2023 Water Quality Report, Dedham, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data both in Dedham 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 Dedham, located on Mother Brook (Figure 1), which is tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature. The following report summarizes the findings for the 2023 season, with raw water quality data available upon request.

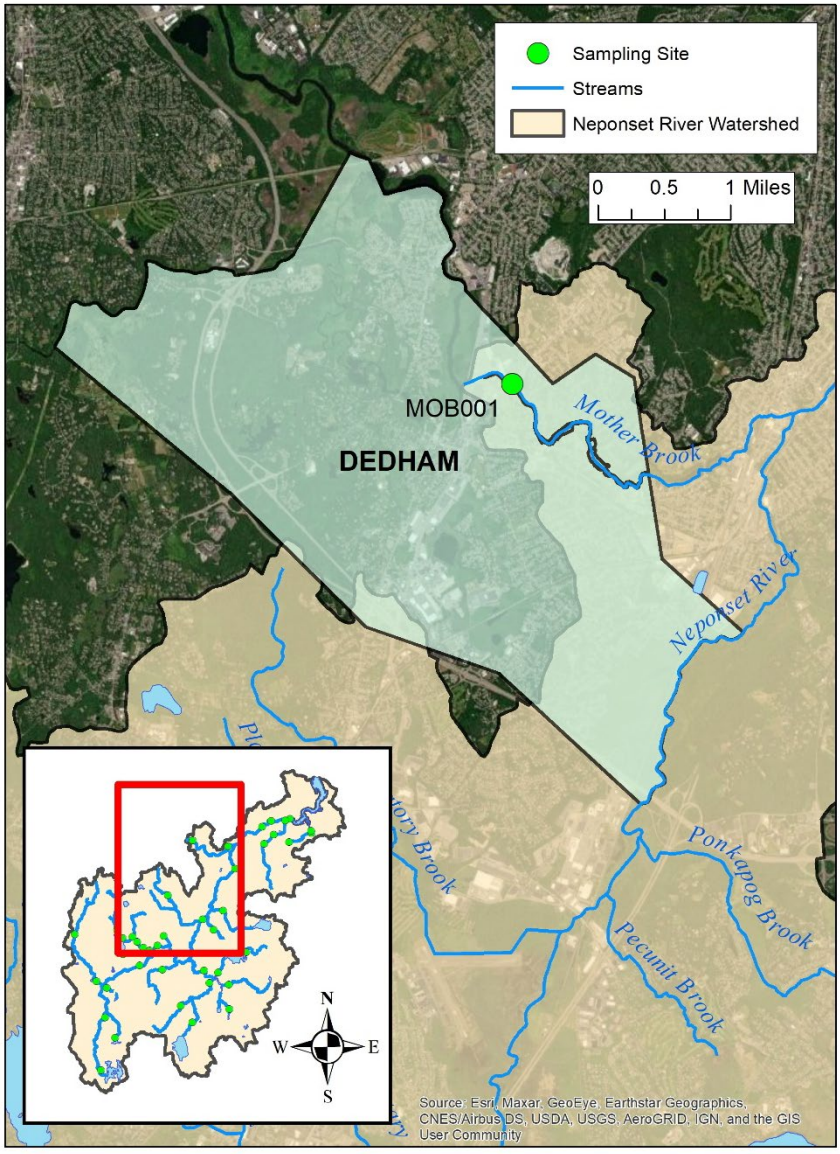

Figure 1: Map of the CWMN sites in Dedham, Massachusetts.

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 or infiltration 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, particularly in overnight hours when decomposition is not offset by active photosynthesis. 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 withdrawals / 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 2023, two sampling days occurred during wet periods and four sampling days occurred during dry periods, matching the 10-year average, while overall the region experienced above average precipitation. 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, the wet/dry ratio of sampling events can vary substantially year-to-year, and may not always reflect drought or flood years. For example, 2021 and 2020 had all but one sampling event occur in dry weather, despite being a drought and flood year respectively. This variability in wet weather sampling suggests we should be cautious in any improvements or changes in parameters, especially for *E. coli*, as the relative improvement may reflect wet vs. dry dynamics more than real improvements to water quality or changes in the frequency of sewage spills. As climate change shifts precipitation patterns, a change in sample collection or weighting may be needed to track water quality changes.

