City of Cambridge Water Department
2017 Source Water Quality Report

Stony Brook Reservoir Gatehouse

January 2019

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List of Abbreviations

CWD	Cambridge Water Department
CFR	Coldwater fish resource or cold water fishery
DO	Dissolved oxygen
EPA	United States Environmental Protection Agency
HDPE	High density polyethylene
INDUST BROOK	Industrial Brook
JFA	Joint-Funding Agreement
LEX BROOK	Lexington Brook
MA DEP	Massachusetts Department of Environmental Protection
MassGIS	Massachusetts Office of Geographic Information
MCL	Maximum contaminant level
MPN	Most probable number
MWRA	Massachusetts Water Resource Authority
MassDOT	Massachusetts Department of Transportation
MassWildlife	Massachusetts Division of Fisheries and Wildlife
ORS	Massachusetts Office of Research and Standards
QC	Quality Control
SMCL	Secondary maximum contaminant level
SpC	Specific conductance
TKN	Total Kjeldahl nitrogen
TSI	Trophic state index
TDS	Total dissolved solids
TOC	Total organic carbon
TP	Total phosphorus
USGS	United States Geological Survey

1 EXECUTIVE SUMMARY

This report presents the 2017 results of the City of Cambridge Water Department (CWD)'s Source Water Quality Monitoring Program, an ongoing study to assess source water quality in Cambridge reservoirs and associated tributaries. In 2017, water quality sampling was conducted year-round in the City's three reservoirs: the Hobbs Brook, Stony Brook, and Fresh Pond. Additionally, water quality data were collected from 12 streams feeding the reservoirs. Calendar year 2017 water quality monitoring results were compared against state and federal ambient and drinking water quality standards, as well as against EPA nutrient criteria guidelines. This report is intended to aid City managers and decision makers, and to educate those who are interested in the Cambridge water supply.

1.1 RESERVOIR WATER QUALITY SUMMARY

Reservoir waters in 2017 generally met the numerical Massachusetts Class A Surface Water Quality Standards (Class A standards) outlined in 314 CMR 4.05. All surface samples from Fresh Pond Reservoir, the terminal reservoir in Cambridge's three reservoir system, were within the acceptable range for Class A waters as assessed by dissolved oxygen (DO), *E. coli* bacteria, pH, and temperature. Monthly profile measurements found that pH and temperature complied with the Class A standards throughout the entire water column. However, profile readings showed that DO levels at the bottom of Fresh Pond Reservoir dropped below the 5 mg/L Class A threshold during June, July, and August. The drop in DO coincided with thermal stratification of the reservoir. When thermally stratified, oxygen-rich surface water cannot easily mix with cooler water lower in the profile, resulting in depleted DO concentrations. In 2017, CWD continuously operated an aeration system to supplement DO in the bottom of the Fresh Pond Reservoir; however, the supplemental oxygen was insufficient to prevent the DO from falling below 5 mg/L at the deepest points in the reservoir.

Exceedances of the numerical Class A water quality standards occurred more frequently in Hobbs Brook and Stony Brook Reservoirs than at Fresh Pond, but overall water quality results still generally met the Class A standards. Exceedances of the Class A *E. coli* standard (235 MPN/100 ml) occurred in less than 10 percent of weekly surface samples collected from the Hobbs Brook and Stony Brook reservoir intake locations. One *in situ* water quality probe pH measurement from the Hobbs Brook Reservoir upper basin (HB @ Upper) was slightly above the acceptable Class A pH range of 6.5-8.3 (8.32). However, the pH measurement of a water quality sample collected simultaneously and analyzed in the CWD laboratory was much lower (6.95) and within the acceptable bounds. The discrepancy between the two readings likely was caused by ice cover at the site.

Temperatures at all depths of Hobbs Brook and Stony Brook reservoirs remained below the Class A maximum for warm water fisheries (28.3 degrees C). In addition, the maximum temperature recorded by a U. S. Geological Survey (USGS) continuous monitoring station at Hobbs Brook Reservoir (station 01104430) was 24.6 degrees C, nearly 4 degrees C lower than the Class A standard maximum. While both reservoirs met the Class A DO standard for warm water fisheries in surface samples (>5 mg/L), DO fell below 5 mg/L in the bottom of the water column during thermal stratification in the summer and early fall.

Despite its lentic attributes, Stony Brook Reservoir is considered a coldwater fish resource (CFR).[1] Therefore, temperature and DO readings were also compared against the relevant Class A standards for CFRs.[2] The CFR temperature standard of 20 degrees C pertains to the mean daily maximum temperature over a seven day period. Although CWD did not continuously monitor temperatures in the Stony Brook Reservoir, discrete measurements indicated that the top 4 to 6 meters of the water column exceeded the temperature standard during the summer months. While Stony Brook Reservoir surface waters met the CFR DO standard of 6 mg/L, the bottom depths of the reservoir dropped below 6 mg/L in the summer and early fall. However, the zone of oxygen depletion (DO less than the Class A standard) only expanded by a meter or less when using the 6 mg/L threshold instead of the less stringent 5 mg/L standard for warm water fisheries.

According to nearly every parameter monitored in 2017, Fresh Pond had the best water quality of the three reservoirs. For example, surface concentrations of total phosphorous (TP), turbidity, and chlorophyll-*a* (chl-*a*) decreased as water moved from Hobbs Brook Reservoir through Stony Brook Reservoir and into Fresh Pond. Transparency of the water, as measured by Secchi depth, increased. All Fresh Pond surface samples were below the TP EPA nutrient criterion (0.008 mg/L)[3] and Fresh Pond had the lowest proportion of Secchi disk depth readings below the EPA nutrient criterion (4.9 m) of the three reservoirs. Fresh Pond was the only reservoir in 2017 with a median Trophic State Index (TSI), calculated based on surface chl-*a* concentrations, in the oligotrophic range. When compared against the Secondary Maximum Contaminant Levels (SMCL)[4] for manganese (0.05 mg/L) and iron (0.3 mg/L), Fresh Pond also had the lowest exceedance rates of the three reservoirs at 43 percent (3 of 7 samples) for manganese and 0 percent (0 of 7 samples) for iron.

Fresh Pond Reservoir also had the best water quality when comparing samples collected from the bottom of each reservoir during periods of thermal stratification. Iron and manganese are aqueous when reduced in low oxygen environments and phosphorous sorbed to iron sediments can be released into the water column. Low dissolved oxygen was coincident with increases in iron and manganese at the bottom of Hobbs Brook and Stony Brook reservoirs in 2017. Iron and manganese concentrations in bottom samples from these reservoirs were an order of magnitude or more higher than surface samples collected on the same dates. Manganese concentrations in Fresh Pond bottom samples were also elevated compared to

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[1] The Stony Brook tributary (SARIS ID 7239200) is categorized as a coldwater fish resource (CFR) by the Massachusetts Division of Fisheries and Wildlife (MassWildlife). Although the Stony Brook Reservoir is an impoundment with lentic attributes, the reservoir has an inlet and outlet and is classified as part of the Stony Brook tributary stream segment in the National Hydrography Dataset (NHD). MassWildlife recognizes that reservoirs may behave differently than a stream or river with respect to cold water fish habitat. Evaluations of habitat impacts in a reservoir would take into account these differences (Rebecca Quiñones and Jason Stolarski, MassWildlife, written and oral commun(s)., 2017).

[2] CFRs are referred to as cold water fisheries in the Class A standards defined in 314 CMR 4.05.

[3] The TP EPA nutrient criterion of 0.008 mg/L was below the detection limit of the test used by the CWD contract laboratory to analyze TP (<0.0106 mg/L). For the purposes of this analysis, it was assumed that any sample <0.0106 mg/L was also below the 0.008 mg/L nutrient criterion.

[4] The SMCL standards are set for aesthetic purposes and apply to treated drinking water rather than ambient source water. However, the SMCLs provide a useful point of comparison for evaluating source water quality. Treated drinking water supplied by the City of Cambridge complies with all applicable local, state, and federal water quality regulations.

surface samples, although difference was less extreme than at Hobbs Brook and Stony Brook reservoirs. Unlike Hobbs Brook and Stony Brook reservoirs, iron samples collected from the bottom of Fresh Pond were below all below the 0.3 mg/L SMCL.

Similar to iron and manganese, TP concentrations at Hobbs Brook and Stony Brook reservoirs were higher in bottom samples during thermal stratification than in surface samples. Elevated TP concentrations in the bottom of the reservoirs in August, along with warmer water temperatures, likely contributed to observed spikes in chl-*a* concentrations, indicating plant or algal growth. Interestingly, Fresh Pond also had elevated chl-*a* in the bottom of the reservoir during August but the increase did not occur alongside an increase in TP, which was below the test detection limit (<0.0106 mg/L).

Nitrate and nitrite nitrogen was one exception where Fresh Pond did not have the best reservoir water quality. Hobbs Brook Reservoir had the lowest median nitrate and nitrite nitrogen concentration in 2017. However, maximum nitrate and nitrite nitrogen levels at all three reservoirs were below 1.1 mg/L, which is far lower than the 10 mg/L MA drinking water Maximum Contaminant Level (MCL) set to protect human health. Median concentrations at all reservoir surface sampling sites exceeded the EPA nutrient criterion for nitrate and nitrate nitrogen, total Kjeldahl nitrogen (TKN), and total nitrogen (TN).

