2020 Water Quality Report, Westwood, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data in Westwood 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 are three permanent CWMN stations within and bordering the town of Westwood on Mill Brook, Purgatory Brook, and the Neponset River (Figure 1). Waterbodies in Westwood are tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature once per month between May and October. Sites PUB022 and NER125 are also tested for ortho-phosphate and ammonia. The parameters discussed in this report are limited to those that are tested at every site including *E. coli*, total Phosphorus, pH, and dissolved oxygen. The raw water quality data are available upon request.

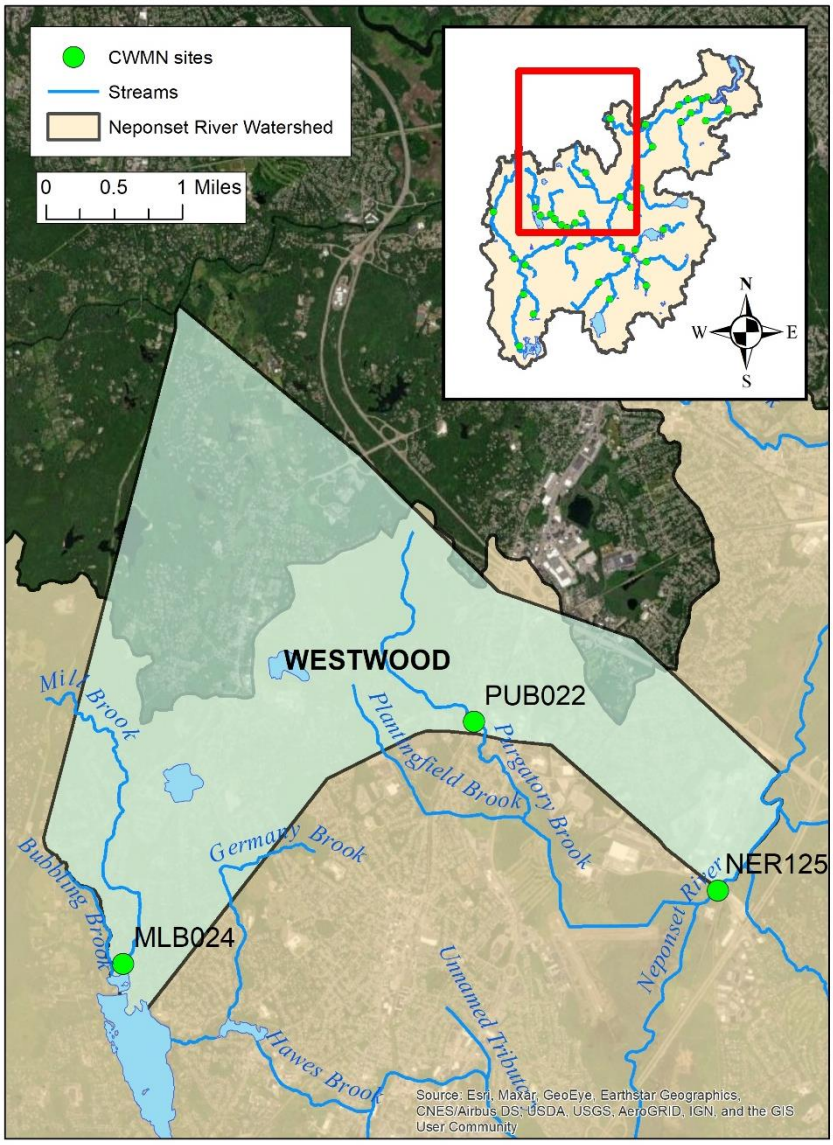

Figure 1: Map of the CWMN sites in Westwood, Massachusetts.

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 three sites in Westwood were greater than the single sample maximum (maximum values in Table 2) but the seasonal limit water sample levels were only surpassed at the sites on Mill Brook and Purgatory Brook - the site on the Neponset River was lower than the threshold (Geometric Mean values in Table 2). Interestingly, at all three sites, the maximum *E. coli* levels were greatest during dry weather. The 2020 dry weather sample max was 19900 cfu/100ml (N=5) on Purgatory Brook, 313 cfu/100ml on the Neponset River, and 364 cfu/100ml on Mill Brook. The high concentration in Purgatory Brook occurred in August and could have been the result of a sewage leak.