Table 1: The number of water quality sampling days that occurred during dry or wet weather since year 2013.

Year	Dry (days)	Wet (days)
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
2022	2	4
2023	4	2

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) was formerly set by a single sample maximum (235 Colony Forming Units (CFU) per 100 mL) and geometric

mean calculation (not to exceed 126 CFU/100mL). State level assessment of bacterial impairment now have criteria set by both a statistical value threshold (<10% of samples should exceed 410 CFU/100mL) and a rolling geometric mean calculation (not to exceed 126 CFU/100mL in 20% of windows). Because NepRWA's sampling is performed monthly rather than weekly, and the purpose of these reports is to provide meaningful historic comparison, the new criteria will not be applied in this report. For Mother Brook, this means no single sample should exceed 235 CFU/100 mL (the single sample standard), nor should the geometric mean of at least 3 sequential samples taken within the same season exceed 126 CFU/100mL (the seasonal standard). For ease of interpretation and for historic comparison, NepRWA calculates the geometric mean on the whole sampling season (6 sampling events).

In the last 10 years *E. coli* levels at the Mother Brook have exceeded the state standards for single sample maximum in every year except 2020. However, since 2020, only 1 year has failed to meet the seasonal geomean (Table 2). In our past reports, we noted this potentially pointed to improvements following the closure of the Dedham Transfer Station in 2019. The 2021 season showed a slight increase in *E. coli* levels, however, both 2022 and 2023 demonstrated a return to lower values. This is despite the increase in wet weather sampling days in 2022. Only 1 sample exceeded the single sample maximum criteria, during a wet weather sample in August. All data since 2020 is well below the maximum and average values from 2017 – 2019, suggesting that the improvements represent a marked decrease in *E. coli* levels (Figure 2).

Table 2: The maximum, average, minimum, and geometric mean *E. coli* concentrations at the site on Mother Brook (MOB001) in Dedham, MA, since year 2013. N=6. Units are in CFU/100mL. Bolded values represent a measure above the former state criteria, bolded years represent failure of either single sample maximum or season geometric mean.

Year	Maximum	Average	Minimum	Geometric Mean
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
2021	**437**	200	30	**142**