Salt impairment is a serious concern in the Cambridge watershed. The Hobbs Brook Reservoir is strongly influenced by runoff from salt-treated impervious surfaces, most notably Route 2 and Interstate 95. Hobbs Brook Reservoir dam releases flow to the Stony Brook Reservoir which feeds Fresh Pond Reservoir, so elevated salt concentrations at Hobbs Brook Reservoir can translate into saltier water in the downstream reservoirs. In 2017, weekly surface samples collected at the Hobbs Brook Reservoir Intake (HB @ Intake) consistently exceeded the chloride SMCL of 250 mg/L throughout the year (98 percent of samples). Exceedances at the Stony Brook Reservoir intake (20 percent of annual weekly surface intake samples) and Fresh Pond (one of seven surface samples) occurred only when water was released from Hobbs Brook Reservoir to supplement downstream flows.

The high chloride SMCL exceedance rates at HB @ Intake and the Stony Brook Reservoir intake (SB @ Intake) are a new phenomenon, comparable only to the 2016 exceedance rates of 92 percent (HB @ Intake) and 27 percent (SB @ Intake). A historic drought officially began in July of 2016 and continued until April of 2017, although storage records at the Hobbs Brook Reservoir suggest reduced inflows occurred as early as 2015. Diminished streamflow due to drought conditions minimized the dilution of salt-impacted base-flow to Hobbs Brook Reservoir. Prior to the 2016-2017 drought, the chloride SMCL exceedance rate at HB @ Intake remained below 25 percent and was often below 10 percent. At SB @ Intake, only a single outlier in 2004 exceeded the SMCL, while all other samples collected between 2002 and 2015 were below the SMCL. Similarly, 2017 was the second year in a row where a water quality sample at Fresh Pond exceeded the chloride SMCL. Prior to 2016, all samples collected by CWD at Fresh Pond were less than the chloride SMCL. Sodium concentrations at all three reservoirs were above the Massachusetts Secondary Drinking Water Guideline (ORS Guideline) of 20 mg/L. While exceedance of the ORS Guideline is common in the Cambridge watershed, median sodium concentrations in 2015 through 2017 were the highest observed by CWD since at least the early 2000s.

1.2 TRIBUTARY WATER QUALITY SUMMARY

Tributary base-flow at the 12 CWD sampling locations largely met the Class A numerical water quality standards in 2017. However, each of the four Class A parameters (E. coli, DO, temperature, and pH) were exceeded at least once at two or more sites. All tributary sites entering the Hobbs Brook Reservoir exceeded the *E. coli* standard in a third to half samples (out of six samples). However, all samples collected from the outlet of Hobbs Brook Reservoir (HB Below Dam) were below the *E. coli* standard. Moreover, HB Below Dam had the lowest median *E. coli* value of all 12 tributary sites. Therefore, any *E. coli* colonies entering the Hobbs Brook Reservoir from upstream tributaries did not appear to be a water quality concern at the reservoir outlet. Two of the six tributary sites ultimately draining to Stony Brook Reservoir exceeded the *E. coli* standard in a 17 to 33 percent of samples collected in 2017 (out of six samples).

All tributary 10 warm water tributary sites met the Class A temperature standard (28.3 degrees C maximum). However, DO at three sites (HB @ Mill St, MBS, and Tracer Ln) fell below the 5 mg/L Class A standard at least once in 2017 and the median MBS concentration was below 5 mg/L. All three sites were downstream of wetland systems, a source of organic matter, and Tracer Ln was also adjacent to interstate 95. The oxygen depletion occurred primarily during the summer months when warm and sometimes stagnant water, combined with a high organic matter load, may have resulted in the depletion of DO during microbial respiration. HB @ Mill St, MBS, and Tracer Ln were also the only tributary sites with pH outside the 6.5-8.3 Class A range in 2017, with pH levels below 6.5 in 17 to 33 percent of samples (out of six samples).

The Cambridge watershed also has two CFR sites (RT 20 and SB @ Viles). Unlike the warm water fishery sites, SB @ Viles and RT 20 both exceeded the Class A temperature standard, with 14 percent and 30 percent of the seven-day maximum daily temperature rolling averages exceeding 20 degrees C, respectively.[5] It is unknown to what extent such anthropogenic factors as heated pavement runoff, loss of riparian vegetation, and upstream impounded waters influenced temperatures. Temperatures at RT 20 appeared to be influenced by releases of water from the Hobbs Brook Reservoir from late July through October. All six CWD DO measurements in 2017 were above the 6 mg/L minimum Class A standard for CFRs at both sites.

Tributary water quality reflected elevated reservoir salt concentrations. Seven of the 12 tributary sites had median chloride concentrations above the SMCL of 250 mg/L. Every tributary sodium sample collected in 2017 was greater than the ORS Guideline of 20 mg/L. The highest sodium and chloride base-flow loads occurred at RT 20, HB @ KG, and HB Below Dam. The high loads were due in part to large drainage catchment areas. However, all three sites were downstream of the Hobbs Brook Reservoir dam outlet and were impacted by releases of high-salt water from the dam. When comparing tributary salt yields to account for catchment size, tributary sites with more intensely developed watersheds, that received highway runoff, and/or were impacted by historic salt management and storage practices were the largest contributors of sodium and chloride. In 2017, the four tributary sites with the highest base-flow salt yields were Indust Brook, WA-17, and Salt Depot, and Lex Brook.

[5] CWD calculated the rolling seven day maximum daily temperature using provisional and approved continuous USGS temperature data from monitoring stations 01104370 (SB @ Viles) and 01104460 (RT 20).

USGS stormwater samples of sodium and chloride collected at Lex Brook, Tracer Ln, WA-17, and Summer St allowed for the calculation of stormwater loads and yields. Summer St was one of the least developed catchments in the Cambridge watershed. Unlike Lex Brook, Tracer Ln, and WA-17, Summer St did not receive highway runoff. Likely as result, Summer St had the lowest total sodium and chloride loads and yields of the four catchments. Summer St also had the lowest proportion of its sodium and chloride loads contributed by base-flow (46 and 44 percent, respectively). By contrast, base-flow contributed between 60 percent and 80 percent of the total sodium and chloride loads at Lex Brook, Tracer Ln, and WA-17. This indicates that repeated applications of deicing salts have permeated the groundwater, resulting in salt-impacted base-flow at these sites.

As with the reservoirs, all tributary sites were well under the 10 mg/L MCL for nitrate and nitrite nitrogen. However, seven of 12 sites had median concentrations above the EPA nutrient criterion of 0.31 mg/L and all sites exceeded the total nitrogen (TN) criterion of 0.61 mg/L. The Summer St nitrate and nitrite nitrogen median base-flow concentration and yield were the highest of the 12 tributary sites, followed by WA-17. Sources of nitrogen in the Summer St catchment included golf course and residential lawn fertilizer applications and septic system leachate. Nitrogen in the WA-17 catchment most likely originated from leaking sanitary sewer lines and fertilizer use at commercially developed properties.

Four of the 12 tributary sites had median base-flow TP concentrations above the EPA nutrient criterion of 0.02375 mg/L. These sites (HB @ Mill St, Tracer Ln, MBS, WA-17) also had the highest TP yields of the 12 tributary sites. All four sites were downstream of wetland systems, which could be a natural source of phosphorus from wetland sediments and organic matter. Unlike sodium and chloride, stormflow was the primary contributor of TP at the four sites sampled by the USGS for stormwater quality in 2017. The proportion of the TP load attributable to stormflow at Lex Brook, Tracer Ln, WA-17, and Summer St ranged from 75 percent to 89 percent. This demonstrates the importance of stormwater management and treatment in controlling phosphorus pollution.

One such stormwater treatment device is a stormwater wetland treatment system that was installed upstream of WA-17 in October 2012. A comparison of base-flow water quality found that TP and turbidity increased at WA-17 after the wetland system installation, especially during the growing season. This indicates that the wetland treatment ponds were not functioning properly and may have been exporting phosphorus in base-flow from plant and algae growth in the treatment ponds. In response, CWD coordinated with the Massachusetts Department of Transportation (MassDOT) in 2018 to install a bypass weir to route base-flow directly to WA-17 without first entering the treatment area. Despite increased TP in base-flow, a comparison of nitrate and nitrite nitrogen concentrations before and after the installation of the treatment system suggests that it may act as a nitrogen sink during the growing season, presumably due to plant uptake.

1.3 Precipitation and Retention Time Summary

In 2017, the Cambridge watershed received 42.87 inches of rain as measured by USGS station 01104430. This is 2.84 inches less than the 45.71 inch NOAA 1981-2010 Climate Normal for precipitation at the Bedford Hanscom Field, MA station, but significantly more rain than in 2016 which ended the year with a 9 inch deficit. The rainfall was also sufficient to end to a drought declared by the Massachusetts Drought Management Taskforce on July 1, 2016 and ended on April 30, 2017. Unlike in 2016, the rainfall was also sufficient to recharge the Cambridge reservoirs and allow CWD to meet 100 percent of water demand without purchasing water from the Massachusetts Water Resources Authority (MWRA). The Hobbs Brook Reservoir 2017 retention time was the longest of the three reservoirs at 21 months. The Fresh Pond retention time was 3.8 months and Stony Brook Reservoir had the shortest retention time at 18 days.

