all the nitrogen in their bodies reenters the nitrogen cycle. Similarly, the excrement from ducks and geese contribute a heavy load of nitrogen to areas where they are plentiful.



The Nitrogen Cycle
<http://soil.gsfc.nasa.gov/NFTG/nitrocyc.htm>

continued on next page

Background Information, *continued*

Chemical Parameters (NO₃) (*continued*)

Sources of Nitrates

Though a certain amount of nitrogen is necessary in aquatic ecosystems, too much can cause problems. An excess of nitrogen can make its way in waterways from runoff that contains fertilizers, sewage from leaky cesspools or sewage treatment plants, manure from livestock, and car exhaust fumes. Increased levels of nitrogen are evident after a storm; however, the presence of nitrates in water during dry weather is an indication of direct drainage of sewage or manure into waterways.

Significant Levels

Nitrates dissolve more readily in water than phosphates do. Thus, they tend to accumulate more quickly in bodies of water than do phosphates. Unpolluted water generally has a nitrate level below 4.4 mg/L. Nitrate levels above 4.4 mg/L indicate unsafe drinking water.

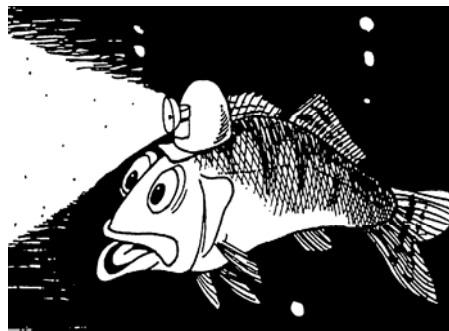
Nitrate Contamination of Groundwater

Though nitrate does not cause any health problems, it is converted to nitrite when ingested, and nitrites may be quite harmful. In regions where large amounts of agricultural fertilizers are applied, nitrate contamination of groundwater is a major concern. Nitrate levels above 4.4 mg/L convert to nitrites that are believed to cause hypoxia (i.e., low level of oxygen) in warm-blooded animals. Though the research is not conclusive, the ingestion of nitrite may be especially dangerous to unborn babies in the first three months of life, making the presence of nitrates in groundwater of special concern to pregnant women. Nitrites may be a cause of “blue baby syndrome” (methemoglobinemia), a potentially fatal condition.

Chemical Parameters (Turbidity)

TURBIDITY

Turbidity is cloudiness. Cloudy or turbid water contains suspended solids such as soil particles (e.g., clay, silt, and sand), plankton, including algae, and various microbes. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand), large enough to block some of the light rays and reduce the amount of light that can pass through. The higher the turbidity, the less light passes through to the plants living under water. Dissolved substances don't generally contribute to turbidity.



continued on next page

Background Information, *continued*

Chemical Parameters (Turbidity) *(continued)*

Turbidity Impacts Aquatic Life

Turbidity causes higher water temperatures because the suspended particles absorb heat and reduce the amount of dissolved oxygen. Dissolved oxygen is also reduced when turbidity reduces the amount of light passing through the water to aquatic plants, and photosynthetic activity is reduced. Suspended materials can also clog the gills of fish and other animals. Since the animals get less oxygen, their body systems are stressed, their resistance to disease is lowered, and their growth rates are reduced. The sediments can also interfere with the development of eggs and young. Particles of sediment may even smother fish eggs and benthic macroinvertebrates.

Sources of Sediments that Cause Turbidity

Soil particles are the most common cause of high turbidity. Normally, plant roots hold soil in place and absorb rainwater. Human activities can remove the soil's protective plant cover, and the soil washes or blows away. The photo to the right is an example of sediment runoff from barren soil and dirt road.



Lake Laura at Bryce Resort, Virginia

Construction companies often leave large areas of exposed soil, farmers may leave fields unplanted after a harvest, and timber companies cut down trees to make lumber or paper, and new trees take years to grow. Rain on any of these areas picks up soil and carries it into streams or rivers. Larger volumes of water cause streams to flow faster, eroding their own banks and increasing sediments in the water. This causes a sharp rise in the turbidity of the stream. Dry weather causes a different kind of erosion problem: wind can carry dirt into streams.

Waste materials from factories, towns, and cities may get into the water by accident, or because the waterway is used as a convenient “dump.” Natural materials (e.g., leaves and grass clippings) dumped into waterways can increase turbidity as they begin to decay.

