2021 Water Quality Report, Foxborough, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data both in Foxborough and throughout the Neponset River watershed since 1996. As part of the Community Water Monitoring Network (CWMN), volunteers collect monthly water samples annually from May to October. Data gathered by the CWMN volunteers are used to track the health of the Neponset River and its tributaries, inform the public about threats to human health and wildlife, 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 following report summarizes the findings for the 2021 season, with raw water quality data available upon request. The parameters discussed in this report are limited to those that have state standards, namely *E. coli*, total Phosphorus, pH, and dissolved oxygen.

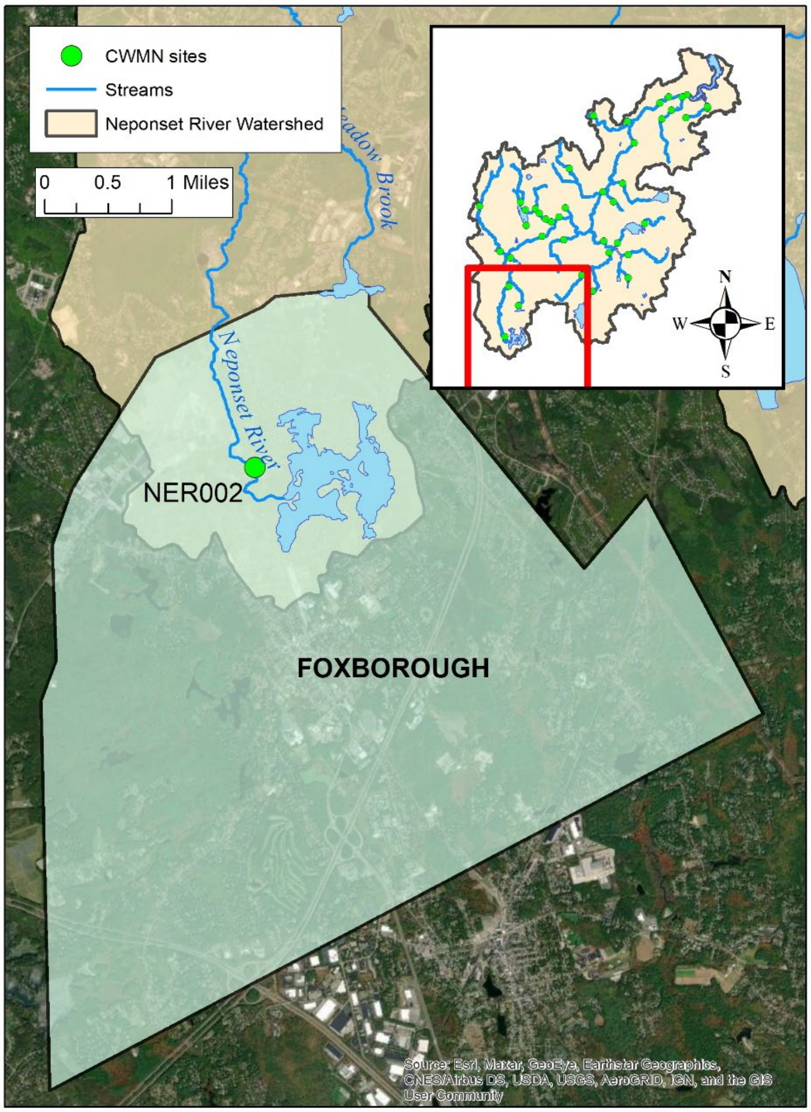

Figure 1: Map of the CWMN site in Foxborough, Massachusetts.

E. coli bacteria concentration is used by NepRWA and the Commonwealth to assess a waterbody's safety for "contact recreation" through activities such as swimming (primary contact) and boating (secondary contact). The presence of E. coli is not necessarily hazardous itself, but it provides evidence of fecal contamination and is an indicator that other, more dangerous, pathogens associated with human and animal waste might be present. The most common source of excess E. coli in our watershed is the 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, so some amount of E. coli in waterbodies is normal. However, elevated concentrations from wildlife are typically due to human activities, such as feeding ducks or large populations of geese. 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. This means that plants and algae will grow until the lack of phosphorus limits them. 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, leading to a process called eutrophication. When these excess plants and algae die, the process of decomposition by bacteria and other decomposers consumes dissolved oxygen from the water. 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 loss of underwater plant communities due to reduced light penetration in turbid and algae-rich waters. Elevated phosphorus concentrations can also cause harmful algal blooms (HABs), where toxins are produced by the algae. A notable culprit is cyanobacteria, which produce toxins harmful to people and pets as well as wildlife.