2022	**256**	101	31	70
2023	**373**	111	10	54

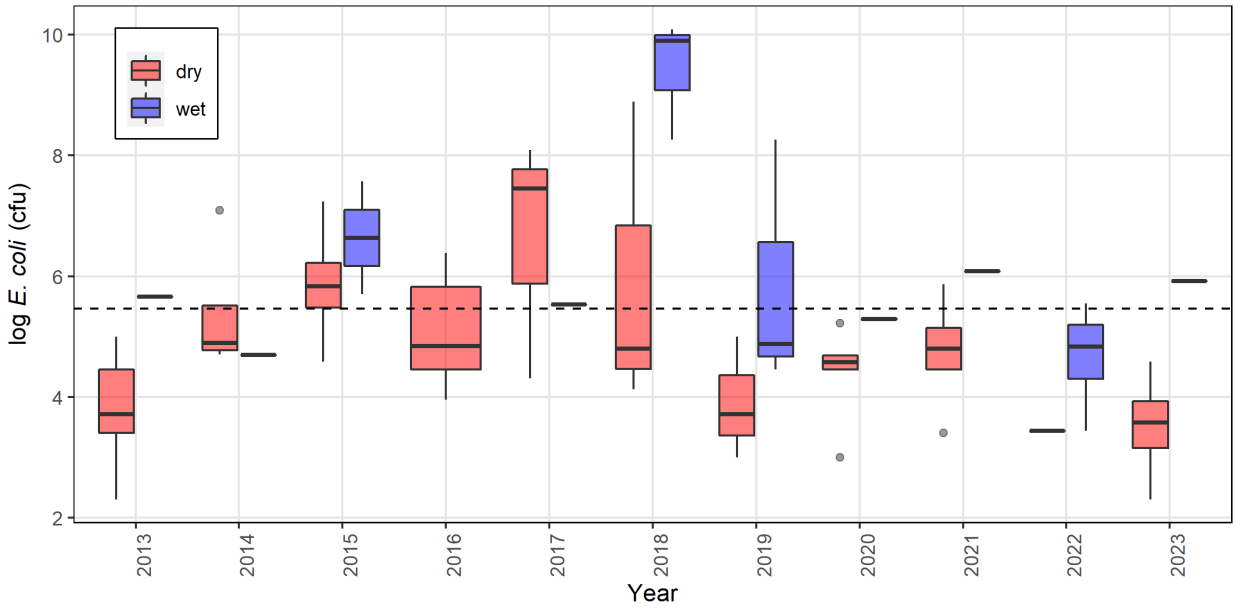

Figure 2: *E. coli* levels at Mother Brook in Dedham, MA from years 2013 to 2023 – note the log scale. The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed line shows the single sample maximum acceptable threshold (235 CFU/100mL). The lower and upper bounds of each box correspond 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 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 due to the Mill Pond downstream. 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 2023 was 0.06 mg/L, which is above the threshold for waters entering a lake or reservoir (Table 3). Since 2013, seasonal averages have ranged from 0.05 mg/L to 0.08 mg/l, with occasional large outliers such as in 2018 (Figure 3). In 2023, values were relatively consistent with historic trends. Overall, phosphorous levels appear to be relatively consistent, though above the criteria for concern. An examination of downstream algae and macrophyte growth may assist in determining the impact of these exceedances.

Table 3: The maximum, average, and minimum values of total phosphorus recorded during 2023 at Mother Brook in Dedham, MA. N=6.

Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
0.09	0.06	0.04	0.05

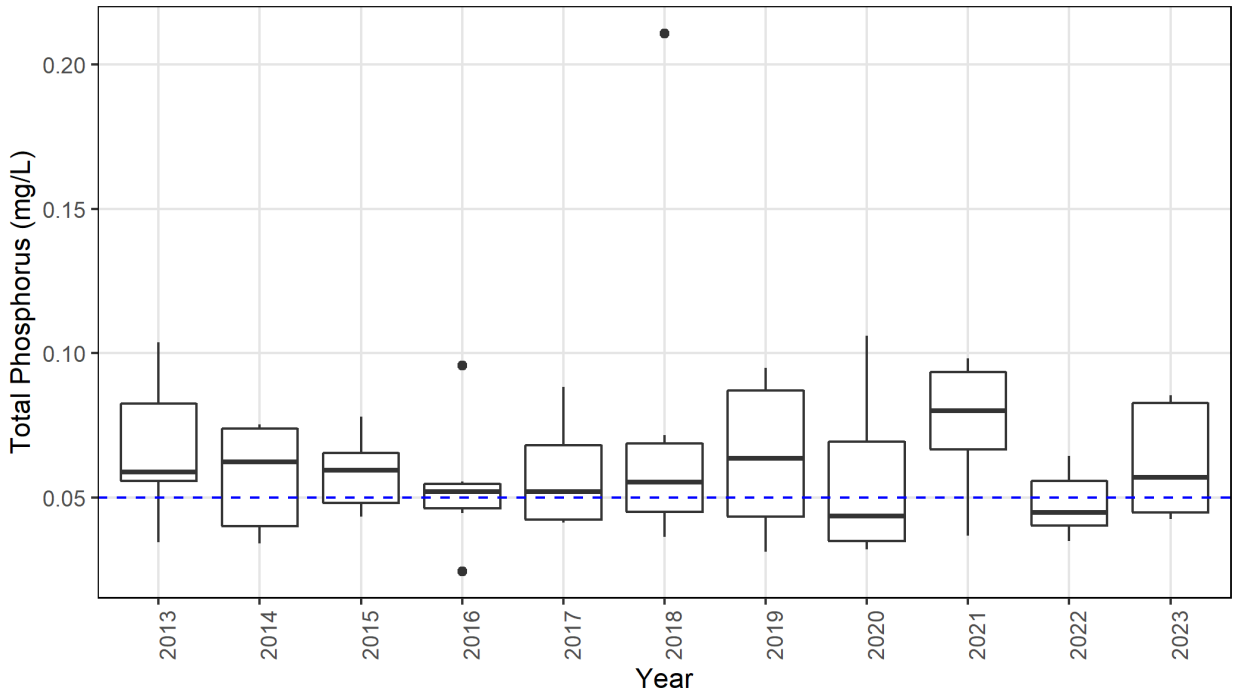

Figure 3: Total phosphorus levels at Mother Brook in Dedham, MA from year 2013 to 2023. The blue dashed line is at 0.05mg/l. Boxplot statistics are the same as in Figure 2.