Significant Levels

Turbidity is measured in Jackson Turbidity Units (JTU). Acceptable turbidity levels should be:

- < 0.5 JTU for drinking water.
- < 1.0 JTU for typical groundwater.
- < 4.0 JTU in streams.

continued on next page

Background Information, *continued*

Chemical Parameters (Temperature)

TEMPERATURE

Temperature affects many of water's chemical properties, as well as many biological and physical processes within the aquatic ecosystem. Among other things, temperature affects the:

- oxygen content of the water (i.e., DO decreases as temperature increases).
- rate of photosynthesis by aquatic plants.
- metabolic rates of aquatic organisms.
- sensitivity of organisms to toxic wastes, parasites, and diseases.

Acceptable temperatures vary from site to site and season to season. In general, temperatures above 27°C (80.6°F) are unhealthy for aquatic life.

Importance of Water Temperature

Water temperature is one of the key factors determining which species are best suited to certain regions. Different species of fish and other aquatic organisms have different optimal temperatures, some survive best in colder water, others in warmer water. Refer to the following chart for temperature ranges.

Range description	Centigrade (°)	Fahrenheit (°)
Warm	20 - 25	68 - 77
Cool	13 - 19	55 - 67
Cold	5 - 12	41 - 54

If temperatures are outside a species' optimal range for a long period of time, organisms become stressed and often die. More sensitive species can be weakened by even a short "temperature shock" and become subject to disease or parasitism as a result. Water temperature affects metabolism in aquatic animals as well as many behaviors, including general activity, feeding, and reproduction. A week or two of high temperatures each year may make a stream unsuitable for sensitive organisms, even though temperatures are within tolerable levels throughout the rest of the year.

Changes in Water Temperature

Obviously, natural processes such as changing weather and groundwater flowing into waterways can cause temperature changes. Humans, also, can impact temperature by:

- removing stream bank vegetation that shades the water.
- impounding water (when we confine it, like with a dam).
- discharging water we heated by using it to cool something or
- channeling water from impervious urban surfaces which heats water going into storm drains that flow into rivers.

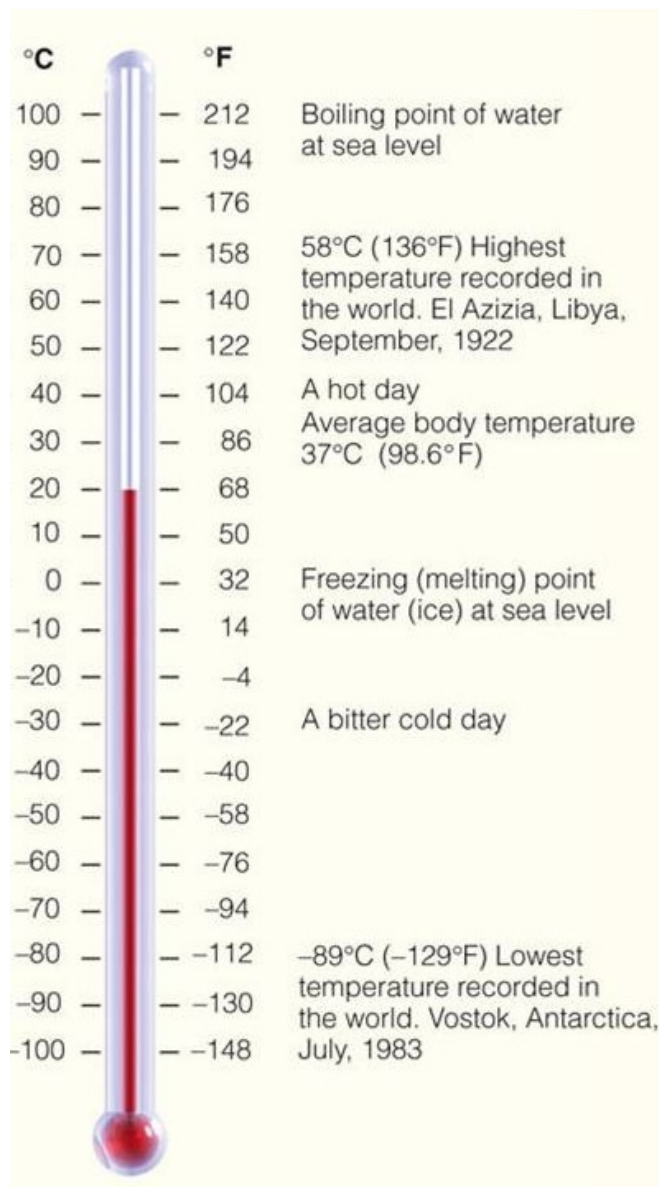
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Background Information, *continued*

Chemical Parameters (Temperature) (*continued*)

Temperature Conversion

Although degrees Fahrenheit is commonly used in the United States, the Celsius (Centigrade) scale is the term used to express temperature in the science community and the rest of the world. Students are expected to record temperature in degrees Celsius in the field. The illustration below may help with conversion.



