NAME: _____

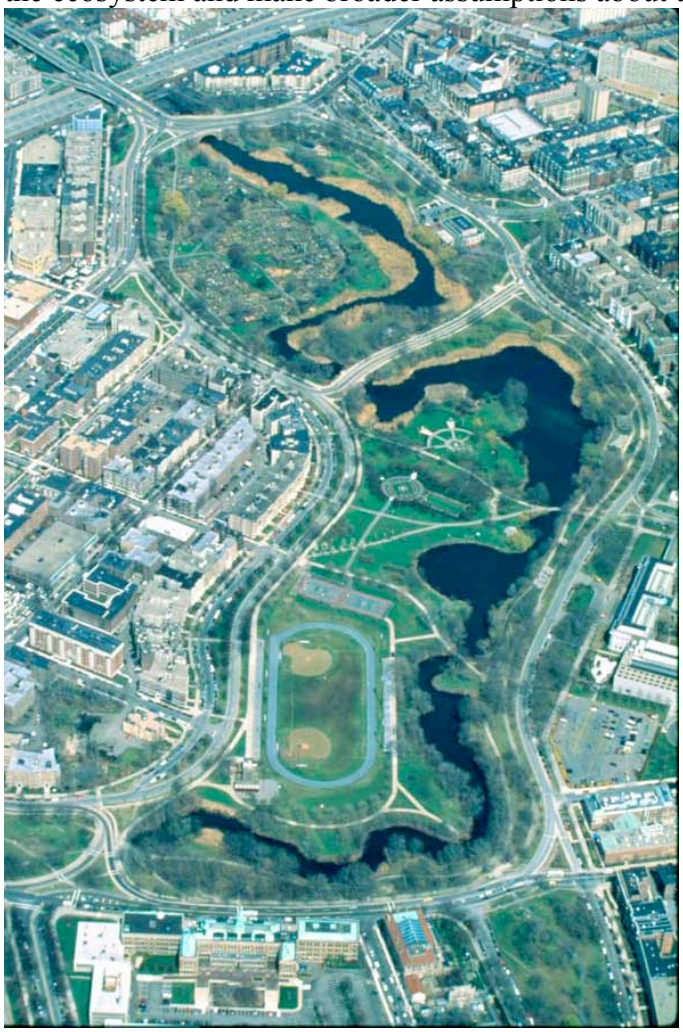
Urban Ecology: Watersheds and Aquatic Ecology

A BIOBUGS program

Objective: To describe the health of the Muddy River in the Fens wetlands system of Boston by examining abiotic and biotic parameters.

Background information: The Fens are a system of connecting freshwater wetlands surrounding the Muddy River, which drains into the Charles River and eventually into Boston Harbor. The Fens are entirely surrounded by an urban environment and provide a respite from the busy city for many residents and visitors, human and non-human alike.

Today we will conduct water quality tests and study the aquatic life at the Fens to determine the health of the ecosystem and make broader assumptions about the impact of the Fens on Boston Harbor.



What is a watershed?

What is point source pollution?

What is non-point source pollution?

Which is easier to control?

What are invasive species?

What do invasive plant species tell us about an ecosystem?

Today we are examining the water quality of the Fens. Do you think that the Fens is a healthy or unhealthy ecosystem? Why?

What kinds of wildlife do you expect to see today?

Water Quality Parameters

Today you will measure three water quality parameters: dissolved oxygen, nitrates, and pH.

Both dissolved oxygen and nitrates are measured in **parts per million** (**ppm**). This is a way of expressing how much of something is dissolved in water. Usually the amounts or concentrations are very small.

1 ppm = 1 milligram of substance (mg) dissolved in 1 liter (l) of water.

Dissolved oxygen (DO): Dissolved oxygen is a measure of how much oxygen gas is dissolved in a body of water. Oxygen is necessary for all animals. Healthy aquatic ecosystems have at least 6 ppm of dissolved oxygen (Table 1).

Table 1. Dissolved oxygen levels (ppm) and responses of living organisms.

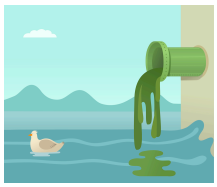
DO (ppm)	Response of organisms
2.0	Few organisms can survive for only short periods
< 3.0	Few fish or large invertebrates can survive for extended periods
4.0	Fish and large invertebrates begin to show stress
< 5.0	Fish grow and develop slowly
6.0 and higher	Optimal for aquatic organisms

Nitrate: Nitrate (NO_3^-) is a compound of nitrogen and oxygen. Plants need nitrogen in order to make proteins to grow and enzymes to catalyze reactions in respiration and photosynthesis. Nitrate is naturally occurring in freshwater ecosystems. Human activities such as using fertilizers on lawns and crops and dumping sewage into waterways add unnatural amounts of nitrate into freshwater ecosystems. This overload of nitrate can begin a process (see Figure 1, next page) that leads to anoxia (lack of oxygen) in the water. Without oxygen, animals cannot survive. Measuring the amount of nitrates in a freshwater system can indicate the quality of the water for living organisms (Table 2).

Table 2. Nitrate levels (ppm) and their corresponding water quality ratings for freshwater.