2 INTRODUCTION

This report describes the results of the City of Cambridge Water Department (CWD)'s source water quality monitoring efforts in calendar year 2017, part of a long-term study of the health and overall state of the City's drinking water supply.

The City obtains water from the Stony Brook watershed (referred to in this report as the Cambridge watershed) located in the towns of Lincoln, Weston, and Lexington and the City of Waltham. The Cambridge watershed is comprised of two primary subbasins: the Hobbs Brook Reservoir subbasin and the Stony Brook Reservoir subbasin (Figure 1). Water travels by gravity to the Walter J. Sullivan Purification Facility in Cambridge through a network of reservoirs, tributaries, and an underground aqueduct (Figure 1). The Cambridge watershed is relatively urbanized. Growth and development have the potential to negatively impact water quality. However, redevelopment projects may improve water quality by upgrading stormwater treatment systems at older sites. The City of Cambridge only owns and controls approximately 10 percent of watershed lands. This lack of land ownership, along with high land development potential, requires collaboration with watershed stakeholders and regular water quality monitoring to ensure the long-term protection of the water supply.

The CWD source water quality monitoring program was designed by the U.S. Geological Survey (USGS), in cooperation with CWD, and is based in part on the results of a 1997 - 1998 comprehensive assessment of reservoir and stream quality (Waldron and Bent, 2001). The assessment, conducted jointly by the USGS and the CWD, included a detailed analysis of the watershed and the identification of subbasins exporting disproportionate amounts of pollutants to the reservoirs. This information was then used to design the monitoring network which now makes up CWD's long-term source water quality monitoring program.

The USGS/CWD partnership continues to this day and funds "real-time" water quantity and quality monitoring stations, data collection, and interpretive analysis. All data collected by USGS is public record and can be retrieved online at this URL.

http://waterdata.usgs.gov/ma/nwis/current?type=cambrid&group_key=NONE&search_site_no_station_nm=&format=html_table

3 PURPOSE

The purpose of this report is to characterize Cambridge watershed source water quality for calendar year 2017. Obtaining long-term water quality information is essential in guiding watershed management practices and informing water treatment operations. By understanding where certain water quality problems exist, CWD can more efficiently and effectively deploy watershed protection resources. Watershed staff also use water quality data to evaluate the efficacy of management initiatives and re-prioritize their efforts if necessary.

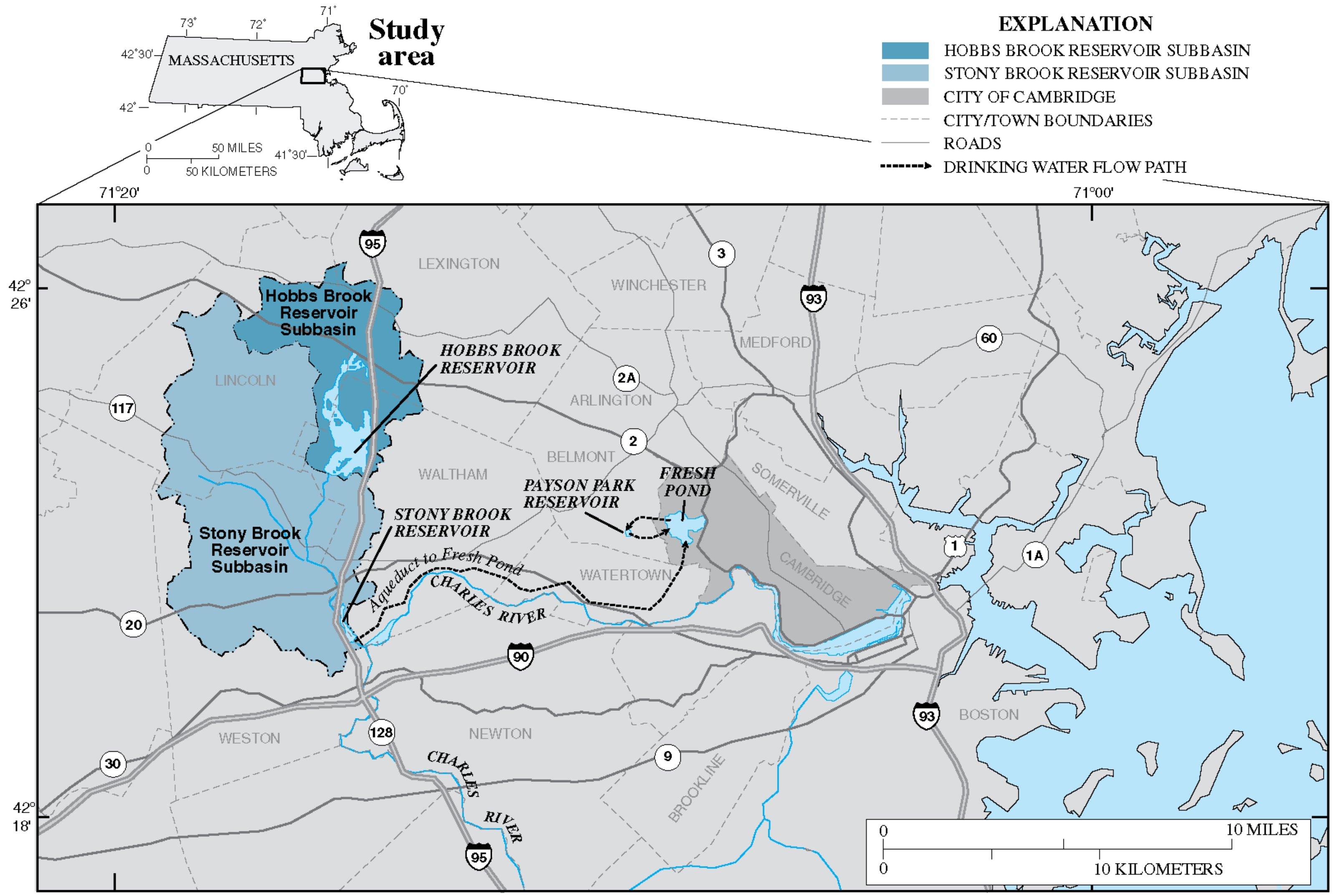

Figure 1. Cambridge Water Supply Source Area

Figure source: Waldron and Bent, 2001

4 WATER SUPPLY NETWORK

The City of Cambridge obtains its water from the 24-square mile Stony Brook (Cambridge) watershed located in the towns of Lincoln, Weston, Lexington and the City of Waltham. This "upcountry" watershed is nested within the Charles River Basin and contains two major impoundments constructed in the 1890's, the Hobbs Brook and Stony Brook Reservoirs (Figure 1). The Hobbs Brook Reservoir (also known as the Cambridge Reservoir) receives water from a 7-square mile (mi^2) subbasin and discharges into Hobbs Brook through a gatehouse on Winter Street in Waltham. Hobbs Brook joins Stony Brook further downstream, which flows into the Stony Brook Reservoir on the Weston, Waltham town line (Figure 1). From the Stony Brook Reservoir, water is fed by gravity through a 7.5 mile underground pipeline to Fresh Pond Reservoir, a kettle pond in western Cambridge, located in the Mystic River Basin.

During high flow periods (mainly winter and spring), the primary source area for the water supply is the Stony Brook Reservoir and its subbasin (Figure 1). During low flow periods (mainly summer and autumn), water is released at the Hobbs Brook dam to supply most of the City's daily water demand.

The Walter J. Sullivan Water Purification Facility, located within the Fresh Pond Reservation, treats water from the Fresh Pond Reservoir. Treated water is pumped to the Payson Park underground storage facility in Belmont, MA where it is then fed by gravity to the City's distribution system (Figure 1). Total capacity at full pool for the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs is roughly 2.5 billion, 418 million, and 1.5 billion gallons, respectively.

In the event of an emergency, the City has a back-up connection to the MWRA (Massachusetts Water Resources Authority) supply. The MWRA supply was used exclusively during the construction of the current Water Treatment Plant from 1999-2001. In calendar year 2016, the City of Cambridge purchased 848 million gallons (MG) from MWRA (18 percent of the total water supplied in 2016 by CWD) due to a combination of use during infrastructure repairs and periods of low flow during drought conditions. However, 100 percent of the water demand in 2017 was met using only water from the Cambridge watershed. CWD did not purchase water from MWRA in 2017.

5 CAMBRIDGE SOURCE WATER QUALITY MONITORING PROGRAM

5.1 MONITORING OBJECTIVES AND PROGRAM OVERVIEW

Given the City's lack of ownership and control of most watershed lands, water quality monitoring is a necessary and effective means of identifying sources of pollution and tracking water quality changes over time. The primary goal of the Cambridge Source Water Quality Monitoring Program is to ensure that water withdrawn from Fresh Pond Reservoir for treatment is as free as possible from contaminants, thereby minimizing the costs of treatment and protecting overall water quality. Specific objectives of the program are to:

- Monitor the condition of source waters in the Cambridge drinking water supply system;
- Determine where, when, and how water quality conditions are changing over time;
- Identify actual and potential problems related to source water quality;
- Evaluate the effectiveness of programs designed to prevent or remediate water quality problems;
- Ensure that all applicable water quality goals, standards, and guidelines are being met; and
- Provide for rapid response to real-time and emerging problems.