In past years, particularly 2019 and 2018, large concentrations of *E. coli* occurred during wet weather suggesting that the excess runoff during precipitation was contaminated with *E. coli* (Figure 2). On Purgatory Brook, there appears to be a problem with *E. coli* contamination during dry weather since 2013. Concentrations during dry weather from 2018 onward have been decreasing and the 2020 samples in May and June were below the single sample maximum (41 cfu/100ml and 62 cfs/100ml, respectively), however, the July, August, and September concentration were high.

Table 2: The maximum, average, minimum, and geometric mean levels of *E. coli* at the sites in Westwood, MA, in 2020. N=6. Units are in cfu/100ml.

CWMN Site	Maximum	Average	Minimum	Geometric Mean
MLB024	364	157	83	137
NER125	313	145	63	123
PUB022	19900	3848	41	519

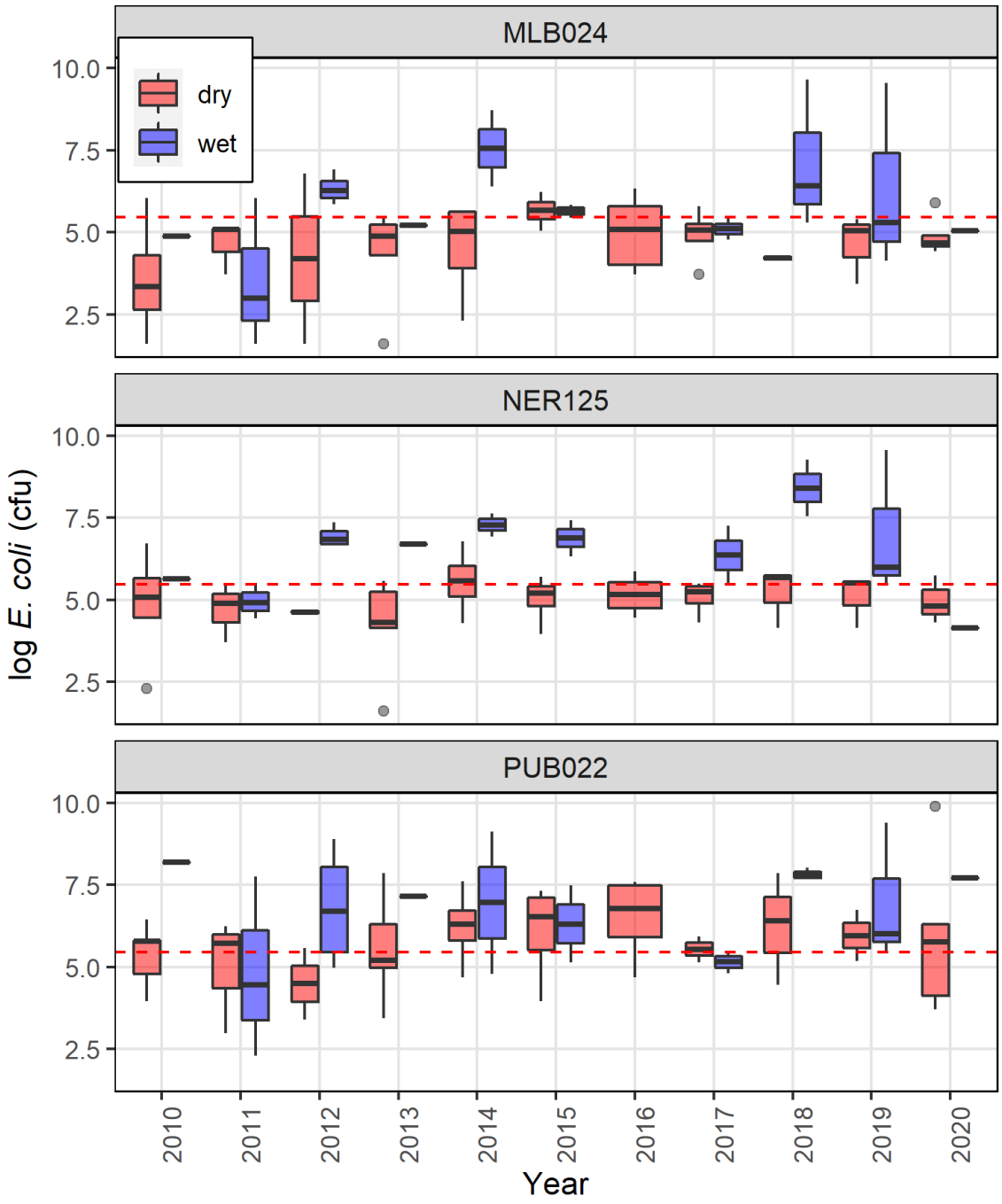

Figure 2: *E. coli* levels at the sites in Westwood, MA from years 2010 to 2020 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The red dashed line at y = log(235) shows the single sample maximum acceptable 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 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. 