°C – °F Temperature Conversion

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Water Quality Testing Instructions

DO Testing Instructions

MEASURING DISSOLVED OXYGEN (DO)

Instructions in the La Motte Field-Test Kit use the Winkler method which indirectly measures the dissolved oxygen in a water sample. The test method is called titration.

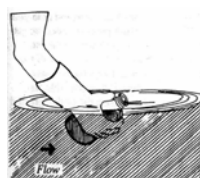
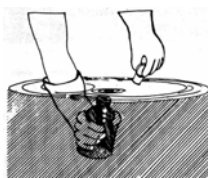
Equipment and reagents needed.

- | | |
|--|---|
| 1 bottle manganous sulfate solution | 1 plastic measuring spoon |
| 1 bottle alkaline potassium iodide azide | 1 titrator (syringe) |
| 1 bottle sulfamic acid powder | 1 glass titration tube with snap-on cap |
| 1 bottle sodium thiosulfate | 1 sampling bottle with screw cap |
| 1 bottle starch indicator | |

BEFORE STARTING THE TEST, MEASURE THE WATER TEMPERATURE AND RECORD IN DEGREES CELSIUS.

PART 1 - SAMPLE COLLECTION

1. Put the **cap on** the sample bottle and dip the **capped** bottle into water.
2. Remove the cap when the bottle is completely submerged and fill the bottle.
3. With the bottle still underwater, tap the side of the bottle to release any air bubbles.
4. With the full bottle still underwater, recap the bottle.
5. Take the bottle out of the water. Make sure there are no air bubbles inside and that the bottle is filled all the way to the top. If there are air bubbles, repeat the sample collection until you get a sample with no bubbles.
6. Take the bottle to your laboratory station and begin Part 2 immediately.



PART 2 - FIXING THE OXYGEN IN THE SAMPLE

1. Locate the manganous sulfate and alkaline potassium iodide azide.
2. Be careful not to add air to the sample while adding reagents.
3. Remove the cap from the water sample bottle.
4. Immediately add 8 drops of manganous sulfate to the water sample.
5. Then, immediately add 8 drops of alkaline potassium iodide azide to the water sample.
6. Recap the bottle and shake to mix.
7. Set the sample bottle down and let the precipitate (cloudiness) form.
8. When the precipitate settles below the top of the bottle, add one level spoon of sulfamic acid powder to the water sample bottle.

continued on next page

Water Quality Testing Instructions, continued

DO Testing Instructions (continued)

9. Recap the sample bottle and gently shake until the precipitate has totally dissolved. The solution will be clear yellow to orange.
 10. The oxygen in the sample is now “fixed.” Basically, that means that it’s now chemically “stuck.”
Contact with the atmosphere won’t affect the test now because oxygen can’t get into or out of the sample.
-

PO₄ Testing Instructions

MEASURING ORTHOPHOSPHATES (PO₄)

Equipment and reagents needed

100 mL plastic sampling bottle	Distilled water for rinsing equipment
Phosphate acid reagent	Distilled water ampoule, 5 mL
Phosphate reducing reagent	Phosphate low-range comparator, 0.0-2.0 mg/L (ppm)
3 glass 10 mL test tubes with caps	Axial reader
1 plastic 1.0 mL pipette	Timing device
1 plastic 0.1 gram spoon	

PART 1 - SAMPLE COLLECTION

1. Wash glassware and rinse thoroughly with distilled water. Wear protective gloves when handling this glassware.
2. Rinse the plastic sampling bottle with water from the stream.
3. Fill the sample bottle with stream water and tightly cap it.

