2020 Water Quality Report, Dedham, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data in Dedham 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 Dedham on Mother Brook (Figure 1), which is tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature once per month between May and October. The raw water quality data are available upon request.

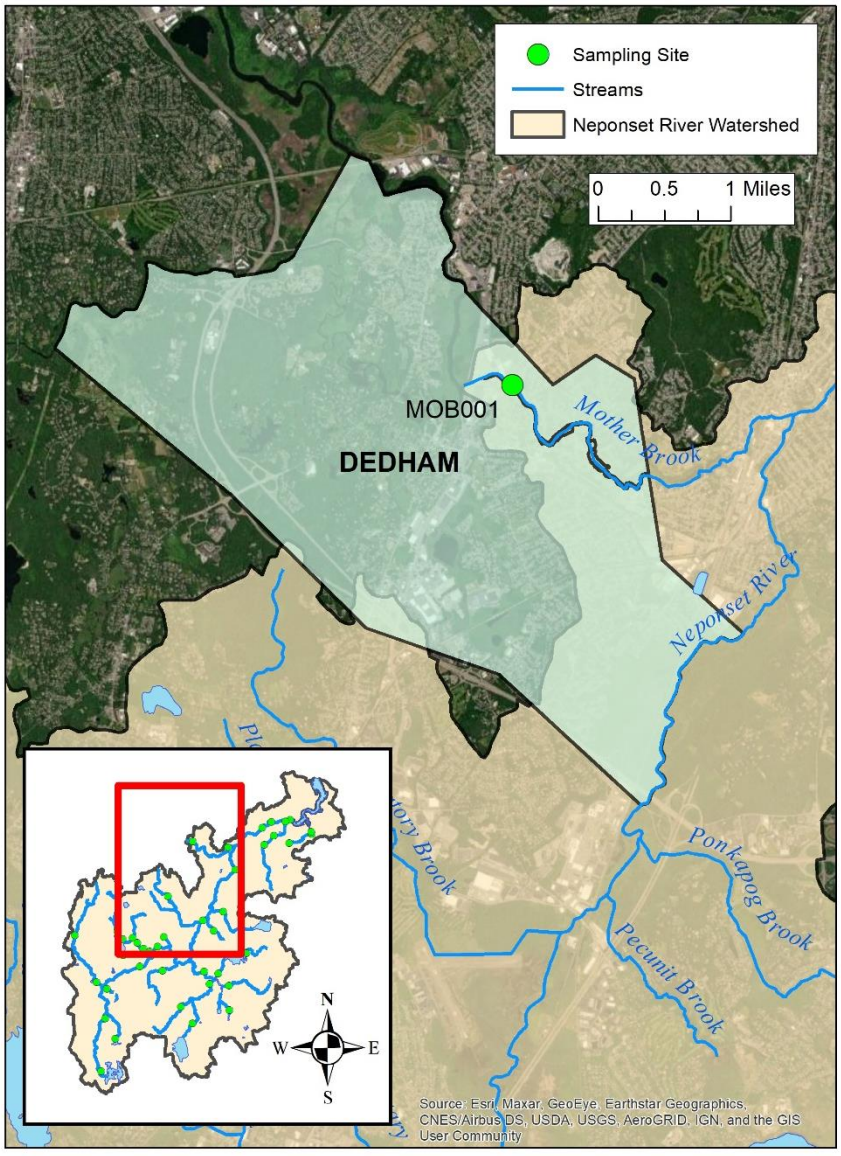

Figure 1: Map of the CWMN sites in Dedham, Massachusetts.

