2020 Water Quality Report, Foxborough, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data in Foxborough and throughout the Neponset River watershed since 1996. Samples are collected by volunteers through the Community (formerly Citizen) Water Monitoring Network (CWMN) and by NepRWA staff through the Hot Spot program. Data gathered by the CWMN volunteers are used to track the health of the Neponset River and its tributaries, and to locate pollution sources (hot spots) for follow-up sampling. There is one permanent CWMN station within the town of Foxborough on the Neponset River on Crackrock Pond (Figure 1), which is tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, temperature, ortho-phosphate, and ammonia once per month between May and October. The parameters discussed in this report are limited to those that have standards including *E. coli*, total Phosphorus, pH, and dissolved oxygen. The raw water quality data are available upon request.

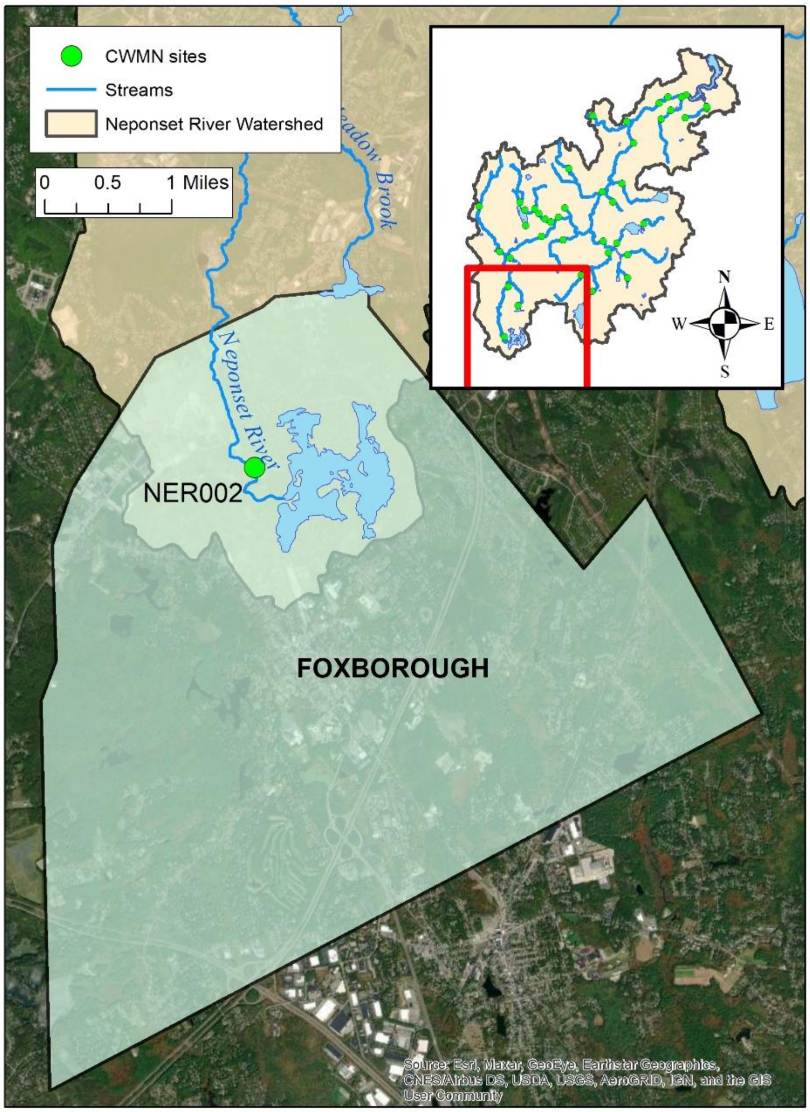

Figure 1: Map of the CWMN site in Foxborough, Massachusetts.

The concentration of *E. coli* bacteria is used to assess a waterbody's safety for "contact recreation" through activities such as swimming, fishing, boating, and wading. The presence of *E. coli* is evidence of fecal contamination and is an indicator of the likely presence of other, more dangerous, pathogens associated with human and animal waste. The most common sources of *E. coli* include improper disposal of pet waste in streets, lawns, and catch basins. Additional common sources include sewer or septic system malfunctions and discharges of organic wastes from household or commercial garbage. Wildlife waste also contains *E. coli*, however elevated concentrations from wildlife are typically associated with human activities, such as feeding ducks. Management interventions to reduce *E. coli* loads can include education on pet waste disposal, proper management of solid waste, frequent cleaning of catch basins, filtration stormwater best management practices (BMPs) to reduce the runoff that reaches a waterbody, and rapid identification and repair of sewage leaks and spills.