PART 2 – PREPARING THE SAMPLE (CHEMICAL REDUCTION METHOD)

1. Fill a test tube to the 10 mL line with stream water sample.
 2. Fill the pipette to the 1.0 mL line with phosphate acid reagent.
 3. Add the phosphate acid reagent to the stream water sample in the test tube. Cap the test tube and mix by shaking.
 4. Use the 0.1 gram spoon to add one level measure of phosphate reducing reagent to the sample in the test tube. Cap the test tube and mix until dissolved.
-

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Water Quality Testing Instructions, *continued*

PO₄ **Testing** **Instructions** *(continued)*

PART 3 - READING THE COLOR

1. Set up the comparator (the black box). Place the axial reader on a table with the open mirrored side facing you.
2. Put the octet comparator in the open slot of the axial reader so the labels face you. The comparator bottom should rest on the table.
3. Fill two test tubes to the 10 mL line with untreated stream water sample. These test tubes will be used as “blanks.”
4. Insert the sealed distilled water standard ampoule into the square hole on the left side of the comparator.
5. Insert the test tube with treated solution from Part 2 into the axial reader slot directly behind the distilled water ampoule.
6. Insert the two untreated “blank” test tubes into slots in the axial reader on either side of the treated test solution.
7. Slide the comparator down until the top is even with the top of the axial reader. Hold the comparator so light shines down through the test tubes. Compare color in the center test tube to the colors in the top left corner of the comparator.
8. If the color of the test sample is less than the color of the lowest value, record the result as “less than” the lowest value.
9. If the color of the test sample matches one of the color standards in the upper left-hand corner, record the result as the value of that color standard in mg/L.
10. If the color of the test sample falls between the two standards, record the result as the average of the two values in mg/L.
11. If the color of the test sample is darker than the color of the second color standard, carefully move the comparator so that the bottom of the axial reader and the bottom of the comparator are even. Compare the test sample with the standards in the lower left-hand corner of the comparator.
12. If a color match is not made with the standards on the left-hand side of the comparator, move the test sample and the “blank” tubes to the right-hand side of the axial reader. Move the ampoule of distilled water to the hole on the right side of the comparator. Be sure the test solution is directly behind the distilled water ampoule.
13. Compare the test sample with the standards on the right side of the comparator using the technique detailed in Steps 8-12.

continued on next page

Water Quality Testing Instructions, *continued*

NO₃ **Testing** **Instructions** *(continued)*

MEASURING NITRATES (NO₃)

Nitrate is reduced to nitrite by chemical reduction. Nitrite forms a reddish purple when sulfanilamide and NED are added. This color is matched to a color standard to determine the nitrate level.

Equipment and reagents needed.

1 plastic water sampling bottle	1 Nitrate-Nitrogen Octa-Slide bar,
Nitrate # 1 tablets	0-15 ppm (mg/L)
Nitrate #2 CTA Tablets	1 Octa-slide Viewer
1 plastic test tube, 5 mL, with cap	Timing device

PART 1 - SAMPLE COLLECTION

1. Rinse the plastic water sampling bottle with water from the test site.
2. Fill the sampling bottle with the water sample from the test site.

PART 2 – ADDING REAGENTS

1. Fill a test tube to the 5 mL line with the water sample.
2. Add one Nitrate # 1 tablet to the test tube.
3. Cap the test tube and mix until the tablet disintegrates.
4. Add one Nitrate # 2 CTA tablet to the test tube.
5. Recap the test tube and mix until the tablet disintegrates.
6. Wait 5 minutes.

PART 3 – READING AND CALCULATING RESULTS

1. Insert the Nitrate-Nitrogen Octa-Slide Bar into the bottom of the Octa-Slide Viewer.
2. Insert the test tube into the Octa-Slide Viewer.
3. Hold the Octa-slide Viewer between yourself and a light source, but not direct sunlight or an unevenly lit background. Light should enter through the back of the Octa-Viewer.
4. Slide the Octa-Slide Bar inside the Octa-Viewer until the visible color standard matches your sample color.
5. Record the number shown below the visible color standard as Nitrate-Nitrogen ppm (mg/L).
6. Convert to nitrate using the following equation:

$$\text{Nitrate-Nitrogen ppm} \times 4.4 = \text{Nitrate ppm}$$

(Note: The hyphen between nitrate and nitrogen does not indicate subtraction.)

continued on next page

Water Quality Testing Instructions, *continued*

Turbidity Testing Instructions

MEASURING TURBIDITY

Equipment and reagents needed.