It is important to note that the Massachusetts DEP asks for additional information to help identify a problem with total phosphorus, such algae or other primary producer data. While we do not have primary producer data at this site, there is a moderately negative correlation between total phosphorus levels and dissolved oxygen levels (R = -0.58) over the last 10 years,

suggests eutrophication may be a concern. While dissolved oxygen levels are not considered low at this site, the strong negative relationship with total Phosphorus implies that it is important to maintain low nutrient levels to ensure sufficient oxygen.

pH

The Commonwealth of Massachusetts considers a pH range between 6.5 and 8.3 to be healthy for waterbodies in the state. Since 2012, pH levels have been within the acceptable range at the Mother Brook site except during one sampling event each in 2020 and 2021 (Figure 4). The October water sample had a pH of 6.26, which is too acidic, but all other samples that year had near neutral values. Additionally, pH in 2022 was lower than typical at this location, however the drought impacts may significantly alter normal flow conditions. Values in 2023 were consistent with the 10 year average and thus pH is not a large concern at this site.

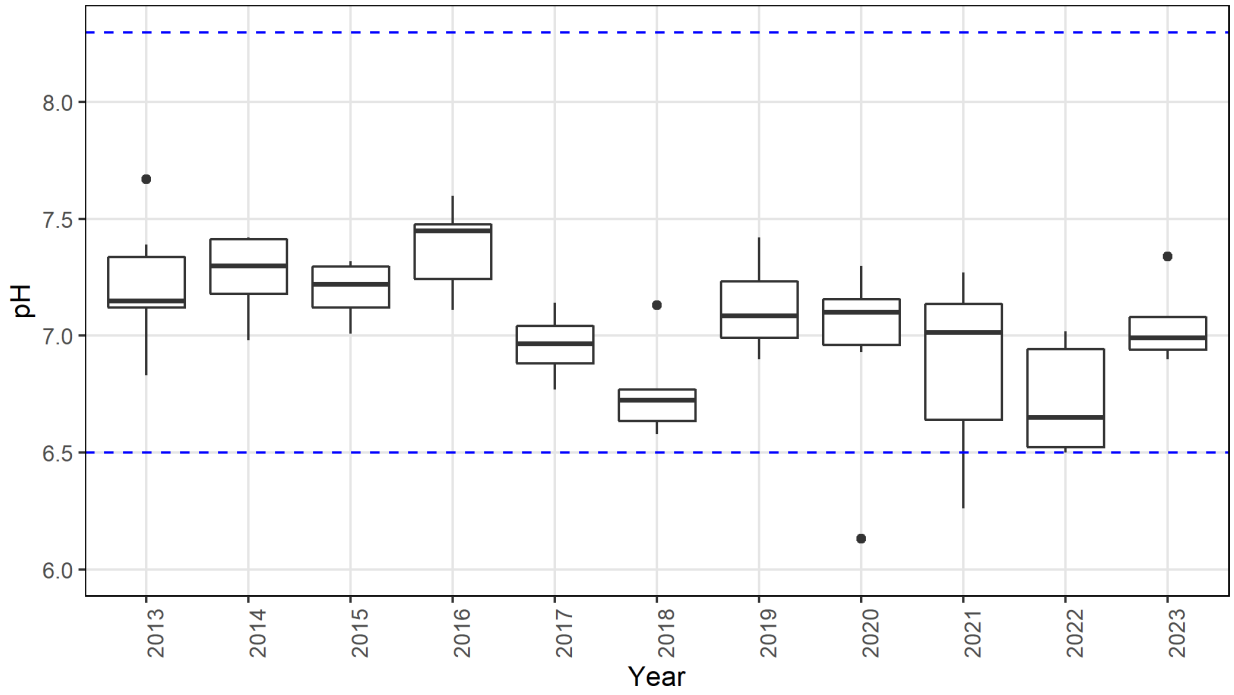

Figure 4: The pH levels at the eight sites in Dedham for years 2013 through 2023. Blue dashed lines represent the Common Boxplots statistics are the same as Figure 2.