Phosphorus is a required plant nutrient that is often the "limiting nutrient" in freshwater ecosystems. Therefore, the concentration of available phosphorus in a freshwater waterbody will often control the rate of aquatic plant growth (the other required nutrients are typically present at proportionately higher levels). *Excess* phosphorus creates *excess* biomass, especially algae, in a process called eutrophication. When the excess plants and algae die, the process of decomposition consumes dissolved oxygen, and in extreme cases dissolved oxygen levels get too low to support aquatic animals such as fish. Other impacts of eutrophication include unattractive and smelly algal blooms and destruction of underwater plant communities through reduced light penetration. Elevated phosphorus concentrations can cause *harmful* algal blooms (HABs), such as cyanobacteria that produce toxins harmful to people. Phosphorus sources can include wet (from rain) or dry (from sprinklers) weather runoff from parking lots, streets/gutters, and lawns. These surfaces contain phosphorus from fertilizers, organic matter (leaves, grass clippings), soil, garbage, and pet waste. Interestingly, phosphorus can also accumulate on these surfaces from atmospheric deposition. Illegal dumping of organic matter such as leaves in or near waterways or catch basins is a common problem. Poorly maintained septic systems, illicit discharges of sewage, and naturally occurring dead aquatic plant materials are additional sources.

The pH of a waterbody is a measure of how much free hydrogen ion (H+) is present in the water—a lot of free hydrogen ion leads to acidity (low pH) and low amounts of free hydrogen ion leads to more basic conditions (high pH). Water that is too acidic or too basic can be toxic to aquatic life. The pH is influenced by bedrock characteristics, groundwater seepage, acid rain, or heavy loading of tannin rich leaves/needles.

Adequate concentrations of dissolved oxygen (DO) are necessary to support fish, amphibians, mollusks, aquatic insects, and other invertebrate species. Many environmental drivers impact the DO levels in a water body. For example, cooler water temperatures sustain higher levels of DO, which is why there is often a seasonal trend in DO concentration: low levels in the warm months and higher levels in the colder months. Rapid mixing and turbulence (such as riffles or step pools) also result in high levels of DO due to atmospheric mixing. Alternatively, large amounts of decaying organic matter consume dissolved oxygen as microorganisms degrade the organic matter and lower levels of DO result. Excessive phosphorous that causes eutrophic conditions is also closely associated with low dissolved oxygen levels because it drives plant growth and subsequent decomposition. In thermally stratified lakes, oxygen deficient conditions can occur in the deeper portions of the water where there is no atmospheric mixing and no photosynthesis (the two sources of DO in aquatic systems). In the summer, ponds and lakes typically have warmer surface waters and thus lower surface DO concentrations. Management interventions that can increase DO levels include increasing riparian shading to maintain lower water temperatures, removing obsolete dams, reducing excessive water diversions, and reducing decaying organic matter though the reduction of phosphorous runoff and other drivers of eutrophication.

Results and Discussion

Monthly sampling events occur on predetermined days each month, which means the weather is not a criterion in determining when to collect the water quality data. However, rain events can significantly alter the concentrations of various parameters by washing bacteria, nutrients, and other chemicals from land surfaces into the river. In 2020, five sampling days occurred during dry periods and just one sampling date occurred during a wet period. A wet period is defined as greater than 0.1 inches of precipitation within the 48-hour period preceding a sampling event. As shown in Table 1, 2020 had more sampling events occur during dry weather since 2016 when all six sampling events occurred during dry weather. The implication of this result is that any improvements in certain parameters like *E. coli* may be a result from the disproportionate sampling during dry weather as opposed to real changes in water quality or real changes in the frequency of sewage spills.

Table 1: The number of water quality sampling days that occurred during dry or wet weather since year 2010.

Year	Dry (days)	Wet (days)
2010	5	1
2011	3	3
2012	2	4
2013	5	1
2014	4	2
2015	4	2
2016	6	0
2017	4	2
2018	3	3
2019	3	3
2020	5	1

Escherichia coli (E. coli)

In Massachusetts there are two criteria that define acceptable levels of *E.coli* in Class B waterbodies (waterbodies that support wildlife, swimming, and boating, but not drinking). In Class B waters, no single sample shall exceed 235 Colony Forming Units (CFU) per 100 ml (the single sample standard), and/or the geometric mean of at least 5 samples taken within the same season shall not exceed 126 CFU/100ml (the seasonal standard).