The Cambridge Source Water Quality Monitoring Program consists of four major elements: (1) routine monitoring of reservoirs and tributary streams during base-flow (dry weather) conditions, (2) continuous recording of stage and selected water quality characteristics at critical sites within the drainage basin, (3) event-based monitoring of streams, storm drains, and other outfalls during wet weather and special water quality investigations, and (4) data management, quality control, analysis and reporting. Results of the sampling program are compared against various state and federal regulations and standards.

5.2 COMPARATIVE WATER QUALITY STANDARDS AND PARAMETERS

CWD evaluated water quality results against three different sets of standards and guidelines: Massachusetts Surface Water Quality Standards, Massachusetts Drinking Water Standards and Guidelines, and U.S. Environmental Protection Agency (EPA) nutrient criteria. A description of each set of standards or guidelines is provided in the following sections.

5.2.1 Massachusetts Surface Water Quality Standards (Class A standards)

The Massachusetts Class A ambient surface water quality standards (Class A standards) are set by the Massachusetts Department of Environmental Protection (MA DEP) (314 CMR 4.00) and were created to implement the Massachusetts Clean Water Act. The MA Clean Water Act requires MA DEP to define permissible uses for all water bodies in Massachusetts and to define minimum water quality criteria necessary to maintain those uses. All drinking water reservoirs and their associated tributaries are considered Class A. Examples of designated uses relevant to Class A waters in the Cambridge watershed include: Public Water Supply, Aquatic Life, Aesthetics, and Primary and Secondary Contact Recreation (even where recreation is not allowed) (314 CMR 4.05 (3) (a) and Massachusetts Division of Watershed Management Watershed Planning Program, 2016).

The 314 CMR 4.00 regulations define numerical ambient surface water quality standards for *E. coli*, DO, pH, and temperature. The regulations also contain narrative descriptions to define water quality requirements for color and turbidity, oil and grease, taste and odor, aesthetics, bottom pollutants or alterations, nutrients, radioactivity, and toxic pollutants (such as chloride, ammonia, and metals). The Massachusetts Consolidated Assessment and Listing Methodology Guidance Manual for the 2016 Reporting Cycle (CALM 2016) expands upon the metrics and narratives in 314 CMR 4.00, defining the methods used by MA DEP to assesses whether water bodies meet their designated uses per the surface water quality standards outlined in 314 CMR 4.00.

CWD monitors the following parameters to compare against the Class A surface water quality standards:

E. coli – This *E. coli* bacteria serotype is found in the digestive systems of warm-blooded animals and is used as an indicator for sewage-related pathogens. Class A ambient water quality standards state that no single sample shall exceed 235 Colonies/100mL (measured as *most probable number* [MPN] by the CWD laboratory).

Dissolved Oxygen (DO) – DO in water is critical to supporting a healthy fish and wildlife population. Low DO and anoxic conditions can mobilize nuisance metals such as iron and manganese and release nutrients from sediments. Class A ambient water quality standards state that dissolved oxygen should not be less than 6 mg/L in cold water fisheries (CFRs)[6] and 5 mg/L in warm water fisheries, unless natural background conditions are lower.

pH – pH is a measure of acidity in water and is defined as the $-\log[H^+]$. Water with a pH level of 7 is considered neutral; water with a pH below 7 is acidic and above 7 is basic. The acceptable range of pH levels for Class A freshwater systems is 6.5 to 8.3, although pH levels must be no more than 0.5 units outside of the background range for the system. Waters with pH levels outside of this range can be harmful to fish and wildlife, and high pH levels can be indicative of algae blooms.

Temperature – Water temperature is an important metric for aquatic habitat suitability. Certain aquatic species are temperature sensitive and require cooler water to survive. Warmer water also holds less DO and can promote harmful biological growth such as algal blooms. The Class A maximum seven-day average water temperature is 20 degrees C for CFRs and 28.3 degrees C for warm water fisheries. The regulations also place limits on the temperature increases permissible from discharges. Exceptions to these standards are made for streams with naturally occurring higher temperatures.

Nutrients – MA DEP does not currently have nutrient criteria standards. Instead, MA DEP evaluates whether waters support the Aquatic Life use with respect to nutrients based multiple primary producer biological and physico-chemical screening guidelines (such as chl-*a* concentrations, macrophyte coverage, Secchi disk transparency, pH, DO, TP, and temperature readings). While it is beyond the scope of this report to determine if waters in the Cambridge watershed met the Aquatic Life use or other uses, a cursory

[6] Coldwater fish resources (called cold water fisheries in 314 CMR 4.00) are defined by the Massachusetts Division of Fisheries and Wildlife.

comparison was made between available CWD nutrient, primary producer, and physio-chemical data and a subset of metrics in the 2016 CALM manual. Specifically, reservoir chl-*a*, reservoir and tributary TP, and reservoir Secchi depth measurements were compared against the corresponding primary producer and physico-chemical screening guidelines shown on page 30 of the 2016 CALM manual. Nutrient results from the reservoirs and tributaries were also compared against the EPA nutrient criteria (see section 5.2.3 *EPA Nutrient Criteria*).

Despite being defined as a use, MA DEP does not assess whether water bodies meet the Public Water Supply use under the MA Clean Water Act (Massachusetts Division of Watershed Management Watershed Planning Program, 2016). Instead, MA DEP determines if water is safe to drink based on standards for finished (treated) water under the Safe Drinking Water Act (see section 5.2.2 *Massachusetts Drinking Water Guidelines and Standards*). Therefore, where possible, surface water quality results were compared against the Massachusetts Drinking Water Standards and Guidelines rather than standards set for the Aquatic Life use or other Clean Water Act uses.

5.2.2 Massachusetts (MA) Drinking Water Standards and Guidelines

MA Drinking Water Standards and Guidelines apply to treated drinking water and are defined by the MA DEP in 310 CMR 22.00 and by the Massachusetts Office of Research and Standards (ORS). Created to implement the requirements of the federal Safe Drinking Water Act, these standards consist of Massachusetts Maximum Contaminant Levels (MCLs), Massachusetts Secondary Maximum Contaminant Levels (SMCLs), and Massachusetts Drinking Water Guidelines (ORS Guidelines). The MCL and SMCL standards are developed by the EPA and adopted or made more stringent by the state of Massachusetts. Parameters in drinking water delivered to customers must not exceed the MCLs. Drinking water is not required to meet SMCLs unless deemed by MA DEP or EPA to be a threat to public health. While not mandatory for compliance, ORS Guidelines can help water suppliers monitor and address pollutants of concern that are not regulated by state or federal agencies. All MCLs, SMCLs, and ORS Guidelines apply to treated drinking water rather than untreated source water. However, these metrics are useful points of comparison to assess ambient water quality in the Cambridge watershed and identify potential contaminants for treatment.

The CWD source water monitoring program tests ambient water for the following subset of MCL, SMCL, and ORS Guideline parameters. CWD performs more extensive testing on treated drinking water to ensure that all required standards and guidelines are met post-treatment.

<u>Nitrate and Nitrite as Nitrogen</u> – Nitrate (NO_3^-) and nitrite (NO_2^-) are common inorganic forms of nitrogen. Typical sources of nitrate and nitrite pollution include the application of fertilizer and effluent from septic systems and other sewage discharges. The drinking water maximum containment level (MCL), set to protect public health, is 10 mg/L; the EPA nutrient criterion is more restrictive at 0.05 mg/L for reservoirs and 0.31 mg/L for tributaries (see section 5.2.3 *EPA Nutrient Criteria*). Nitrate nitrogen and nitrite nitrogen were quantified separately by CWD and summed to quantify the total amount of nitrogen from nitrate and nitrite. If the nitrate or nitrite result was below the method detection limit, detection limit was used for the purposes of calculating nitrate and nitrite nitrogen. This errs on the side of over estimating nitrate and nitrite nitrogen concentrations in the Cambridge watershed.

Chloride, Sodium, and Calcium – Sodium chloride (NaCl) is the most commonly used winter deicing agent in the Cambridge watershed. Calcium chloride ($CaCl_2$) is another deicing agent used in the watershed, although to a lesser extent than NaCl. Tracking chloride, sodium, and calcium levels in the water supply helps steer efforts to reduce their use and protect long term water quality. Chloride concentrations in drinking water above 250 mg/L (SMCL) typically correspond with sodium levels high enough to impart a noticeably "salty" taste. The ORS Guideline for sodium is 20 mg/L. Calcium does not have a guideline under the drinking water standards but is important to monitor given its presence in the deicing compound $CaCl_2$.

Iron/Manganese – Iron (Fe) and manganese (Mn) in drinking water are not considered health hazards but an excess can lead to staining and other aesthetic issues. These metallic elements are naturally-occurring in the earth's crust and soils. The SMCLs are 0.3 mg/L for iron and 0.05 mg/L for manganese.

Total Dissolved Solids (TDS) – TDS is a measure of all organic and inorganic particles and ions dissolved in water. Elevated TDS levels can lead to taste, odor, or other aesthetic issues. The SMCL for TDS is 500 mg/L.