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 sampling site on Mill Brook is directly upstream of Pettee Pond so we apply the 0.05mg/l threshold. The other two sites do not empty directly into a pond or lake, so we apply the 0.1mg/l threshold. The seasonal average total Phosphorus concentration in 2020 was in compliance for the sites on the Neponset River and Purgatory Brook but was above the threshold for the site on Mill Brook (Table 3). The high concentrations of total Phosphorus observed in 2020 on Mill Brook were greater than past years (Figure 3). Monthly values were almost double the 10-year average monthly concentration for the summer months and returned to average levels in September (Figure 4). The July concentrations were higher than average on the Neponset River. At the site on Purgatory Brook the June concentrations were more than double the ten-year mean, and concentrations remained high in July, but returned to average levels in August.

Table 3: The maximum, average, and minimum values of total phosphorus recorded during 2020 at the three sites in Westwood, MA. N=6.

Site	Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
MLB024	0.12	0.08	0.03	0.05
NER125	0.14	0.07	0.03	0.1
PUB022	0.2	0.09	0.04	0.1

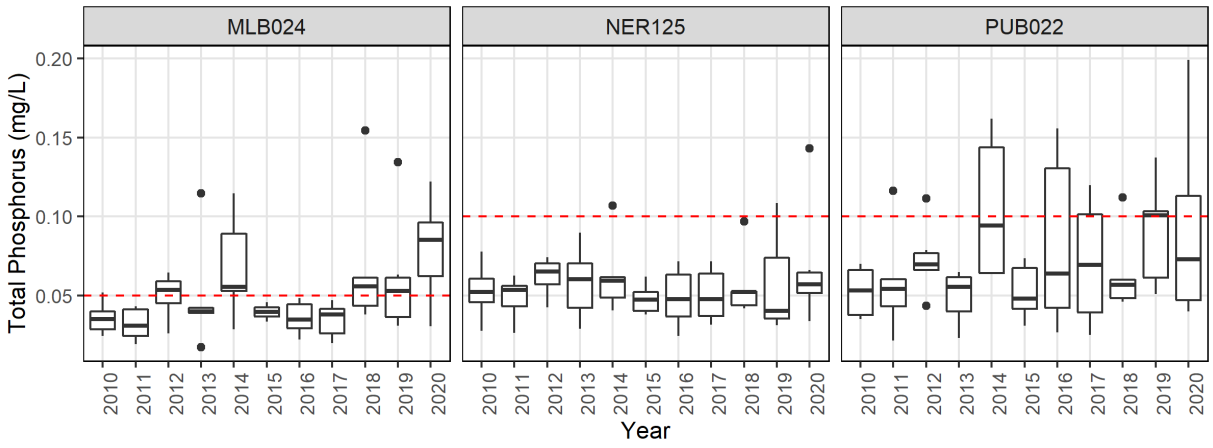

Figure 3: Total phosphorus levels at the three sites in Westwood, MA from year 2010 to 2020. The red dashed line is at 0.05mg/l for Mill Brook and at 0.1mg/l for the sites on the Neponset River and Purgatory Brook. Boxplot statistics are the same as Figure 2.