In 2020 maximum *E. coli* levels in Crackrock pond were less than the single sample standard threshold (*E. coli* maximum = 63cfu/100ml) and the geometric mean of samples collected in 2020 was 25cfu/100ml, the lowest concentrations since 2015 (Table 2).

Table 2: Concentrations of *E. coli* at the Crackrock pond site from 2010 through 2020. Unit are in cfu/100ml. N = 6 each year. Bolded rows indicate that the single sample standard was violated.

Year	Maximum	Mean	Minimum	Geometric mean
2010	52	33	10	26
2011	**253**	**54**	**10**	**22**
2012	41	24	5	19
2013	226	45	5	13

2014	**1860**	**324**	**5**	**32**
2015	41	17	5	13
2016	175	48	10	22
2017	**301**	**87**	**10**	**47**
2018	**496**	**146**	**10**	**56**
2019	189	78	10	52
2020	63	33	10	25

Wet weather concentrations are generally higher than dry weather concentration, and in 2011, 2014, 2017, and 2018 wet weather concentrations exceeded the single sample threshold (Figure 2). Dry weather concentrations since 2010 have been less than the single sample threshold. In 2020 a sample during dry weather was the seasonal maximum *E. coli* concentration (63 cfu/100ml compared to a maximum of 43 cfu/100ml during the wet weather sampling event).