- 1 bottle Standard Turbidity Reagent
- 1 plastic pipette (0.5 mL) with cap
- 2 turbidity columns (marked “Std” and “Sample”)
- 1 stirring rod
- Distilled water

Procedure:

1. Choose a sampling site away from the shore and below the surface of the water.
2. Fill the “Sample” turbidity column to the 50 mL line with a sample of this water. If the black dot on the bottom of the tube is not visible when you look down through the water column, pour out half the sample so that the tube is filled to just the 25 mL line.
3. Fill the “Std” turbidity column with an equal amount of distilled water; this is the standard.
4. Look down through the water in each tube to the black dot at the bottom. If the dot is equally clear in both tubes, turbidity is zero. If the dot in the “Sample” column is less clear than in the “Std” column, continue to step 5.
5. Vigorously shake the closed bottle of standard turbidity reagent.
6. Fill the pipette (eyedropper) to the 0.5 mL line with the turbidity reagent and add to “Std” column.
7. Gently stir the “Std” column to mix the turbidity reagent in the water.
8. Look down into each tube at the black dot. If the “Std” column dot and the “Sample” column dot are equally cloudy, note the total amount (in mL) of turbidity reagent added. Use the table below to determine the JTUs. If the “Sample” column dot is still cloudier than the “Std” column dot, continue to Step 9. Remember, you are matching the cloudiness of the two columns, not color. Ignore color differences between the two columns.
9. Add turbidity reagent in 0.5 mL increments to the standard (“Std”) water tube. Gently stir the column after each addition and check turbidity by viewing the black dots in each tube. Continue to add turbidity reagent until the clarity of the black dot appears equal in both tubes. Record the amount of turbidity reagent added.



“Sample” turbidity column

continued on next page

Water Quality Testing Instructions, *continued*

Turbidity Testing Instructions (*continued*)

10. Use the following table to determine turbidity in Jackson Turbidity Units (JTUs).

Turbidity Test Results			
No. of Measured Additions	Amount mL	50 mL Gradation JTU	25 mL Gradation JTU
1	0.5	5	10
2	1.0	10	20
3	1.5	15	30
4	2.0	20	40
5	2.5	25	50
6	3.0	30	60
7	3.5	35	70
8	4.0	40	80
9	4.5	45	90
10	5.0	50	100
15	7.5	75	150
20	10.0	100	200

Apparent Color

The apparent color of water is the result of both dissolved substances and suspended materials, so color can provide useful information about the water's source and content. Pure water absorbs various wavelengths of light at different rates. Blue light and blue-green light are the wavelengths best transmitted through water, so a white surface under pure water appears blue. Natural metallic ions, plankton, algae, industrial pollution, and plant pigments from humus and peat may all produce different colors in water.

Determine the apparent color of water by lowering a white (Secchi) disc far enough below the water surface to produce a distinct color. Use the table of colors below to hypothesize the source of the water color.

Color	Source
Blue	Low accumulation of dissolved materials and particulate matter (indicating low productivity)
Yellow or brown	Organic materials: humus, peat, decaying plants
Reddish or deep yellow	Algae or dinoflagellates
Green	Phytoplankton or algae
Yellow, red, brown, or gray	Soil runoff

continued on next page

Water Quality Testing Instructions, *continued*

Odor

The odor (smell or scent) of water can indicate what's in it. Odor can be caused by municipal or industrial wastes, decomposing plants, or microbial activity. Odor affects how acceptable we find drinking water, how willing we are to use a waterway for recreational purposes, and how fish and other aquatic foods taste to us.

Odor Test: Your nose is an excellent odor-detecting device. Collect a water sample in a wide-mouthed jar. Waft the air above the water sample toward you with your hand. Use the table of odors below to describe what you smell.

Odor	Nature of Odor
Aromatic (spicy)	Cloves, lavender, lemon
Flowery	Geranium, violet, vanilla
Chemical	Industrial wastes, chlorine, oil refinery wastes, medicinal, sulfur (rotten eggs)
Disagreeable/unpleasant	Fishy, pigpen, septic (stale sewage)
Earthy	Damp earth
Grassy	Crushed grass
Musty	Decomposing straw, moldy

Comparing Water Quality Data

Reflecting Pool Data

Reflecting Pool Water Quality Data						
Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Temp (°C)						
DO (mg/L)						
NO ₃ (mg/L)						
PO ₄ (mg/L)						
Turbidity (JTU)						

Constitution Gardens Data

Constitution Gardens Lake Water Quality Data						
Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Temp (°C)						
DO (mg/L)						
NO ₃ (mg/L)						
PO ₄ (mg/L)						
Turbidity (JTU)						

Simon Bolivar Data

Simon Bolivar Pond Water Quality Data						
Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Temp (°C)						
DO (mg/L)						
NO ₃ (mg/L)						
PO ₄ (mg/L)						
Turbidity (JTU)						