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, from fine dust particles and aerosols. 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 acidic the water is, with low pH meaning the water is more acidic than neutral, and high pH meaning it is more basic or alkaline. Water that is too acidic or too basic can be toxic to aquatic life. The pH is influenced by soil and bedrock characteristics, groundwater seepage, acid rain, carbon dioxide in the atmosphere, 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 can sustain higher concentrations 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 increase levels of DO due to atmospheric mixing. Aquatic plants also generate oxygen via photosynthesis during daytime hours. 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 rain or shine on the second Thursday of the month during the sampling season. This means that weather is not a criterion in determining when to collect water quality data. This allows our sampling program to address the different conditions that occur in our waterbodies in wet vs. dry weather. Rain events result in significant increases in street runoff via stormwater and overland flow into our rivers, which can significantly alter the concentrations of bacteria, nutrients, and other chemicals. In 2021, 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, both 2021 and 2020 had more sampling events occur during dry weather than any year since 2016, when all six sampling events occurred during dry weather. This lack of additional data during wet weather suggests we should be cautious in any improvements in parameters, especially for *E. coli*, as the relative improvement may reflect wet vs. dry dynamics rather than real improvements to water quality or 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 2011.

Year	Dry (days)	Wet (days)
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
2021	5	1

Escherichia coli (E. coli)

In Massachusetts, the criteria that defines acceptable levels of *E.coli* in Class B waterbodies (waterbodies that support wildlife, swimming, and boating, but not drinking) is set by both single sample maximum and a geometric mean. For Crackrock Pond, no single sample should exceed 235 Colony Forming Units (CFU) per 100 mL (the single sample standard), nor should the geometric mean of at least 5 samples taken within the same season exceed 126 CFU/100mL (the seasonal standard). For ease of interpretation, NepRWA calculates the geometric mean on the whole sampling season (6 sampling events).

In 2021 maximum *E. coli* levels in Crackrock Pond were less than the single sample standard threshold (*E. coli* maximum = 156 CFU/100mL) and the geometric mean of samples for the season was 62 CFU/100mL (Table 2). This is a slight increase over last year's values, but below the state threshold and demonstrates that E. coli is not a persistent concern at this site. However, 4 years have had samples above the single sample maximum, suggesting there are occasional issues with *E. coli*, all tied to wet weather events.

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 values represent a measure above the state criteria, bolded years represent failure of either single sample maximum or season geometric mean.

Year	Maximum	Mean	Minimum	Geometric mean
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
2021	156	82	20	62

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 2021 the maximum concentration was found during dry weather (156 CFU/100mL compared to a maximum of 135 CFU/100mL during the only wet weather sampling event).