Dissolved Oxygen:

The Commonwealth of Massachusetts considers DO levels below 5 mg/L to be stressful to all aquatic organisms and below 6 mg/L to be stressful to certain species of fishes that require colder water. Mother Brook is not a cold-water resource according to the Massachusetts Division of Fisheries and Wildlife, so here we use the 5 mg/l threshold.

Monthly dissolved oxygen and water temperature levels in 2023 were similar to the 10-year averages, while total phosphorus values improved over the 10-year average in June but were higher in July and August (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 anomalous, but it is helpful to understand what conditions created the hypoxia to prevent that in the future.

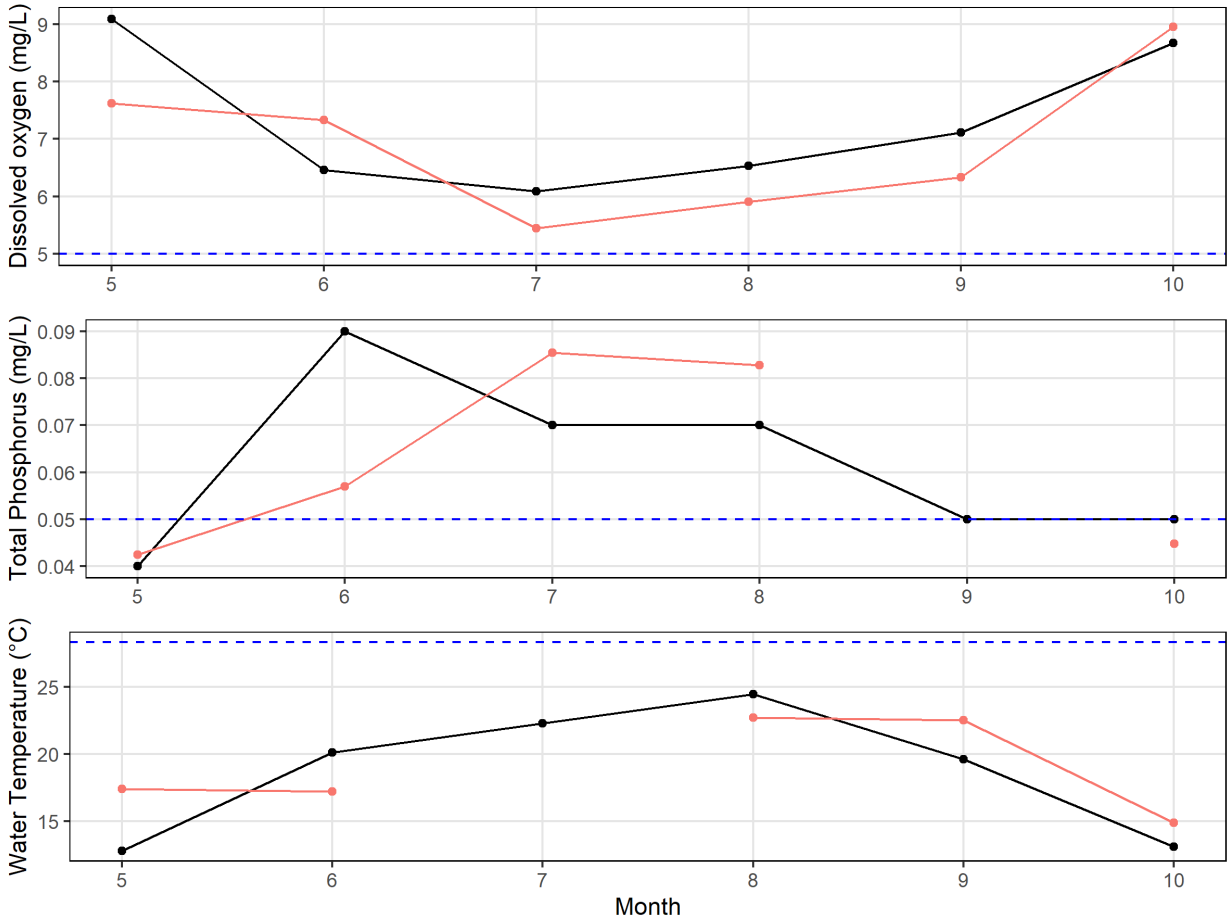

Figure 5: Monthly dissolved oxygen levels (top plot), total phosphorus levels (middle plot) and water temperature levels (bottom plot) at Mother Brook in Dedham. The black line shows the mean monthly value from 2013 to 2023 and the red line shows the 2022 values. The blue dashed lines represent the state criteria, namely 5 mg/L for DO, 0.05mg/L for phosphorus, and 28.3°C for warm water maximum temperature.