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 at the Mother Brook site were within the single sample standard for the first time in 10 years (Table 2). Levels of *E. coli* in 2020 were also below the seasonal sample limit, for the first time since 2013. The 2020 wet weather sample maximum was 199 cfu/100ml (N=1) and the dry weather sample maximum was 185 cfu/100ml (N=5), suggesting that the excess runoff during precipitation was not contaminated with high levels of *E. coli* like it was in previous years (Figure 2). In 2018, we investigated the high levels of *E. coli* and identified the source of contamination as the Dedham Transfer Station. The Dedham Engineering and Public Works Departments were altered of this, and the station was officially closed in 2019, which led to the lower *E. coli* concentrations in 2020 (good news!).

Table 2: The maximum, average, minimum, and geometric mean *E. coli* concentrations at the site on Mother Brook (MOB001) in Dedham, MA, since year 2010. N=6. Units are in cfu/100ml.

Year	Maximum	Average	Minimum	Geometric Mean
2010	740	190	41	105
2011	3450	653	5	94

2012	19900	3538	5	261
2013	288	100	10	60
2014	1200	337	109	191
2015	1940	735	98	457
2016	591	235	52	161
2017	3260	1327	74	569
2018	24200	9237	62	2160
2019	3870	716	20	132
2020	199	116	20	93