5.2.3 EPA Nutrient Criteria

EPA nutrient criteria represent concentrations of nutrients in lakes, reservoirs, and tributaries which have not experienced accelerated eutrophication due to anthropogenic nutrient inputs (reference conditions).[7] Nutrients facilitate plant and algal growth and promote eutrophication (water body productivity). Excessive nutrient inputs can cause increased rates of eutrophication, leading to water quality impairments including, but not limited to, taste and odor problems and low dissolved oxygen availability for fish and wildlife.

The EPA developed these criteria to help states adopt nutrient water quality standards to maintain the uses defined by the Clean Water Act (U.S. Environmental Protection Agency 2000, 2001). Because Massachusetts does not include numeric criteria for nutrient compounds in its Class A Water Quality Standards, this report uses the nutrient criteria developed by EPA as a benchmark for assessing nutrient concentrations in the Cambridge watershed. CWD also compared water quality results for select available parameters against indicators of nutrient enrichment as described in section 5.2.1.

Nitrate/Nitrite – see section 5.2.2 Massachusetts Drinking Water Standards and Guidelines

Total Kjeldahl Nitrogen (TKN) – TKN is the total of organic nitrogen and ammonia nitrogen. The EPA nutrient criterion for TKN is 0.43 mg/L for reservoirs and 0.30 mg/L for tributaries. CWD also monitors

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[7] It is assumed that the 25th percentile of median nutrient concentrations in lakes, reservoirs, and tributaries monitored by EPA in the relevant subregions of Ecoregion XIV represented reference conditions (U.S. Environmental Protection Agency 2000, 2001). The Cambridge watershed is located nutrient Ecoregion XIV and subregion 59. EPA encourages states to compare local conditions to the regional nutrient criteria and to develop nutrient criteria that are specific to conditions observed at the local level.

ammonia concentrations separate from TKN.

Total Nitrogen (TN) – TN is the sum of nitrate and nitrite nitrogen and TKN. The EPA nutrient criterion for TN is 0.48 mg/L mg/L for reservoirs and 0.61 mg/L for tributaries. Nitrate nitrogen, nitrite nitrogen, and TKN results below the detection limit were set the detection limit for the purposes of calculating TN. Therefore, TN results err on the towards of overestimation of actual nitrogen concentrations.

Secchi Depth (m) – Secchi depth is a measure of water clarity, similar to turbidity (see below). It is quantified by lowering a Secchi disk into the water column and recording the depth at which the disk is no longer visible. CWD recorded two separate Secchi depths during each reservoir sampling event. First, CWD recorded the Secchi depth without using an aquascope. Next, CWD recorded the Secchi depth while looking through an aquascope, a tube-shaped device that blocks glare from the water surface to help see objects underwater. The EPA nutrient criterion for Secchi depth in reservoirs is 4.9 meters.

Total Phosphorus (TP) – The EPA TP nutrient criterion is 0.02375 mg/L for streams and 0.008 mg/L for lakes/reservoirs. Phosphorus is believed to be the limiting nutrient for plant and algal growth in the Cambridge watershed (Waldron and Bent, 2001). Phosphorous sorbed to sediment particles can be released into the water column under anoxic conditions, which can lead to excessive plant and algal growth, especially during the warm summer months.

Turbidity – Turbidity is a measure of water clarity. Turbid water often has increased levels of suspended dirt and organic matter, which can have adverse effects on water quality and aquatic habitat. The EPA nutrient criterion for streams in ecoregion 59 is 1.68 NTU. The EPA did not present a turbidity nutrient criterion for reservoirs.

5.2.4 Other Parameters

The CWD Source Water Monitoring Program also monitors additional water quality indicators, including:

Chlorophyll-*a* (chl-*a*) – The measured amount of chl-*a* in the water column is indicative of suspended algae biomass and is used to characterize a reservoir's productivity or trophic state. Chl-*a* was also compared against the 2016 CALM screening criteria to help assess nutrient impairment.

Reservoir Trophic State (TSI) - Carlson's trophic state index (TSI) is a dimensionless numerical index ranging from 0 – 100, indicating the degree of nutrient enrichment or biomass productivity of a water body (North American Lake Management Society Secchi Dip-In Program, [n.d]; Carlson, 1977). TSI values less than 40 indicate a low productivity state (oligotrophic) and optimal water quality for drinking water supplies (Table 1). Values ranging between 40 and 50 indicate moderate productivity (a mesotrophic state) and may correspond with taste and odor problems. Values greater than 50 indicate a water body that is highly productive (eutrophic), potentially from external nutrient loading, and likely to produce algal blooms.

The TSI of a water body can be estimated using chl-*a* concentrations, TP concentrations, or measured

Secchi depths (SD). Since TSI is an estimator of algal biomass weight in the reservoir, chl-*a* is typically the optimal parameter for calculating TSI (North American Lake Management Society Secchi Dip-In Program, [n.d]; Carlson, 1977). The formula for calculating TSI using chl-*a* is as follows (North American Lake Management Society Secchi Dip-In Program, [n.d]):

$$\text{TSI (CHL)} = 9.81 \ln(\text{chl-}a\ mg/m^3) + 30.6$$

Table 1. Trophic State Index Explanation and Water Quality Implications

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

TSI	Chl-*a* (µg/L)	SD (m)	TP (ug/L)	Attributes	Water Supply
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for an unfiltered water supply.
30 - 40	0.95 - 2.6	8 - 4	6 - 12	Hypolimnia of shallower lakes may become anoxic.	
40 - 50	2.6 - 7.3	4 - 2	12 - 24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	Iron, manganese, taste, and odor problems worse. Raw water turbidity requires filtration.
50 - 60	7.3 - 20	2 - 1	24 - 48	Eutrophy: Anoxic hylpolimnia, macrophyte problems possible.	
60 -70	20 - 56	0.5 - 1	48 - 96	Blue-green algae dominate, algal scums and macrophyte problems.	Episodes of severe taste and odor possible.
70 - 80	56 - 155	0.25 - 0.5	96 - 192	Hypereutrophy: (light limited productivity). Dense algae and macrophytes.	
>80	>155	<0.25	192 - 384	Algal scums, few macrophytes.	

Table source: North American Lake Management Society Secchi Dip-In Program, [n.d]

Specific Conductance (SpC) – Specific conductance is the ability of water to conduct electrical current, normalized to 25°C. In the field, it is used as a surrogate for sodium and calcium chloride deicing agents. Abrupt changes in specific conductance can also be an indicator of pumping, dumping or other activities requiring investigation.

Total Organic Carbon (TOC) – TOC is used to quantify naturally-occurring organic matter in the water supply. When mixed with chlorine, carbon can react to form disinfection byproducts (haloacetic acids and trihalomethanes) regulated by Massachusetts Drinking Water Standards and monitored by CWD during the treatment and water distribution processes.

5.3 Monitoring Equipment

CWD measures temperature, DO, specific conductance, TDS, and pH *in situ* using a calibrated Eureka Water Probes Manta2™ Multiprobe. Grab samples are also collected from streams and reservoirs using 1 Liter Teflon bottles for nutrients and high-density polyethylene (HDPE) bottles for all other parameters. A peristaltic pump and pre-cleaned Tygon tubing is used for collecting samples from bottom depths of the reservoirs. All samples are transported back to the Walter J. Sullivan Purification Facility on ice for processing. A contracted laboratory analyzes samples for TKN, ammonia, TP, and chlorophyll-*a.* The CWD laboratory performs the tests for all other parameters.

5.4 Routine Base-flow Reservoir and Tributary Water Quality Monitoring

Base-flow (dry weather) sampling was conducted on days with no more than 0.10 in of rain within the prior 72 hours. In 2017, base-flow water quality samples were collected at 9 reservoir and 12 tributary sampling stations using *Clean Water* protocols (Wilde and others, 1999) for all aspects of sample collection, preservation, and transport (Figures 2 and 3).

The Hobbs Brook Reservoir is divided into three basins by State Route 2, Trapelo Road, and Winter Street (Figure 2). Hobbs Brook Reservoir has four monitoring sites, two of which are sampled from the shoreline (HB @ Upper and HB @ Middle), and the other two (HB @ DH and HB @ Intake), are sampled by boat at fixed mooring locations (Figure 2). Stony Brook Reservoir has two sites (SB @ DH, and SB @ Intake), and Fresh Pond Reservoir has three sites (FP @ Cove, FP @ DH, FP @ Intake), all sampled by boat. All tributary monitoring sites are sampled from the stream center using the centroid dip technique (Edwards and Glysson, 1999).

In 2017, water quality profiles of temperature, DO, specific conductance, pH, and TDS were collected between 4 and 9 times at each reservoir site when weather conditions and water levels permitted (Tables 2 and 3). Water quality profiles began at 0.3 meters below the reservoir surface and the Manta2™ Multiprobe recorded measurements every 1 to 2 meters in depth down to one meter above the reservoir bottom. The profiles were used to monitor thermal and chemical stratification within the reservoirs, and to inform the operation of the aeration system at Fresh Pond (see section 6.0 *Reservoir Water Quality* for more information). The Manta2™ Multiprobe was also used to evaluate surface water quality at the 12 tributary monitoring sites (Tables 4 and 5).