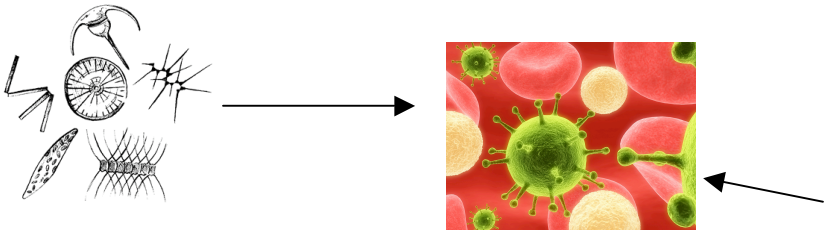
Nitrates (ppm)	Water quality rating
< 1.0	High
1.0 – 1.8	Fair
1.8 – 2.8	Fair to poor
> 2.8	Poor

Figure 1.


1. Nitrates enter the freshwater ecosystem after heavy rains wash fertilizers off of lawns, golf courses, and farms into rivers, lakes, and ponds. Heavy rains also often lead to overflow of sewage systems and the run-off of animal wastes from farms into freshwater systems.

2. Nitrates cause a bloom of phytoplankton (algae). They grow and reproduce exponentially. Soon they use up all the nutrients in the water. The phytoplankton then die and sink to the bottom of the water body.



3. At the bottom of the water body, bacteria breakdown the phytoplankton. Because there is so much, the bacteria are able to reproduce quickly. They use up all the oxygen in the water to help them breakdown the decaying phytoplankton. This causes animal life in the pond to die due to anoxia (lack of oxygen).

pH: pH is a measure of the acidity (higher number of hydrogen ions, H^+, than hydroxide ions, OH^-) or alkalinity of a substance. The pH scale ranges from 0 (most acidic) to 14 (most basic); 7 is completely neutral, pure water (H_2O or HOH). Table 3 shows some familiar liquids and their pH values.
Most aquatic organisms require near neutral conditions to survive. The extreme ends of the scale are lethal to most organisms (Table 4).

Table 3. pH scale and corresponding familiar substances.

pH	Substance
14	Liquid drain cleaner, caustic soda
13	Bleaches, oven cleaner
12	Soapy water
11	Household ammonia (11.9)
10	Milk of magnesium (10.5)
9	Toothpaste (9.9)
8	Baking soda (8.4), seawater, eggs
7	Pure water
6	Urine, milk (6.6)
5	Acid rain (5.6), coffee
4	Tomato juice (4.1)
3	Grapefruit and orange juices, soda
2	Lemon juice (2.3), vinegar (2.9)
1	HCL (stomach acid)
0	Battery acid

Table 4. The effects of pH on freshwater organisms. (Robertson-Bryant, Inc. 2004. pH Requirements of Freshwater Aquatic Life. Technical Memorandum.)

pH level		Effects on freshwater organisms	
Acidic	**3.0-3.5**	No fish can survive. Only very tolerant invertebrates can survive, such as midges and mosquito larvae.	Most harmful
	3.5-4.0	Lethal to most fish. Only plants that can survive are cattails	
	4.0-4.5	Few fish, amphibians, or insects can survive; exceptions include some caddis flies and dragonflies.	
	4.5-5.0	Most fish eggs will not hatch; lethal to stoneflies, harmful to caddis flies and midge larvae.	Harmful
	5.0-5.5	Benthic bacteria and plankton die off, few clams and snails can survive. May be lethal to some eggs and larvae. Lethal to mayflies.	
	5.5-6.5	Most plants and animals survive; exceptions include mollusks (shelled invertebrates) which require neutral conditions.	Less harmful
Biologically neutral	**6.5-8.0**	Optimal for most organisms.	Beneficial
Alkaline (basic)	**8.0-9.0**	Most plants and animals survive.	Less harmful
	9.0-10.5	Harmful to amphibians, some fish and many invertebrates.	Harmful
	10.5-11.0	Lethal to most species, including stoneflies and dragonflies.	Most harmful
	11.0-11.5	Lethal to almost all species, only some caddis flies can survive.	
	11.5-12.0	Lethal to all living organisms.	

Additional reference: MA Water Resources Authority. 2008. Water Quality, A Field Based Water Quality Testing Program for Middle and High Schools.

DATA

Muddy River at the Riverway Park in the Fens

Site Description

Category	Description	Potential Impact on Wildlife
Landscape features		
Human activities		
Human impacts		
Invasive plant species Name and quantify (what percentage of the plants along the riverway are invasive species?)		
Other		
Weather Air temperature Humidity Wind speed Date of last rain		

Water Quality Tests

Test	Result	Results from other teams	Assessment
Dissolved oxygen			
pH			
Nitrates			

Aquatic macroinvertebrates

Name & # caught	Sketch	Micro-habitat?	Level of Pollution Sensitivity*

***Level of sensitivity to pollution can be found by checking the "Quick Reference Guide to Aquatic Invertebrates".**

List macroinvertebrates caught by other teams in your class. Indicate their levels of sensitivity to pollution.

Analysis

How is the water quality of the Muddy River today? Explain your answer by analyzing each water quality parameter that we measured (see pages 5-7).

What is the long-term water quality of the Muddy River? Explain your answer.

What human activities and landscape features in the immediate and surrounding areas do you think have the biggest impacts on the short-term and long-term water quality of the Fens?

What do you think the water quality of (a) the Fens, (b) the Charles River, and (c) Boston Harbor is like after a heavy rainstorm? Explain your answer.

What are some actions that people (including you!) can take to lessen their impacts on the Boston Harbor Watershed?