Ideal and Actual Management Values for Pools

Reflecting Pool Water Quality Data		
Parameters	Ideal	Actual Management
Temp (°C)	> 32°F or 0°C To keep the pool from freezing and to maintain the reflection.	At this time, there is no management to control or maintain the temperature of the Reflecting Pool.
DO (mg/L)	Any Value No management for aquatic life.	≥ 2.0 mg/L To destroy algae and digest nutrients/fecal matter added to the pool, a bacterial agent is added to the pool that requires a certain amount of DO to survive.
NO ₃ (mg/L)	0 Algal blooms will not occur.	As close to 0 as possible* Actual nitrate levels will vary, but the closer to 0 they are, the less management will be needed to control algal blooms. <i>* Managed in part by the bi-annual draining and scrubbing of the pool.</i>
PO ₄ (mg/L)		
Turbidity (JTU)	0 Clear water provides the best reflection and is most pleasing visually.	As close to 0 as possible* Although turbid water would still reflect the buildings, pool aesthetics and how they affect park visitors must be considered. <i>* Managed in part by the bi-annual draining and scrubbing of the pool.</i>

Constitution Gardens Water Quality Data		
Parameters	Ideal	Actual Management
Temp (°C)	Winter: 50°F/ 10°C At temperatures lower than this, bass and bluegill will stop growing, eating, and reproducing. Summer: 80°F/27°C; Optimum temperature for the bass lifecycle.	Year Round: ≥ 32°F/0°C to ≤ 98°F/37°C Though bass and bluegill can survive in bodies of water covered in ice, they will die if the pool freezes completely. At 98°F, the water will be too warm for the fish, and they will die.
DO (mg/L)	≥ 9 mg/L Spawning is supported at levels greater than 6 mg/L. Growth and feeding will occur at levels higher than 7 mg/L. At 9 mg/L, a healthy and abundant fish population can be supported.	≥ 5 mg/L Lower than this, bass and bluegill will be stressed and possibly die.
NO ₃ (mg/L)	5 mg/L Average level of nitrates in natural systems.	≤ 10 mg/L Above this level, nitrates will be a problem, and the fish will become very stressed.
PO ₄ (mg/L)	1 mg/L At this level, aquatic life can be sustained, yet the level is low enough to prohibit algal blooms.	≤ 3 mg/L Above this level, phosphates may trigger algal growths and surpass natural eutrophication rates.
Turbidity (JTU)	≤ 10 JTU Above this level, the water becomes aesthetically displeasing to the eye. However, it is beneficial to the fish to have somewhat turbid waters.	≤ 40 JTU Above this level, the particles in the water begin to clog fish gills and make it hard for them to find food.

Ideal and Actual Management Values for Pools, continued

Simon Bolivar Pond Water Quality Data		
Parameters	Ideal	Actual Management
Temp (°C)	Winter: 50°F/10°C At temperatures lower than this, koi and goldfish will stop growing, eating, and reproducing. Summer: 65°F/19°C to 80°F/27°C The best temperature range for the koi and goldfish life cycle.	Year Round $\geq 32^{\circ}\text{F}/0^{\circ}\text{C}$ to $\leq 98^{\circ}\text{F}/37^{\circ}\text{C}$ Although koi and goldfish can survive in bodies of water covered in ice, they will die if the Bolivar Pond freezes completely. At 98°F, the water will be too warm for the fish, and they will die.
DO (mg/L)	≥ 9 mg/L Spawning is supported at levels greater than 6 mg/L. Growth and feeding will occur at levels higher than 7 mg/L. At 9 mg/L, a healthy and abundant fish population can be supported.	≥ 5 mg/L Lower than this level, and, at first, the koi and goldfish will gulp air at the surface, and then they may become stressed and possibly die.
NO ₃ (mg/L)	5 mg/L Average level of nitrates in natural systems.	≤ 10 mg/L Above this level, nitrates will be a problem, and the fish will become very stressed.
PO ₄ (mg/L)	1 mg/L Aquatic life can be sustained; however, the level is low enough to prohibit algal blooms.	≤ 3 mg/L Above this level, phosphates may trigger algal growths and surpass natural eutrophication rates.
Turbidity (JTU)	≤ 10 JTU Above this level, the water becomes aesthetically displeasing to the eye. However, it is beneficial to the fish to have somewhat turbid waters.	≤ 40 JTU Above this level, the particles in the water begin to clog fish gills and make it hard for them to find food.