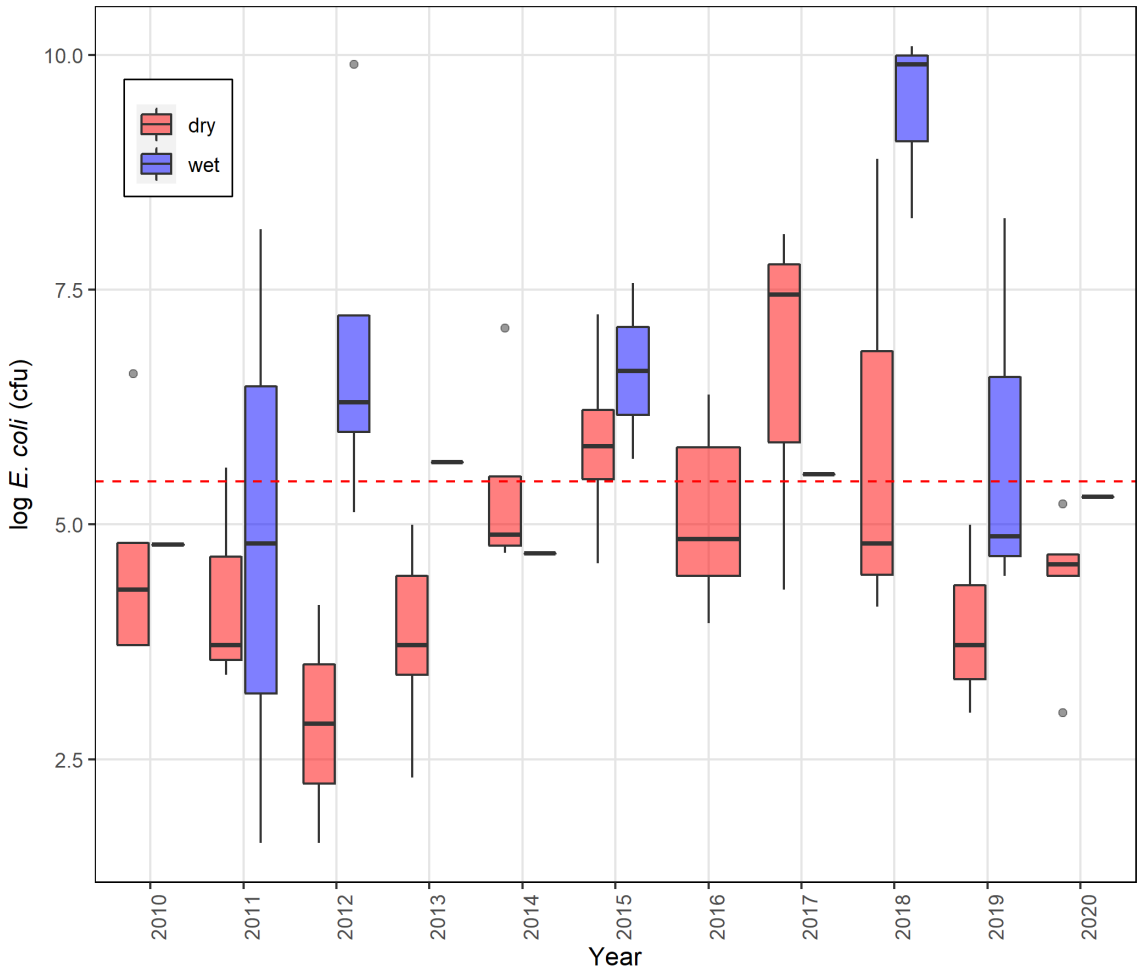

Figure 2: *E. coli* levels at Mother Brook in Dedham, MA from years 2010 to 2020 – note the log scale. The plot shows levels grouped by weather (blue = wet, red = dry). The red dashed line at y = log(235) shows the single sample maximum acceptable threshold. Boxplot statistics: The lower and upper hinges 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 an average of at least three samples exceeding 0.1mg/l as the upper threshold for flowing waters and 0.05mg/l for streams entering a lake/reservoir. We considered the Mother Brook site in Dedham to be entering a lake or reservoir. 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 seasonal average total Phosphorus level in 2020 was 0.06 mg/l, which is just above the threshold for waters entering a lake or reservoir (Table 3). Since 2010 seasonal averages have ranged from 0.05mg/l to 0.08 mg/l in 2018 due to a large outlying value (Figure 3).

Table 3: The maximum, average, and minimum values of total phosphorus recorded during 2020 at Mother Brook in Dedham, MA. N=6.

Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
0.11	0.06	0.03	0.05

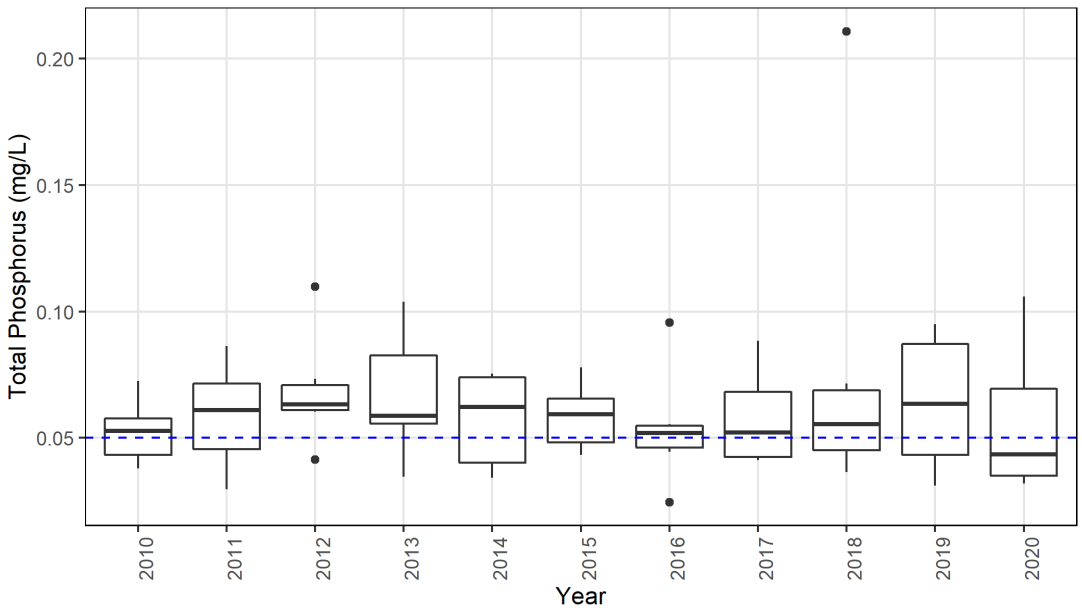

Figure 3: Total phosphorus levels at Mother Brook in Dedham, MA from year 2010 to 2020. The blue dashed line is at 0.05mg/l. Boxplot statistics are the same as Figure 2.