Surface grab samples in 2017 were collected 6 to 7 times in each reservoir sampling location and analyzed for select nutrients and metals, chlorophyll-*a*, bacteria, and Eureka Water Probes Manta2™ parameters (Tables 2 and 3). During the spring, summer and early fall months, when the water column was thermally stratified, water quality grab samples were also collected from one meter above the reservoir bottoms.[8] Surface grab samples were collected at all tributary sites 6 times in 2017 and analyzed for the same parameters as the reservoirs, except for chl-*a* (Tables 4 and 5).

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[8] Prior to October 2016, samples were collected from 0.5 meters, rather than 1 meter, above the reservoir bottoms.

Through a joint funding agreement (JFA) between the City of Cambridge and the United States Geological Survey (USGS), USGS also collected water quality grab samples during base-flow conditions in 2017. USGS samples were collected between four and six times in 2017 at the following tributary sties: Lex Brook, Tracer Ln, WA-17, and Summer St (Figure 3). USGS water quality results are publicly accessible through the agency's website: [https://nwis.waterdata.usgs.gov/ma/nwis/qwdata.](https://nwis.waterdata.usgs.gov/ma/nwis/qwdata) See Appendix A for a list of CWD site names and corresponding USGS station numbers.

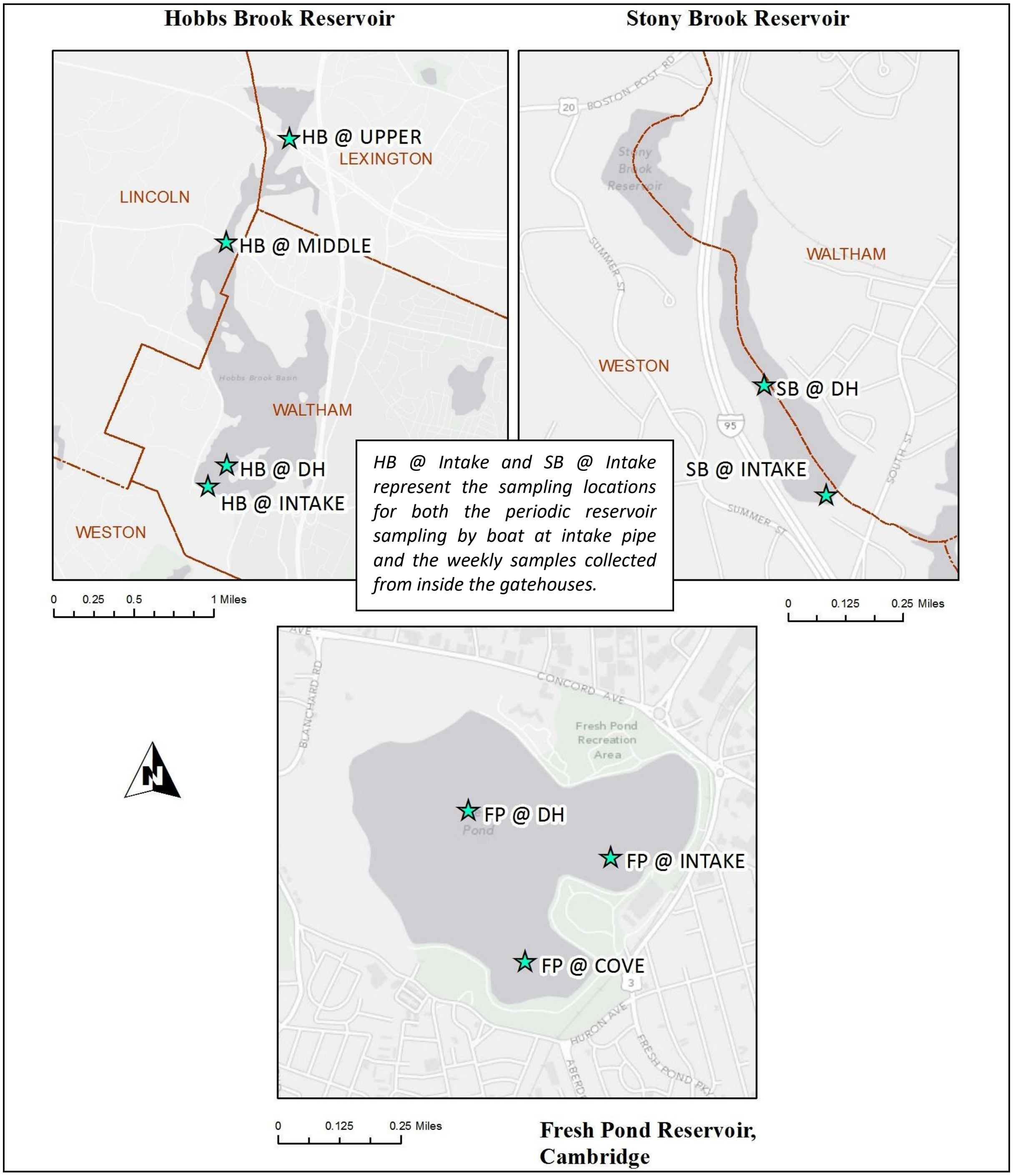

Figure 2. Reservoir Sampling Locations.

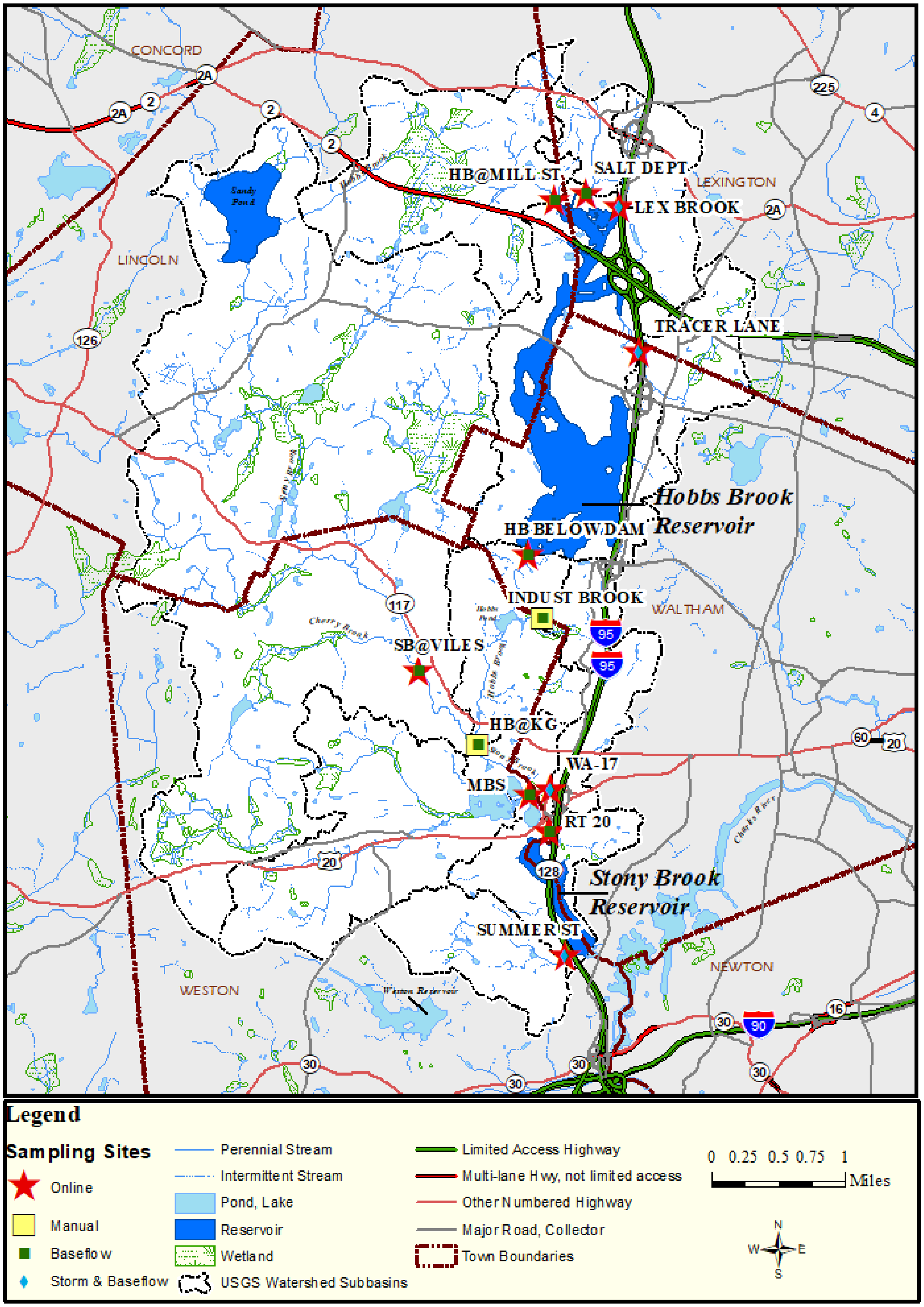

Figure 3: Tributary Monitoring Station Locations within the Cambridge Watershed

Table 2: Number of Reservoir Base-flow Sampling Events by Parameter and Site, 2017.