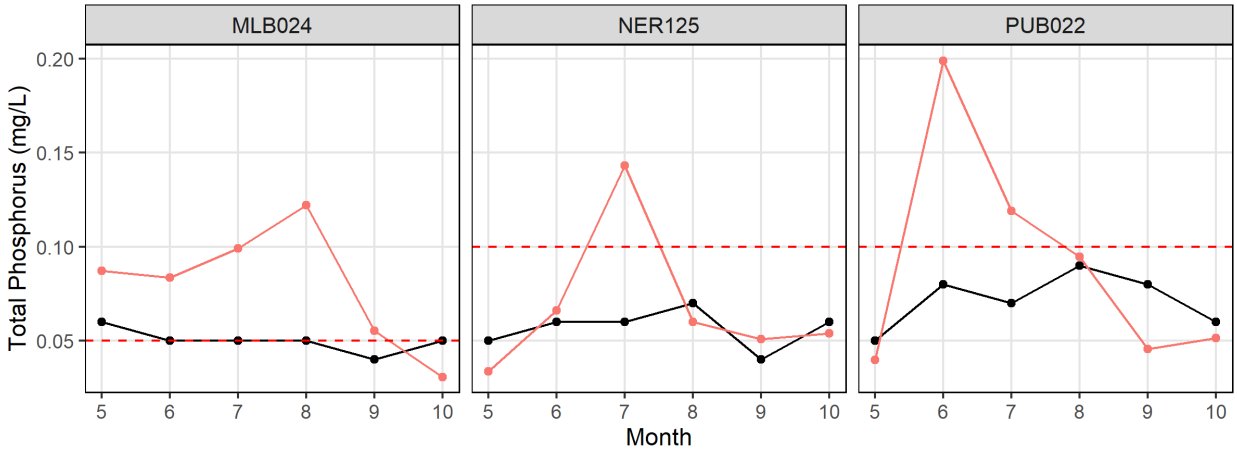

Figure 4: Monthly total Phosphorus concentrations at the three sites in Westwood, MA. The black line shows the mean monthly value from 2010 to 2019 and the red line shows the 2020 values. The red dashed line is at 0.05mg/l for Mill Brook and at 0.1mg/l for the sites on the Neponset River and Purgatory Brook.

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 these sites, there are strong negative correlations between total Phosphorus levels and dissolved oxygen levels (R^2 = -0.17, R^2 = -0.36, R^2 = -0.37 at MLB024, NER125, and PUB022, respectively), which can be a symptom of eutrophication.

pH

The state of Massachusetts considers a pH range of 6.5 to 8.3 healthy for waterbodies in the state. Since 2010 pH has been within acceptable range at all three sites (Figure 5).

Interestingly the range of values appears to be larger than past years at the site on Mill Brook and Purgatory Brook, but more years of data would been needed to identify whether this is a trend.

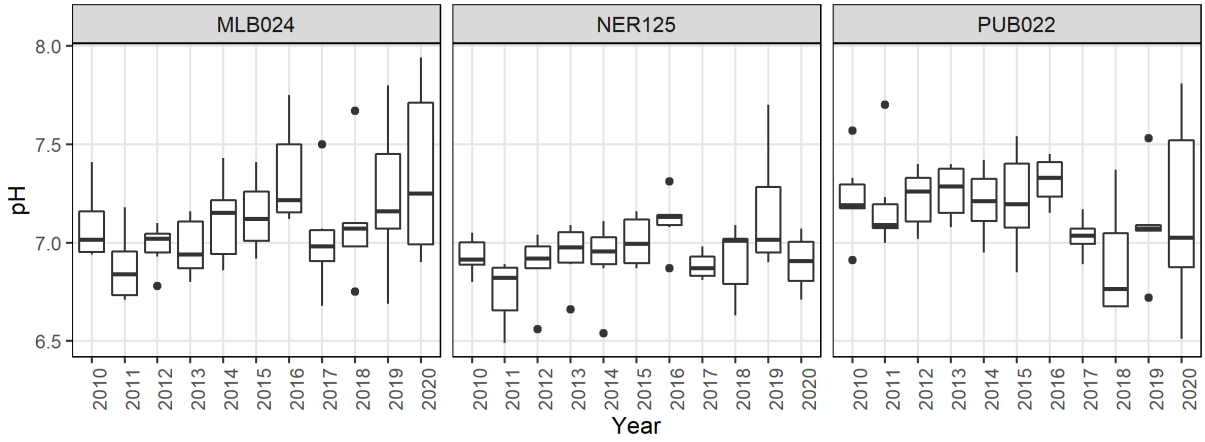

Figure 5: The pH levels at the three sites in Westwood for years 2010 through 2020. Boxplots statistics are the same as Figure 2.