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. While we do not have primary producer data at this site, there is a strong negative correlation between total Phosphorus levels and dissolved oxygen levels (R^2 = -0.55), which can be a symptom of eutrophication. While dissolved oxygen levels are not considered low at this site, the strong relationship with total Phosphorus implies that it is important to maintain low nutrient levels.

pH

The state of Massachusetts considers a pH range between 6.5 and 8.3 to be healthy for waterbodies in the state. Since 2010 pH levels have been within the acceptable range at the Mother Brook site except during one sampling event in 2020 (Figure 4). The July water sample had a pH of 6.13, which is too acidic, but all other samples that year had near neutral values. It is not clear what could have caused the low reading and an instrument error or recording error is always possible. Future years of data will show whether the water is becoming more acidic or whether this was a one-time event.

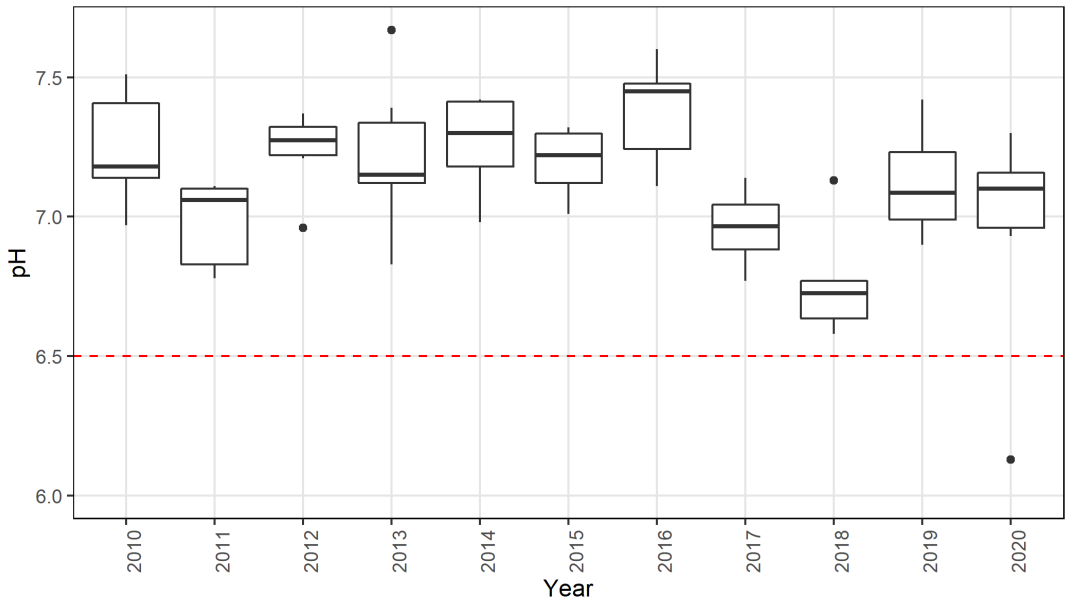

Figure 4: The pH levels at the eight sites in Dedham for years 2010 through 2020. Boxplots statistics are the same as Figure 2.

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. Mother Brook is not listed as a cold-water resource by the Massachusetts Division of Fisheries and Wildlife so we use the 5 mg/l threshold.

Dissolved oxygen levels in 2020 were similar to the 10-year average levels (Figure 5). Trends in seasonal dissolved oxygen are likely driven by stream temperatures and nutrient enrichment. Ten years of data shows that DO levels are typically above the stressful threshold except in 2018 when the June and July levels were DO = 1.7mg/l and DO = 2.3mg/l, respectively (Figure 6). The June 2018 total Phosphorus concentration was 0.21mg/l, which could have fueled plant growth and a subsequent reduction in DO. Considering the 10 years of data shown in Figure 6, the hypoxic conditions in 2018 appear to be an anomalous, but it would be helpful to understand what environmental conditions created the hypoxic stream conditions to prevent that in the future.