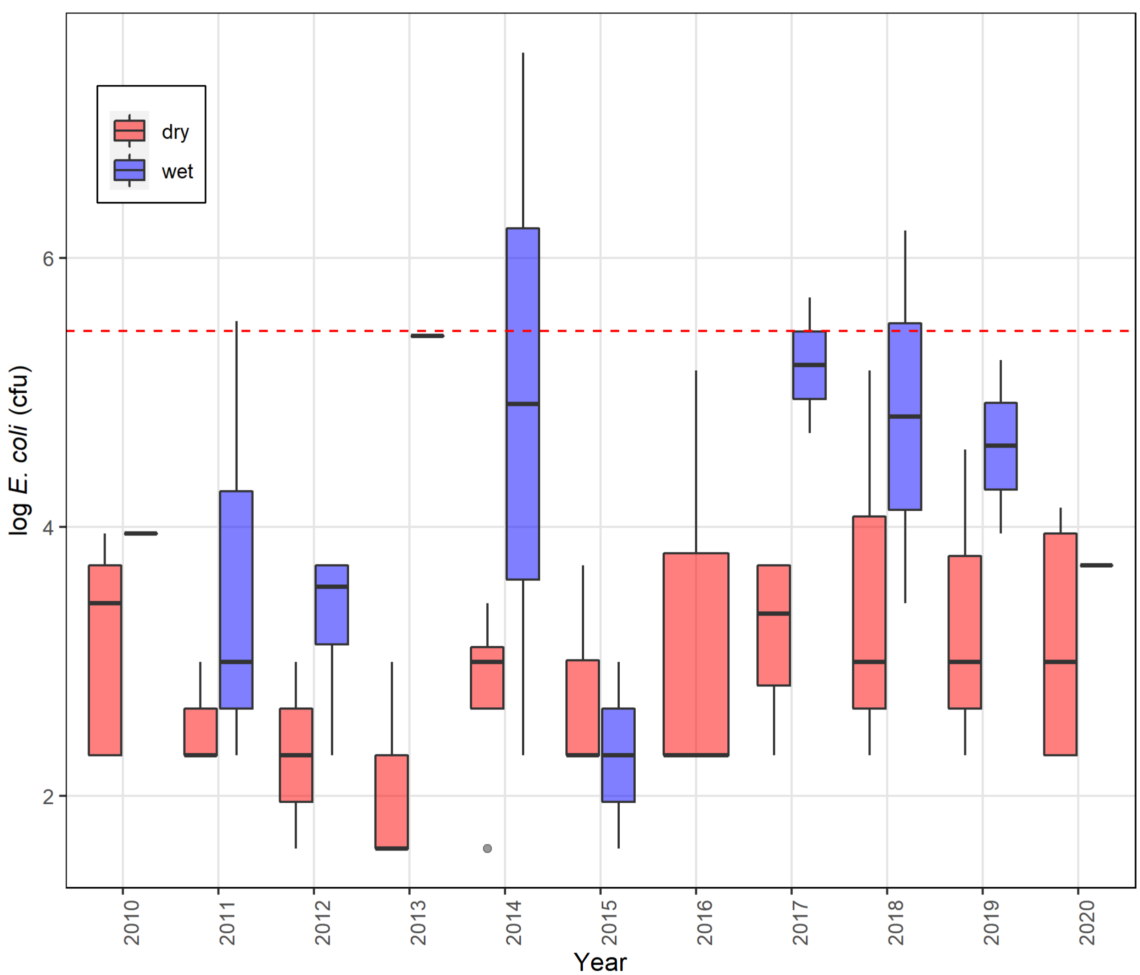

Figure 2: *E. coli* levels at Crackrock pond in Foxborough, MA from years 2010 to 2020 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The red dashed line at y = log(235) shows the single sample maximum acceptable threshold. Boxplot statistics: The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends from the hinge to the largest value no further than 1.5 * IQR from the hinge (where IQR is the inter-quartile range, or distance between the first and third quartiles). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Data beyond the end of the whiskers are called "outlying" points and are plotted individually.

Phosphorus

The state of Massachusetts does not provide numerical phosphorus standards for classification of water quality impairments. Instead, the Massachusetts Department of Environmental Protection (MassDEP) uses a narrative standard that considers the EPA gold book standard, dissolved oxygen levels, and excessive primary producer growth. The EPA gold book standard identifies a total Phosphorus average of at least three samples exceeding 0.1mg/l as the upper threshold for flowing waters, 0.05mg/l for streams entering a lake/reservoir, and 0.025mg/l for lakes. We consider this site to be a lake site. Dissolved oxygen and excess primary producer growth like algal blooms are used as evidence that the Phosphorus levels are causing an impact to the stream ecology.

The average total Phosphorus levels at Crackrock pond in 2020 were over ten times the allowable concentrations at a lake or pond site (Average value in Table 3). High concentrations of total Phosphorus have been observed since 2017 and they appear to have peaked in 2019 (Figure 3). The 2020 concentrations have decreased substantially from 2019 but are still above the allowable levels. Dissolved oxygen levels are dangerously low at this site, as shown in Figure 4, which provides evidence that the phosphorus concentrations may be impacting conditions for aquatic animals.

Table 3: The maximum, average, and minimum values of total phosphorus recorded during 2020 at Crackrock pond. N=6.

Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
0.43	0.27	0.04	0.025

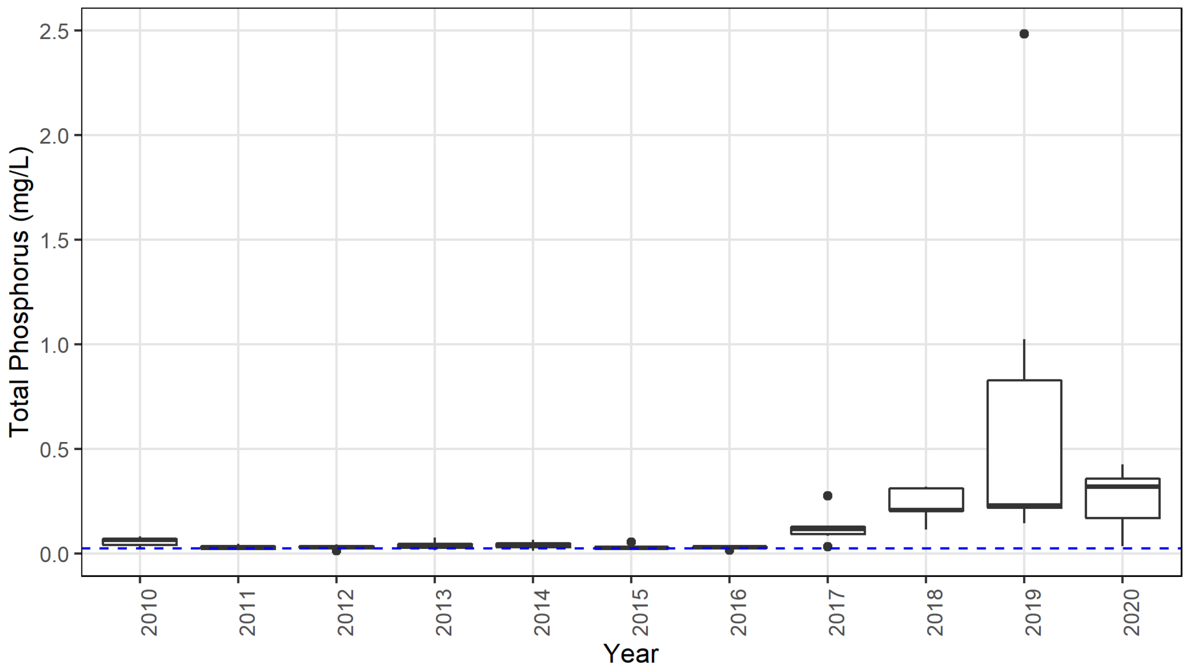

Figure 3: Total phosphorus levels at Crackrock pond from year 2010 to 2020. The blue dashed line is at 0.025mg/l. Boxplot statistics are the same as Figure 2.

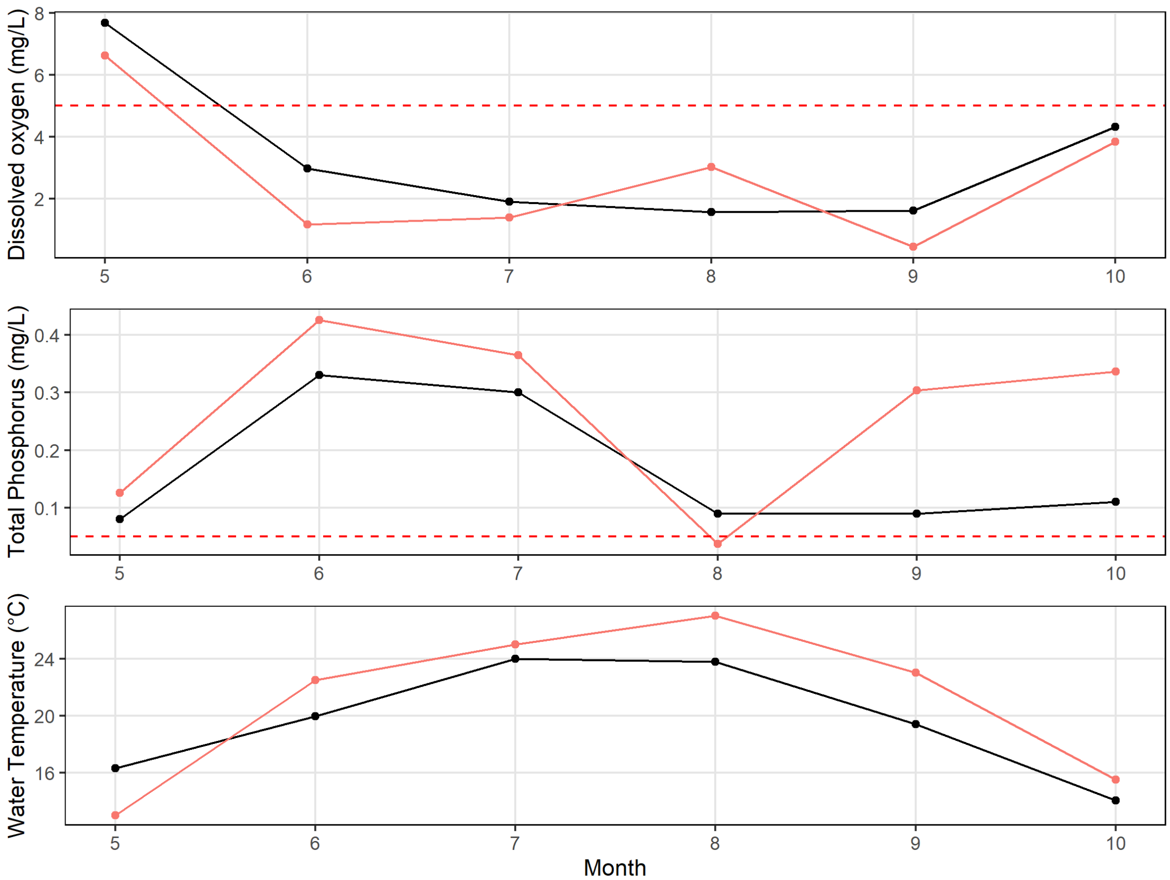

Figure 4: Monthly dissolved oxygen levels (top plot), total Phosphorus (middle plot), and water temperature (bottom plot) levels at Crackrock pond. The black line shows the mean monthly value from 2010 to 2019 and the red line shows the 2020 values. The red dashed line is at 5mg/l in the top plot and at 0.025mg/l in the middle plot.