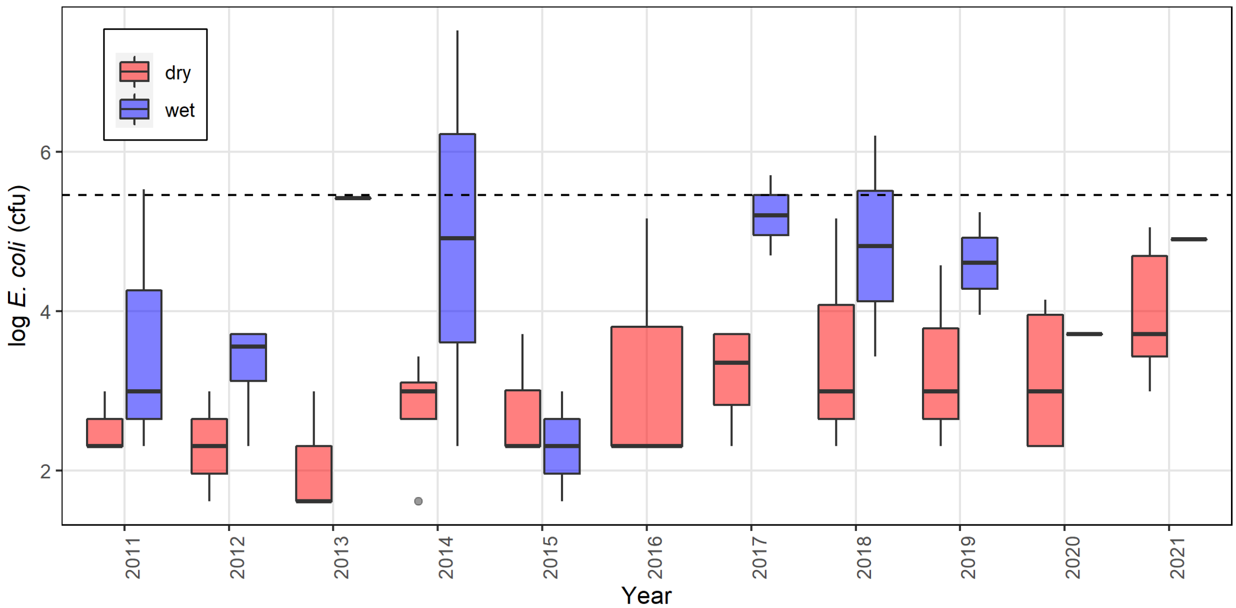

Figure 2: *E. coli* levels at Crackrock pond in Foxborough, MA from years 2011 to 2021 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed line shows the single sample maximum acceptable threshold (235 CFU/100mL). The lower and upper bounds of each box correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends to the largest value or no further than 1.5 * the range between these two quartiles. Similarly, the lower whisker extends from the hinge to the smallest value or 1.5 * this interquartile range. Data beyond the end of the whiskers are "outlying" points and are plotted individually.

Phosphorus

The Commonwealth of Massachusetts does not currently provide numerical standards for classification of water quality impairments by phosphorus alone. Instead, the Massachusetts Department of Environmental Protection (MassDEP) uses a narrative standard that considers the EPA gold book standard for phosphorus alongside dissolved oxygen levels and excessive primary producer growth. The EPA gold book standard identifies an 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 water within a lake/reservoir. 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 and 2021 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 2021 at Crackrock pond. N=6.

Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
0.59	0.38	0.26	0.025

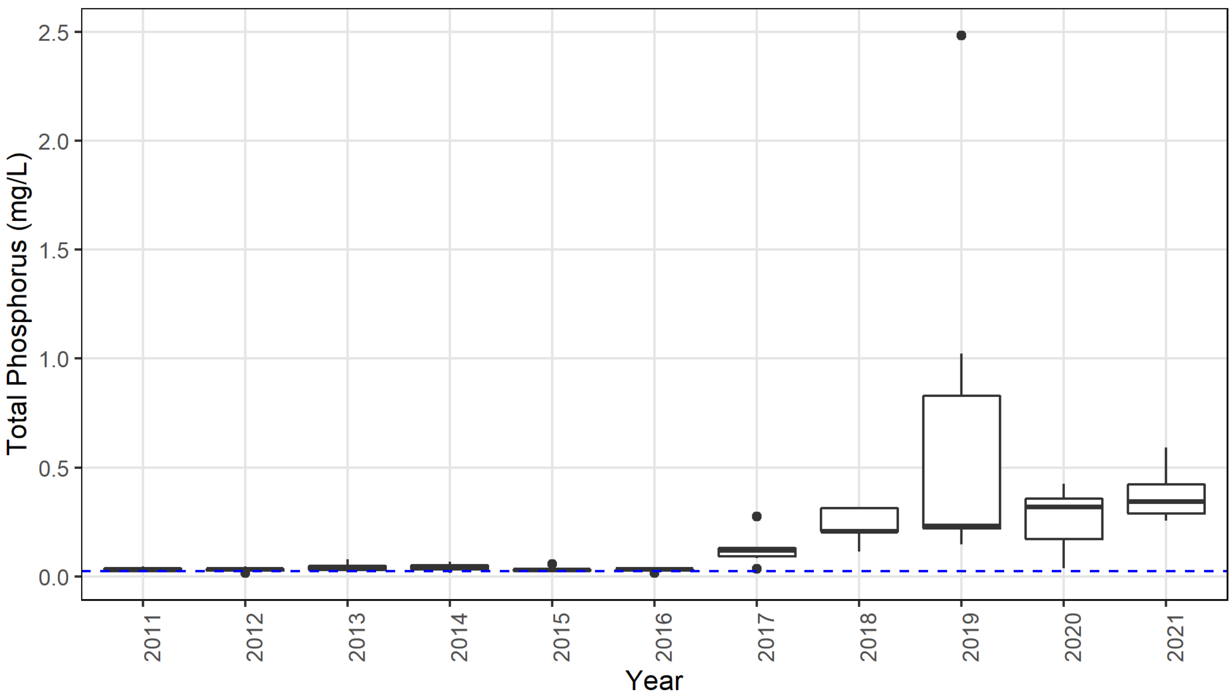

Figure 3: Total phosphorus levels at Crackrock pond from year 2011 to 2021. The blue dashed line is at 0.025mg/l. Boxplot statistics are the same as Figure 2.

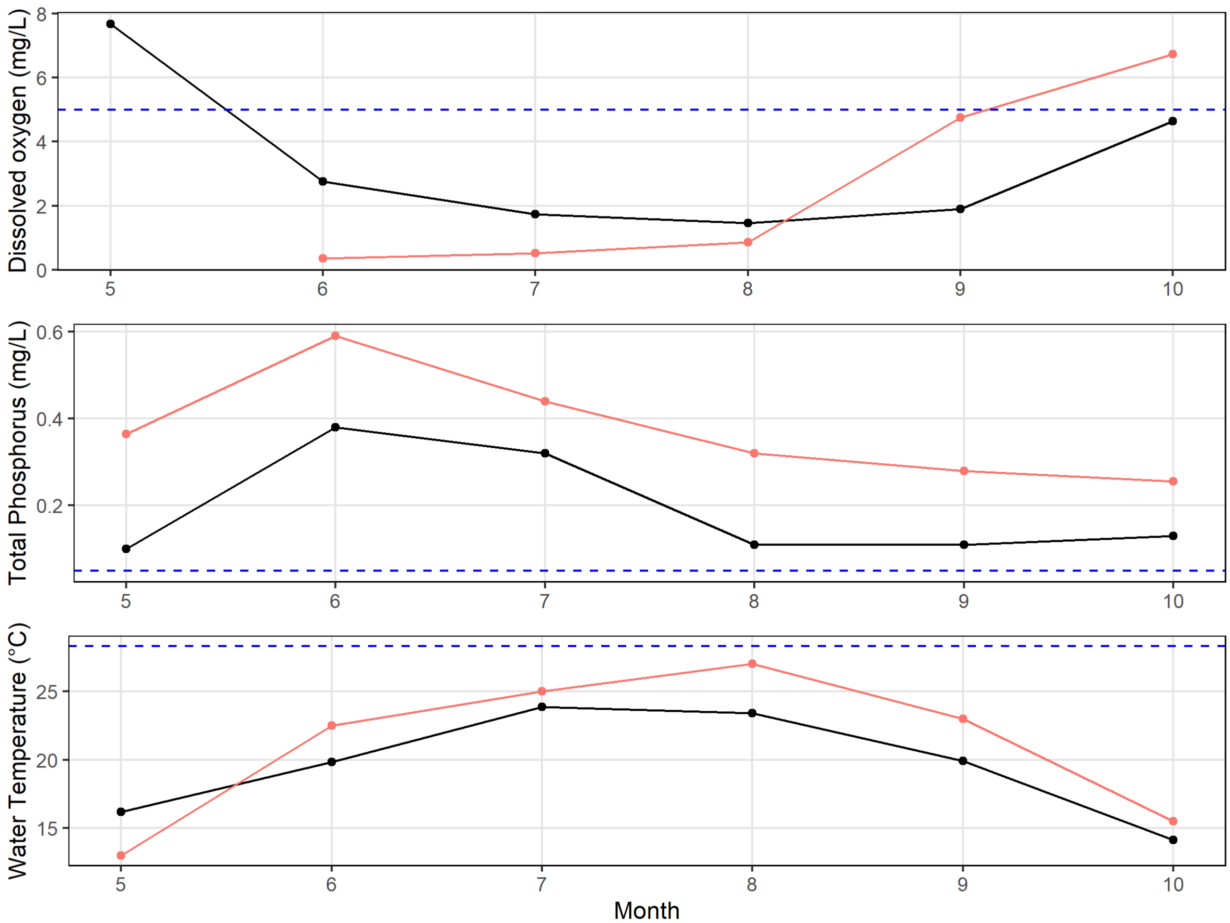

Figure 4: Monthly dissolved oxygen levels (top plot), total Phosphorus (middle plot), and water temperature (bottom plot) levels at Crackrock pond. The black line shows the mean monthly value from 2011 to 2021 and the red line shows the 2021 values. The blue dashed line is at 5mg/l in the top plot, and at 0.025mg/l in the middle plot.