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. Purgatory Brook and Mill Brook are listed as a cold-water resource by the Massachusetts Division of Fisheries and Wildlife so we apply the 6 mg/l threshold for those two sites and the 5mg/l threshold for the site on the Neponset River (but it is important to note that the Massachusetts Department of Environmental Protection does not recognize Purgatory Brook and Mill Brook as cold-water fishery streams and they are therefore not regulated as such by the Massachusetts Water Quality Standards).

Dissolved oxygen concentrations in 2020 were very similar to the 10-year average levels at the site on Mill Brook, which is interesting because this was the site with consistently higher than average total Phosphorus (Figure 6). The Mill brook site had levels that support cold water species through the entire sampling season. The site on the Neponset River experiences low dissolved oxygen concentrations in the summer months based on the ten-year mean values, which are just below the 5mg/l threshold. However, anoxic conditions were

observed in August of 2020 (DO = 0.73mg/l) and concentrations were not recovered until October. Total Phosphorus levels were high at this site in July, so it is possible plant and algae growth and decomposition fueled the decrease in dissolved oxygen. Additionally, water temperature measured on that day was 25°C, which also could have fueled the decrease in dissolved oxygen. The concentrations on Purgatory brook were similar to the ten-year average values and remained above the threshold to support cold-water fish.

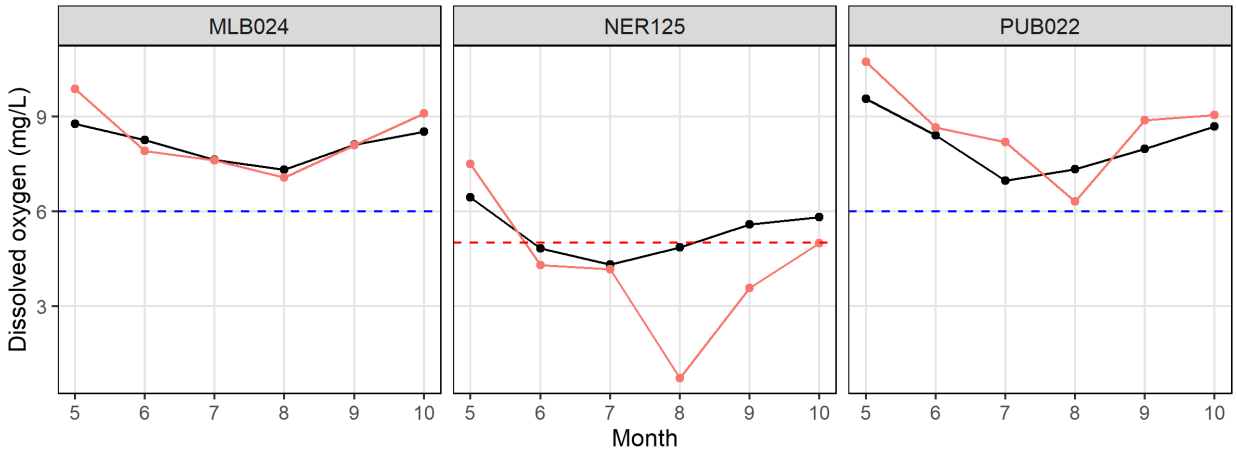

Figure 6: Monthly dissolved oxygen levels at the three sites in Westwood, MA. The black line shows the mean monthly value from 2010 to 2019 and the red line shows the 2020 values. The blue dashed lines are at DO = 6mg/l for MLB024 and PUB022, and the red dashed line is at DO = 5mg/l at NER125.

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. TP = total phosphorus, DO = dissolved oxygen.

Site	Parameter	Recommendation
MLB024	TP	• Identify sources of Phosphorus. • Assess runoff during dry weather. • Assess primary producer growth at this site and at Pettee Pond to identify ecological impacts.

NER125	DO	• Evaluate flow rates and shading in August. • Evaluate loads of organic matter.
	TP	• Identify sources of Phosphorus that could have contributed to the high concentration in July.
PUB022	TP	• Identify sources of Phosphorus that could have contributed to the high concentration in June.
	E. coli	• Assess runoff during dry weather. • Identify the cause of the high levels measured in August 2020.