S = surface (0-0.3 m depth); B=0.5 m from the reservoir bottom; P = water quality profile, measurements collected at 0.3 m depth and every 1 – 2 m in depth. SpC = specific conductance.
- - indicates that the site or location was not sampled for the given set of parameters.

Parameters		HB @ Upper	HB @ Middle	HB @ DH			HB @ Intake			SB @ DH			SB @ Intake			FP @ DH			FP @ Cove	FP @ Intake		
		S	S	S	B	P	S	B	P	S	B	P	S	B	P	S	B	P	P	S	B	P
Manta2™ Multiprobe Reading, ***measured in situ***	**DO** **SpC** **Temperature** **pH** **TDS**	6	6	6	6	6	6	6	6	6	6	6	4	4	4	9	9	9	9	9	9	9
Secchi Disk Depth, ***measured in situ***	**Secchi Disk Depth**	--	--	6	--	--	6	--	--	6	--	--	4	--	--	9	--	--	9	9	--	--
Water Quality Grab Samples, ***Analyzed by CWD laboratory***	**Al** **Alkalinity** **Ca^{2+}** **Cl^-** **Color** **Fe** **Mn** **Na^+** **NO_3^- / NO_2^*** **pH** **SpC** **TOC** **Turbidity**	6	6	6	3	--	--	--	--	6	4	--	--	--	--	7	5	--	--	--	--	--
	E. coli	6	6	--	--	--	5	--	--	--	--	--	5	--	--	--	--	--	--	7	--	--
Water Quality Grab Samples, ***Analyzed by contract laboratory***	**Chl-*a*** **NH_3** **TKN** **TP**	6	6	6	3	--	--	--	--	6	4	--	--	--	--	7	5	--	--	--	--	--
*NO_3^-/NO_2^+ samples were analyzed by a contract lab if scheduling conflicts prevented CWD staff from performing the analysis in house.																						

Table 3: Reservoir Base-flow Sampling Events by Date and Site, 2017.

M=Manta2™ Multiprobe surface reading; MP = Manta2™ Multiprobe water column profile; E = E. coli sample; WL = water quality sample analyzed by CWD laboratory (except E. coli); WC = water quality grab sample analyzed by contract laboratory; B = bottom grab sample analyzed for WL and WC parameters. See Table 2 for list of parameters analyzed by the Manta2™ Multiprobe, CWD laboratory (WL), and contract laboratory (WC).

Date	Jan	Feb	Mar	April		May	June		Jul			August			Sept	Oct			Nov		Dec
	4	23	21	13	20	10	13	22	6	19	20	22	30	31	19	3	4	18	28	30	14
HB @ Upper		M, E, WL, WC	M, E, WL, WC						M, E, WL, WC					M, E, WL, WC		M, E, WL, WC					M, E, WL, WC
HB @ Middle		M, E, WL, WC							M, E, WL, WC					M, E, WL, WC		M, E, WL, WC					M, E, WL, WC
HB @ DH					MP, WL, WC, B			MP, WL, WC, B			MP, WL, WC		MP, WL, WC, B				MP, WL, WC			MP, WL, WC	
HB @ Intake					MP, E			MP, E			MP, E		MP				MP, E			MP, E	
SB @ DH					MP, WL, WC, B			MP, WL, WC, B			MP, WL, WC		MP, WL, WC, B				MP, WL, WC, B			MP, WL, WC	
SB @ Intake					E			E			MP, E		MP				MP, E			MP, E	
FP @ DH	MP			MP, WL, WC, B		MP, WL, WC, B	MP, WL, WC, B			MP		MP, WL, WC, B			MP, WL, WC, B			MP, WL, WC	MP, WL, WC		
FP @ Cove	MP			MP		MP	MP			MP		MP			MP			MP	MP		
FP @ Intake	MP			MP, E		MP, E	MP, E			MP		MP, E			MP, E			MP, E	MP, E		

Table 4: Number of Tributary Surface Sampling Events by Parameter and Site, 2017

Parameters		HB @ Mill St	Salt Depot	Lex Brook	Tracer Ln	HB Below Dam	Indust Brook	HB @ KG	SB @ Viles St	MBS	WA-17	RT 20	Summer St
Manta2™ Multiprobe Reading, ***measured in situ***	DO SpC Temperature pH TDS	6**	6	7	6	6	6	6	7	6	6	6	6
Water Quality Grab Samples, ***Analyzed by CWD laboratory***	Al Alkalinity Ca Cl^- Color Fe Mn Na^+ NO_3^- / NO_2^* pH SpC TOC Turbidity *E. coli*	6	6	6	6	6	6	6	6	6	6	6	6
Water Quality Grab Samples, ***Analyzed by contract laboratory***	NH_3 TKN TP	6	6	6	6	6	6	6	6	6	6	6	6

*NO_3^-/NO_2^+ samples were analyzed by a contract lab if scheduling conflicts prevented CWD staff from performing the analysis in house. **Temperature, TDS, and SpC readings from 1/31/2017 excluded due to sensor error.

Table 5: Tributary Surface Sampling Events by Date and Site, 2017.

Unless otherwise indicated, all sampling events included a Manta2™ Multiprobe reading, E. coli sample, and all water quality grab sample parameters analyzed by the CWD laboratory and contract laboratory. See Table 4 for list of parameters analyzed by the Manta2™ Multiprobe, CWD laboratory, and contract laboratory. X = sampling date.

Date	**Jan**		**Feb**		**Mar**			**April**	**June**	**Jul**	**Aug**						**Sept**	**Oct**		**Nov**	**Dec**
	17	**31***	**2****	**23**	**6**	**21**	**23**	**11**	**27**	**6**	**1**	**9#**	**15**	**16#**	**29**	**31**	**27**	**3**	**19**	**2**	**14**
HB @ Mill St		X^	X				X		X				X				X			X	
Salt Depot		X	X				X		X				X				X			X	
Lex Brook	X				X			X			X	X			X				X		
Tracer Ln		X	X				X		X				X				X			X	
HB Below Dam	X				X			X			X				X				X		
Indust Brook				X		X				X						X		X			X
HB @ KG				X		X				X						X		X			X
SB @ Viles		X	X				X		X				X	X			X			X	
MBS		X	X				X		X				X				X			X	
WA-17	X				X			X			X				X				X		
RT 20	X				X			X			X				X				X		
Summer St	X				X			X			X				X				X		

**E. coli* samples collected on 1/31/2017 were not analyzed due to laboratory error. Replacement samples were collected on 2/2/2017 and analyzed instead. ^Temperature, TDS, and SpC readings from HB @ Mill St were excluded due to sensor error. ***E. coli* only. #Manta2™ Multiprobe reading only.

5.5 Weekly Reservoir Water Quality Monitoring and Watershed Continuous Monitoring Stations

5.5.1 Weekly Reservoir Water Quality Monitoring

In addition to the dry weather reservoir monitoring program, CWD collects weekly surface grab samples, regardless of the weather, from inside the Hobbs Brook Dam and Stony Brook Dam gatehouses (HB @ Intake Weekly and SB @ Intake Weekly). During weeks when the Hobbs Brook Reservoir was frozen, the sample was collected downstream of the gatehouse at the dam outlet. When weekly sampling events coincided with a routine dry-weather reservoir sampling event, the weekly samples were collected form the HB @ Intake site instead of inside the gatehouse (Figure 2).

Weekly samples help identify immediate contamination, capture seasonal and climatic water quality variability, and track chemical concentration changes over time. Weekly samples are analyzed for *E. coli* bacteria, alkalinity, color, select metals and salts (Al, Ca^{2+}, Cl^{-}, Fe, Mn, Na^{+}), pH, specific conductance, TOC, and turbidity.

5.5.2 Continuous Watershed Monitoring Stations

In addition, nine of the 12 primary tributary sites, as well as all three reservoirs, are equipped with USGS stations that continuously monitored (10-15 minute data collection interval) stream and reservoir stage, reservoir storage, and reservoir discharge as part of the JFA between CWD and USGS (Figure 3). Temperature, specific conductance, stream discharge (based on stage), and other water quality parameters such as chl-*a* and turbidity were also collected continuously at a subset of stations. Precipitation was monitored at the three reservoir stations, and wind speed and direction were measured at the Stony Brook Reservoir. Data from these sites are available in real time on the USGS website:

(http://waterdata.usgs.gov/ma/nwis/current/?type=cambrid&group_key=basin_cd&site_no_name_select=siteno).

CWD maintains a HOBO-U20L water level logger, installed in October of 2016, that collects 15-minute water level and temperature data at HB @ KG. Using a CWD-generated stage-discharge relationship (rating curve), CWD maintains a database of continuous calculated discharge at the site. CWD also collects periodic instantaneous discharge measurements (approximately 6 measurements per year) to maintain the rating curve, applying shifts to the rating curve as needed.

Continuous stage data at HB @ KG was missing from August 31, 2017 at 12:00 PM through October 20, 2017 at 11:30 AM due to site vandalism. Daily average discharge from September 1, 2017 through November 19, 2017 was estimated based on average daily flow at SB @ Viles and daily average flow at HB Below Dam as described in Appendix B.