It is important to note that the Massachusetts DEP asks for additional information to help identify a problem with total Phosphorus, such as primary producer data. Since 2019 volunteers at this site have noted complete coverage in aquatic plants by the end of the summer.

pH

The state of Massachusetts considers a pH of 6.5 to 8.3 a healthy range for waterbodies in the state. Since 2010 pH has been within the acceptable range at Crackrock pond, except once in 2019 (Figure 5).

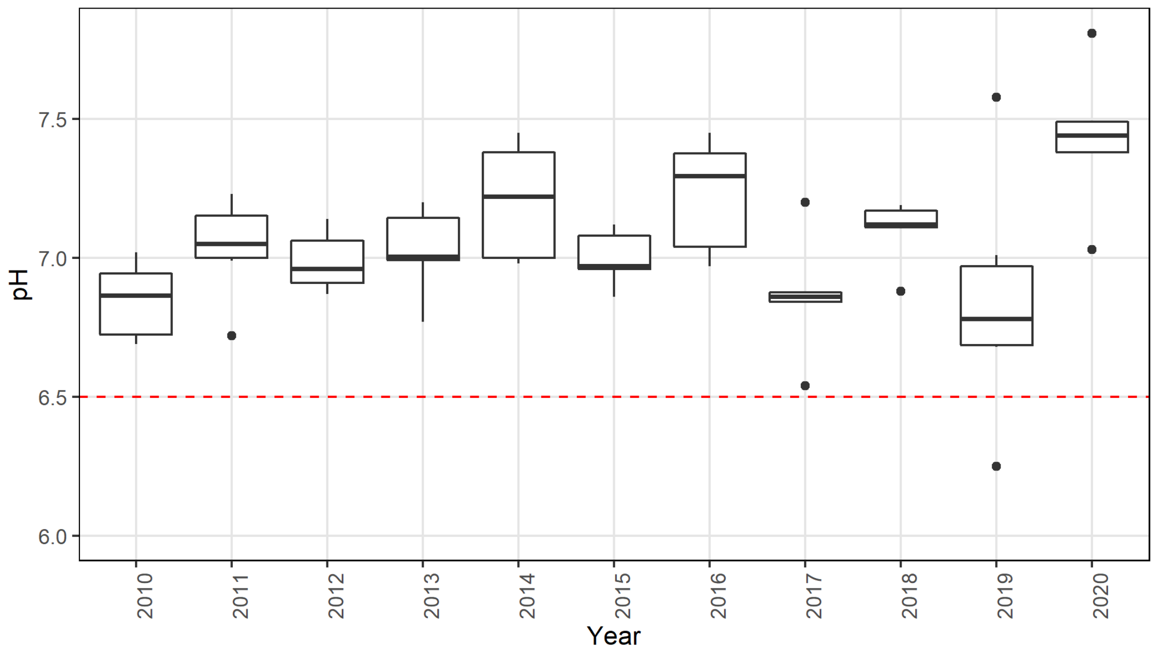

Figure 5: The pH levels at Crackrock pond for years 2010 through 2020. Boxplots statistics are the same as Figure 2.

Dissolved Oxygen:

The state of Massachusetts considers DO levels below 5 mg/L to be stressful to all aquatic organisms and 6 mg/L to be stressful to certain species of fishes that require colder water. At this site, we apply the 5 mg/l threshold.

Dissolved oxygen concentrations have consistently been lower than 5mg/l at Crackrock pond since 2010 (Figure 6). In 2020, dissolved oxygen concentrations were less than 2mg/l in June, July, and September (DO = 1.16 mg/l, 1.39 mg/l, and 0.44 mg/l, respectively), which are hypoxic conditions in the beginning of the summer and anoxic conditions at the end of the summer. In October, the water sampler noted that the water odor was earthy and rotten eggs, which suggests the presence of anaerobic bacteria decomposing organic matter and producing hydrogen sulfide.