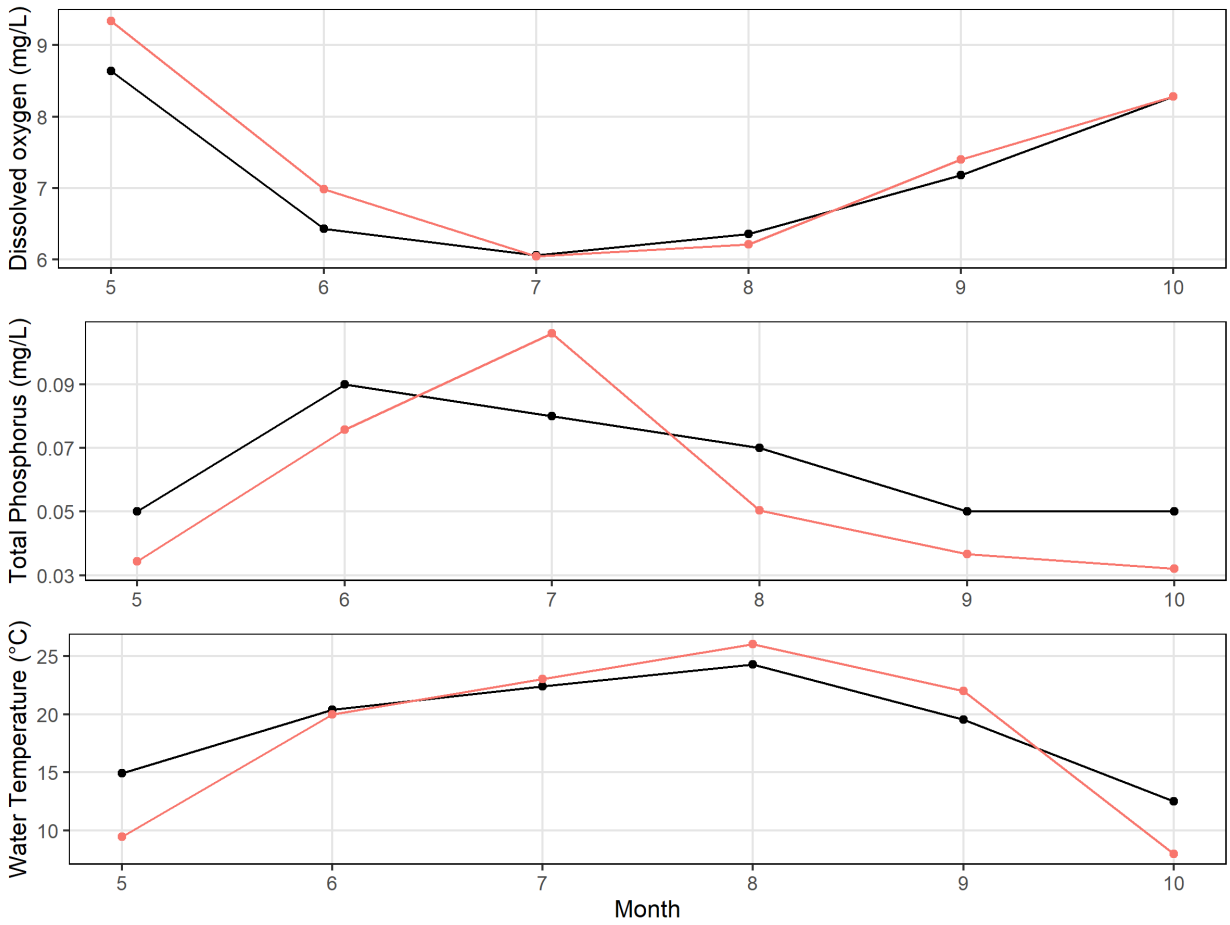

Figure 5: Monthly dissolved oxygen levels (top plot), total phosphorus levels (middle plot) and water temperature levels (bottom plot) at Mother Brook in Dedham. The black line shows the mean monthly value from 2010 to 2019 and the red line shows the 2020 values.