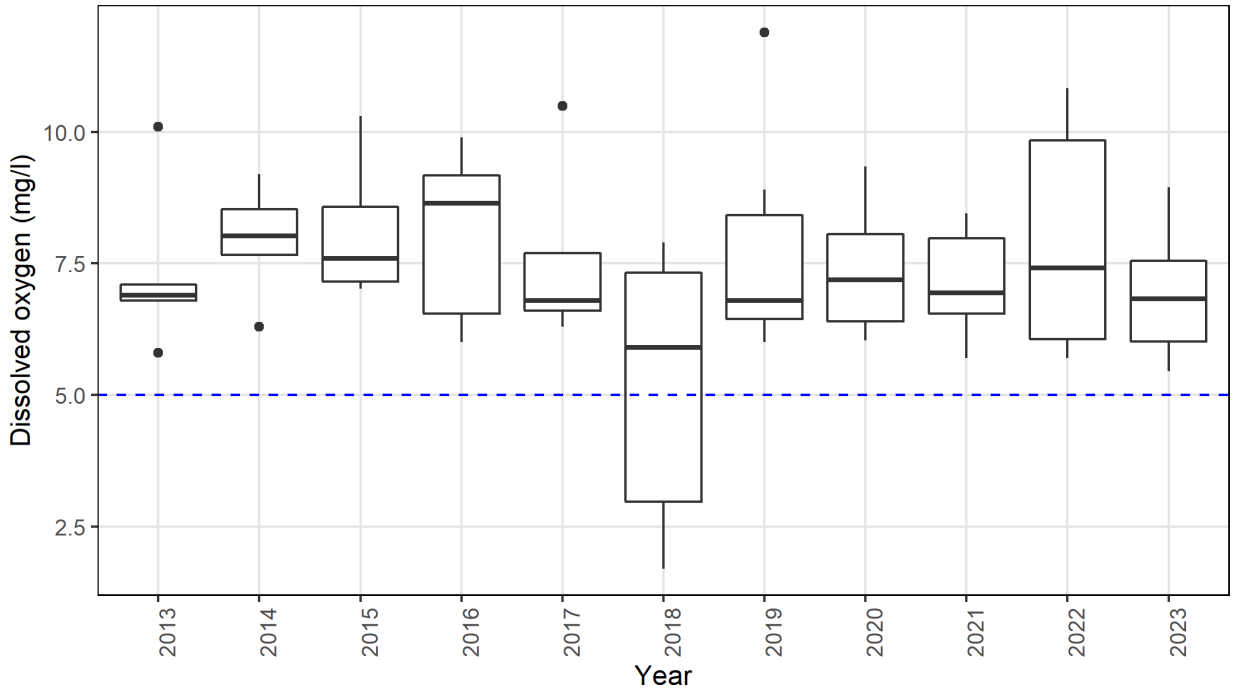

Figure 6: Dissolved oxygen levels at Mother Brook in Dedham, MA, from year 2013 to year 2023. N=6 for each year. The blue dashed line is at 5mg/L.

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 **Mother Brook @ Washington St.**	TP	• Identify sources of phosphorus and continue to reduce concentrations - including reviewing available Charles River data in an effort to determine whether sources may be upstream rather than on the Brook itself. • Consider a monitoring program for plant and algae growth to identify ecological impacts of the high phosphorus concentrations both at the site and within the downstream impoundments.
	E. coli	• Continue monitoring to ensure that the levels remain low following the closure of the Dedham Transfer Station. Identify other, non-sewage sources of *E. coli* contamination, such as pet waste and consider outreach campaigns to curtail them.