Total Phosphorus levels are high at this site, so it is possible plant and algae growth and decomposition contribute to the low levels of dissolved oxygen. Additionally, water temperatures rose from 13°C in May to 22.5°C in June, which could have fueled the rapid decrease in dissolved oxygen (Figure 4). Temperatures in July and August measured 25°C and 27°C, respectively, and warm water has less capacity to hold dissolved oxygen. It would be interesting to investigate the impact of releases from the Neponset Reservoir on dissolved oxygen concentrations in Crackrock pond – it is possible that low releases lead to more stagnant water and less opportunity for atmospheric mixing. It is also possible that if water is released from low levels in the Neponset Reservoir, the water is arriving to Crackrock pond with low dissolved oxygen levels.

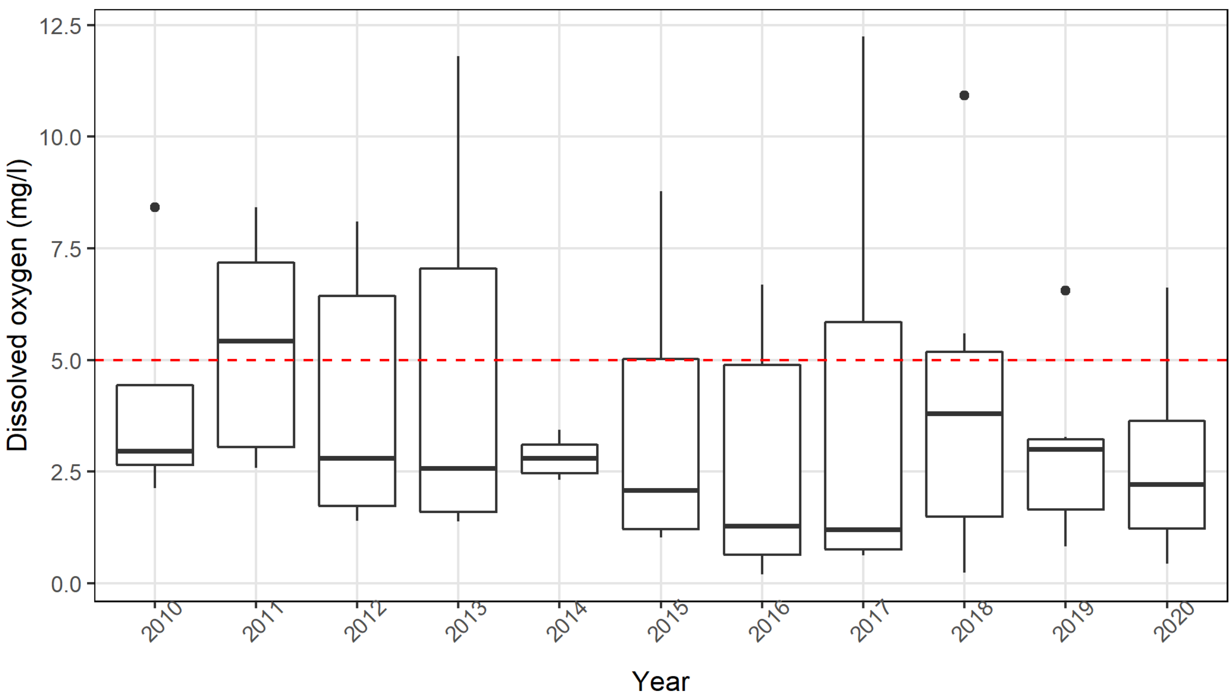

Figure 6: Dissolved oxygen levels at Crackrock pond. The red dashed line is at DO = 5mg/l.

Conclusion

The water quality data that we collect through the CWMN program is used to inform our messaging to the public and follow up site visits to sites to investigate problems (hot spot sampling). Table 4 details our recommendations and items to discuss with the Town.

Table 4: Major parameters of concern at Crackrock pond with recommendations on first steps to address the problem. TP = total phosphorus, DO = Dissolved oxygen.

Site	Parameter	Recommendation

NER002	TP	• Investigate the new source of phosphorus that is causing high concentrations since 2017. • Reduce all know forms of nutrient runoff toward this site. • Assess runoff during dry weather. • Monitor for primary producer growth at this site.

	DO	• Reduce all forms of nutrient runoff toward this site
		• Consider adding in mechanical aeration
		• Decrease the residence time of the water in the pond
		• Evaluate potential influence of Neponset Reservoir management practices on Crackrock Pond
		  ○ How much water is released?
		  ○ What is the depth of water that is released?