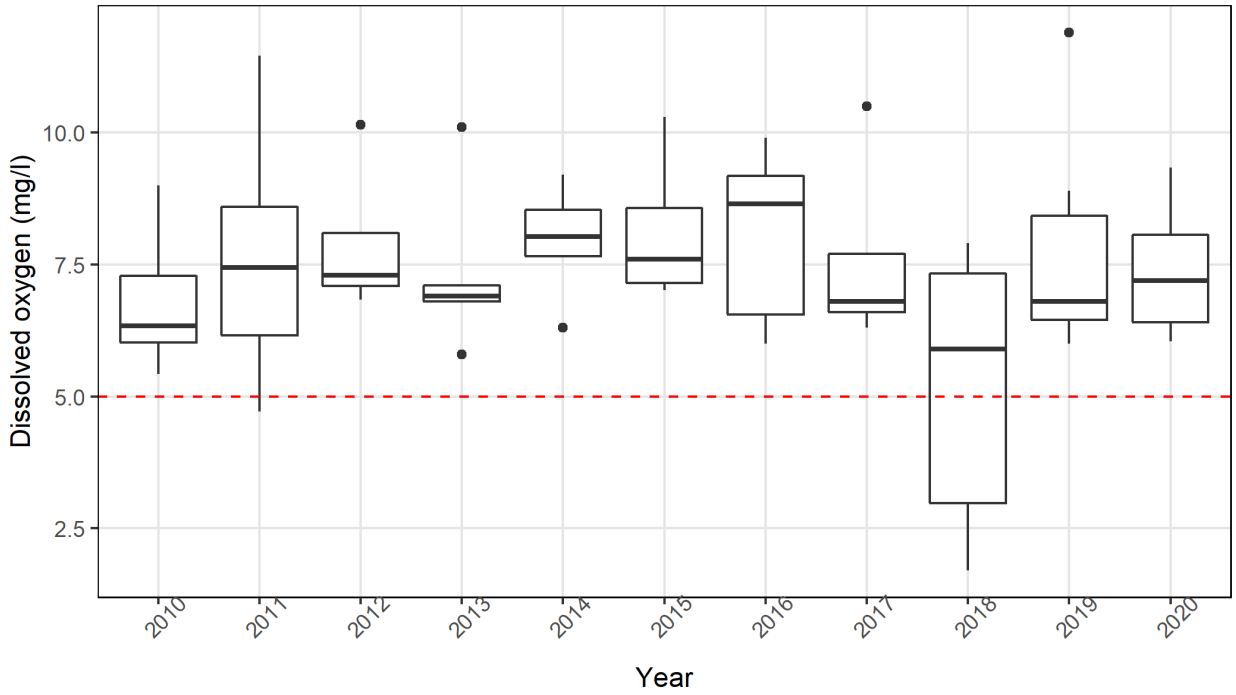

Figure 6: Dissolved oxygen levels at Mother Brook in Dedham, MA, from year 2010 to year 2020. N=6 for each year. The red dashed line is at DO = 5mg/l.

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 by site with recommendations on first steps to address the problem.

Site	Parameter	Recommendation
MOB001	TP	• Identify sources of phosphorus and aim to reduce concentrations -including areas upstream on the Charles River. • Monitor for plant and algae growth to identify ecological impacts of the high phosphorus concentrations.
MOB001	*E. coli*	• Continue to monitor to ensure that the levels remain low following the closure of the Dedham Transfer Station.