It is important to note that the Massachusetts DEP requires 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. A more quantitative survey of plant coverage would assist in having this site listed as impaired for phosphorus.

pH

The Commonwealth of Massachusetts considers a pH of 6.5 to 8.3 a healthy range for waterbodies in the state. Since 2011, pH has been within the acceptable range at Crackrock pond, except once in 2019 (Figure 5). However, in 2021 pH values were outside the acceptable range in 2 instances, in our May and June samples. Given the unlikely swing between highly acidic and highly basic, these values were likely aberrant, but future data will clarify if pH is becoming an issue on site.

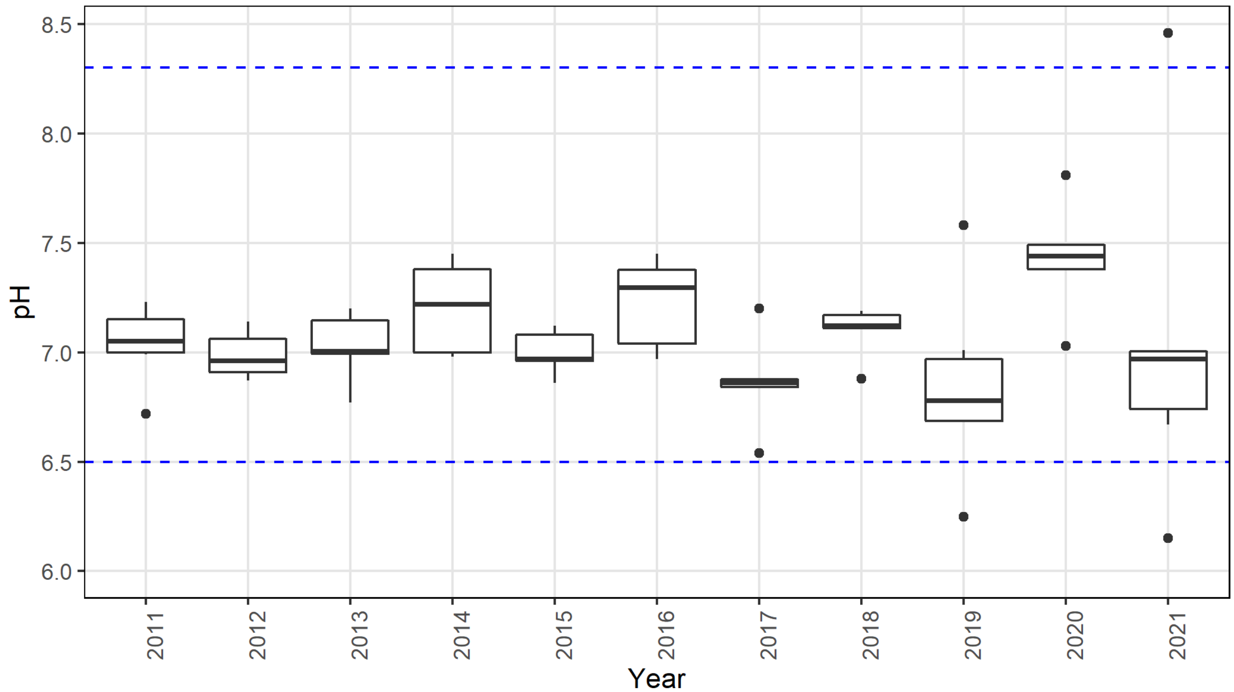

Figure 5: The pH levels at Crackrock pond for years 2011 through 2021. Blue dashed lines represent pH of 6.5 and 8.3 respectively. Boxplots statistics are the same as Figure 2.

Dissolved Oxygen:

The Commonwealth 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, as it has not been designated a Coldwater Fish Resource by the Division of Fish and Game.

Dissolved oxygen concentrations have consistently been lower than 5mg/L at Crackrock pond since 2011 (Figure 6). In 2021, dissolved oxygen concentrations were less than 1 mg/L in June, July, and August (DO = 0.35 mg/L, 0.52 mg/L, and 0.86 mg/L, respectively), and May data was excluded due to sampling issues. These are anoxic conditions at the throughout the summer. In the past two years, the water sampler noted that the water odor was earthy and smelling of rotten eggs on multiple occasions, 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 15°C in May to 24°C in June, which is a strong heating effect. This both lowers the amount of oxygen capable of being dissolved and creates better growth conditions for algae, which might have fueled the rapid decrease in dissolved oxygen (Figure 4). Crackrock Pond also has the Neponset Reservoir directly upstream of it, which may be contributing to both low dissolved oxygen and high phosphorus. A study of the inflowing water would likely be informative in developing a management plan for these issues.

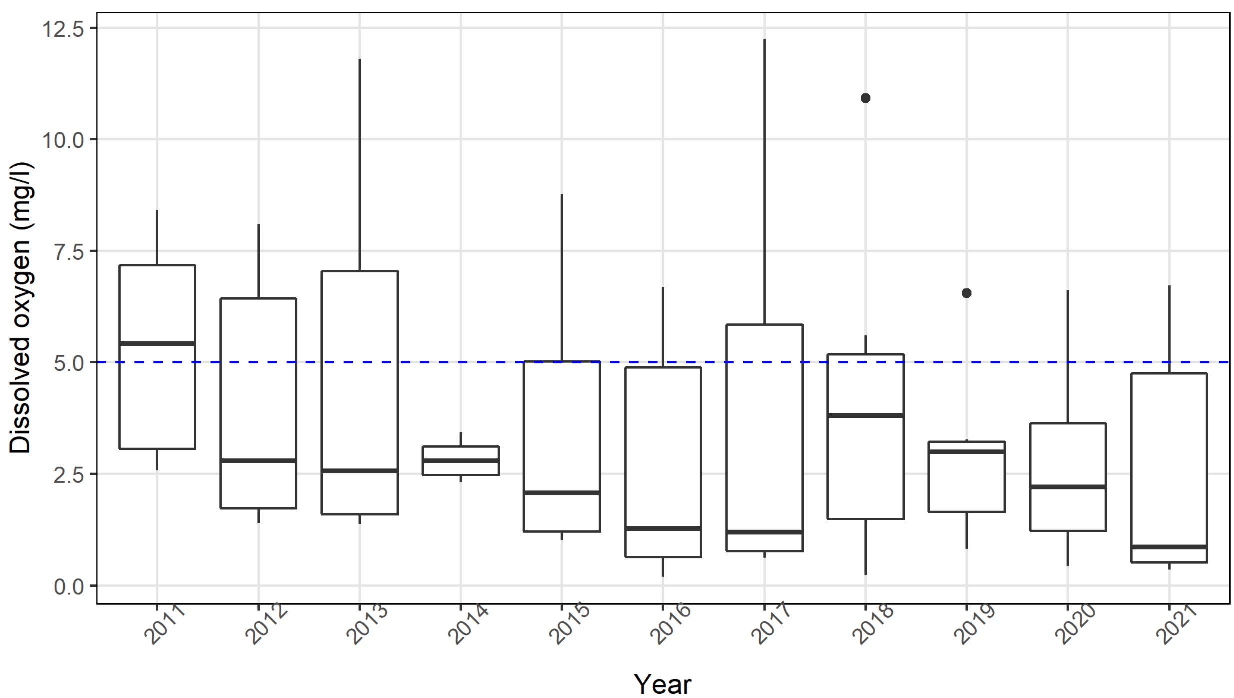

Figure 6: Dissolved oxygen levels at Crackrock pond. The blue dashed line is at DO = 5mg/L.

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, including inflows from Neponset Reservoir • Assess runoff and inflows during dry weather. • Quantitatively monitor for primary producer growth at this site for DEP phosphorus impairment.

	DO	• Reduce all forms of nutrient runoff toward this site
		• Consider adding in mechanical aeration at inflow
		• Adjust impoundment to increase flow and decrease the residence time of water within the pond.
		• Investigate the status of DO in incoming water from the Reservoir
		    o How much water is released?
		    o What is the depth of water that is released?
		    o What is the oxygen and phosphorus concentration?