5.6 Event-Based Water Quality Monitoring

5.6.1 Stormwater Sampling

Wet weather or stormwater sampling by staff in the field can be difficult to schedule due to the unpredictable timing of precipitation events. Thus, automatic sampling is a preferred method for obtaining wet weather samples. USGS continuous monitoring stations at Lex Brook, Tracer Ln, WA-17, and Summer St are equipped with automatic samplers which collect storm water when triggered by high stream flow (Figure 3). USGS storm sample collection dates for 2017 are presented below in Table 6. The range of dates indicates the duration of the storm from which the composite sample was derived. Results from USGS stormwater sampling in 2017 are presented in this report, but are also publicly accessible from the USGS website:

https://nwis.waterdata.usgs.gov/ma/nwis/qwdata

Table 6. USGS Wet Weather Sampling Dates, 2017

Site	Lex Brook	Tracer Ln	WA-17	Summer St
USGS Site ID	**01104415**	**01104420**	**01104455**	**01104475**
USGS Wet Weather Sampling Dates	5/5-5/7	5/5-5/7	5/5-5/7	5/5/-5/7
		7/7-7/8		7/7-7/8
		7/24-7/24	7/24-7/25	
		9/6-9/7	9/6-9/7	
				9/14-9/15
	10/24-10/27	10/24-10/26	10/24-10/26	10/24-10/26
	11/16-11/16		11/16-11/17	
	12/6-12/6	12/5-12/6	12/5-12/6	12/6-12/6

5.6.2 Incident-Based Sampling

CWD staff perform additional sampling on an as-needed basis to investigate problems associated emergency spills or illicit discharges within the watershed, and to monitor runoff from construction activities. These test results help guide spill response and enforcement activities within the watershed and are not included in this report.

5.7 Data Management, Quality Control, Analysis and Reporting

All water quality monitoring and quality-assurance data are entered into a CWD-maintained database that enables the CWD analyze, track, and report changes in water quality efficiently. This report satisfies the reporting portion of the Cambridge Source Water Quality Monitoring Program. Source water quality data is available upon request. To submit a data request, email joconnell@cambridgema.gov.

5.7.1 Quality Control: Field Duplicates and Field Blanks

Field duplicates and field blanks provide quality control checks on CWD data. Field duplicates, when a second or "duplicate" sample is collected during a sampling event, are a measure of sample precision and environmental variability. Field blanks ensure there is no cross-contamination of the samples during sample collection, transport, and processing.

Where field duplicate samples were collected, results and statistics presented in this report were calculated using the mean concentration of the sample and duplicate sample. For example, when tallying the total number of samples at a site, the mean of the sample and duplicate was reported as a single sample rather than two separate samples. If a sample was below the detection limit, the sample was set to the detection limit in order to average the two samples. Assigning a value of the detection limit errs on the side of overestimating rather than under estimating parameter concentrations.

The precision of the data was measured using the Relative Percent Difference (RPD) metric. RPD was calculated using the equation:

$$RPD = \frac{|x_1 - x_2|}{(x_1 + x_2) * (\frac{1}{2})} * 100\%$$

x_1 and x_2 are the CWD measurement and corresponding field duplicate measurement

Due to the nature of measurement error and environmental sampling constraints, differences within 20 percent are generally considered acceptable measurements.

The average RPD for duplicate samples analyzed by the CWD laboratory and presented in this report was 9 percent (Table 7).[9] The CWD laboratory also analyzed additional parameters that were not documented in this report. The average RPD for all parameters analyzed by CWD in 2017 was 14 percent and the average RPD for parameters analyzed by a contract laboratory, Microbac Laboratories, Inc., was 13 percent. While certain individual tests had an RPD above 20 percent, on average the RPD between duplicate samples was below 20 percent (Tables 7). Large variations between samples and duplicates could represent environmental variation, contamination of the sample, or an error in the laboratory analysis. See Appendix C for detailed results of duplicate samples and RPDs.

[9] This average includes RPDs for duplicate samples collected at Blacks Nook and North Pond. These sites are two small ponds located at Fresh Pond Reservation and are sampled by CWD on a quarterly basis. The ponds are not part of the drinking water supply, so water quality results from these stations are not discussed in this report. However, the results of duplicate samples collected at these locates are reported in Table 7 and Appendix C. Go to https://www.cambridgema.gov/Water/watershedmanagementdivision/sourcewaterprotectionprogram/sourcewaterqualitymonitoringprogram/datamanagement/reportsandresearch to view water quality reports specific to these ponds.

Table 7: Average Relative Percent Differences (RPD), 2017

RPD	Microbac	CWD – reported parameters	CWD – all parameters
Average	13%	9%	14%
Min	0%	0%	0%
Max	53%	77%	170%
See footnote 9 regarding sites included in the average RPD calculations. "CWD - reported parameters" statistics were calculated using only parameters discussed in this report. "CWD – all parameters" includes the RPDs for all parameters analyzed by CWD in 2017.			

Field blanks in 2017 were included with tributary and reservoir samples on March 21, March 23, July 20, August 30, October 19, and November 28 (Appendix C). Nearly all results were below the detection limit or were not detected in quantities large enough to meaningfully affect sample results presented in this report. Values for pH were within the expected ranges for de-ionized water exposed to the atmosphere. These results indicate that discrepancies between samples and field duplicates were unlikely due to contamination during sample transport or processing. See Appendix C for detailed field blank results.

5.8 Load and Yield Calculations

The water quality monitoring program described above measures the concentration of pollutants in tributaries at specific points in time. However, the impact of a pollutant on water quality depends not only on pollutant concentration, but also on the volume of water flowing through the tributary catchment. For example, a small (low flow) tributary with a high salt concentration may transport less sodium during a given timeframe than a large (high flow) tributary with a lower concentration of sodium. Therefore, to account for the effect of tributary water volume on water quality, the annual base-flow load and yield of sodium, chloride, nitrate and nitrite nitrogen, and TP were calculated at each monitoring station as follows:

$$\text{Load}_{\text{base-flow}} = \mu_{\text{CWD}} \times Q_{\text{base-flow}}$$

$$\text{Yield}_{\text{base-flow}} = \text{Load}_{\text{base-flow}} / \text{tributary catchment area (mi}^2\text{)}$$

Where:

μ_{CWD} = 2017 mean concentration of sodium, chloride, nitrate and nitrite nitrogen, or TP measured by CWD during dry conditions, in mg/L

$Q_{\text{base-flow}}$ = 2017 base-flow, in L/yr

The volume of base-flow ($Q_{\text{base-flow}}$) at tributary sites with continuous discharge data was calculated using the fixed-interval base-flow and stormflow separation method described in Appendix B. For sites without continuous discharge data, CWD performed discrete discharge measurements in cubic feet per second (cfs) during each base-flow water quality sampling event. These measurements were averaged to estimate the average annual base-flow in cfs. The total annual base-flow ($Q_{\text{base-flow}}$, in L/yr) was calculated by multiplying this average (cfs) by the number of seconds in a year (3,153,6000 seconds) to derive total cubic feet of flow. This total was then converted from cubic feet to liters.

Continuous USGS discharge data were available for the following sites: Lex Brook, Tracer Lane, HB Below

Dam, SB @ Viles, WA-17, Summer St, and RT 20. In October of 2016, the USGS ended discharge monitoring at Salt Depot. However, the USGS continued to collect continuous stage data (10-minute intervals). CWD maintained the USGS-provided stage-discharge relationship by conducting periodic discharge measurements and applying rating curve shifts as needed, allowing for the calculation of continuous discharge data in 2017. Continuous discharge data were also available at HB @ KG from a CWD-maintained monitoring station.[10] The sites without continuous discharge data, where $Q_{\text{base-flow}}$ was estimated based on the average of discharge measurements performed during sampling events, were as follows: HB @ Mill St, Indust Brook[11], and MBS.

In 2017, the USGS collected stormwater water quality samples from Lex Brook, Tracer Lane, WA-17, and Summer St. This allowed CWD to also calculate stormwater loads and yields as follows:

$$Load_{stormflow} = \mu_{USGS} \times Q_{stormflow}$$

$$Yield_{stormflow} = Load_{stormflow} / \text{tributary catchment area (mi}^2\text{)}$$

Where:

μ_{USGS}= 2017 mean concentration of sodium, chloride, or TP measured by USGS during storm events, in mg/L

$Q_{stormflow}$ = 2017 stormflow, in L/yr

See Appendix B for the methodology used to separate base-flow and stormflow from total discharge at each site.

5.9 Boxplot Key

All boxplots presented in this report use the format shown in Figure 4. The median was included in the 25th and 75th percentile calculations. The inter quartile range (IQR) was calculated as the difference between the 75th and 25th percentiles (Figure 4). Sample results below the detection limited were set to the detection limit for the purposes of generating the boxplot and calculating the boxplot statistics.

[10] Continuous stage data at HB @ KG was missing from August 31, 2017 at 12:00 PM through October 20, 2017 at 11:30 AM due to site vandalism. Daily average discharge from September 1, 2017 through November 19, 2017 was estimated based on flow at SB @ Viles and HB Below Dam as described in Appendix B.

[11] No discharge measurement was performed during the March 21, 2017 sampling event at Indust Brook. Instead, discharge was quantified based on stage and a USGS-provided rating table. The rating table was created when Indust Brook was an active USGS monitoring site (station 0114433). Indust Brook was decommissioned by the USGS in 2007.

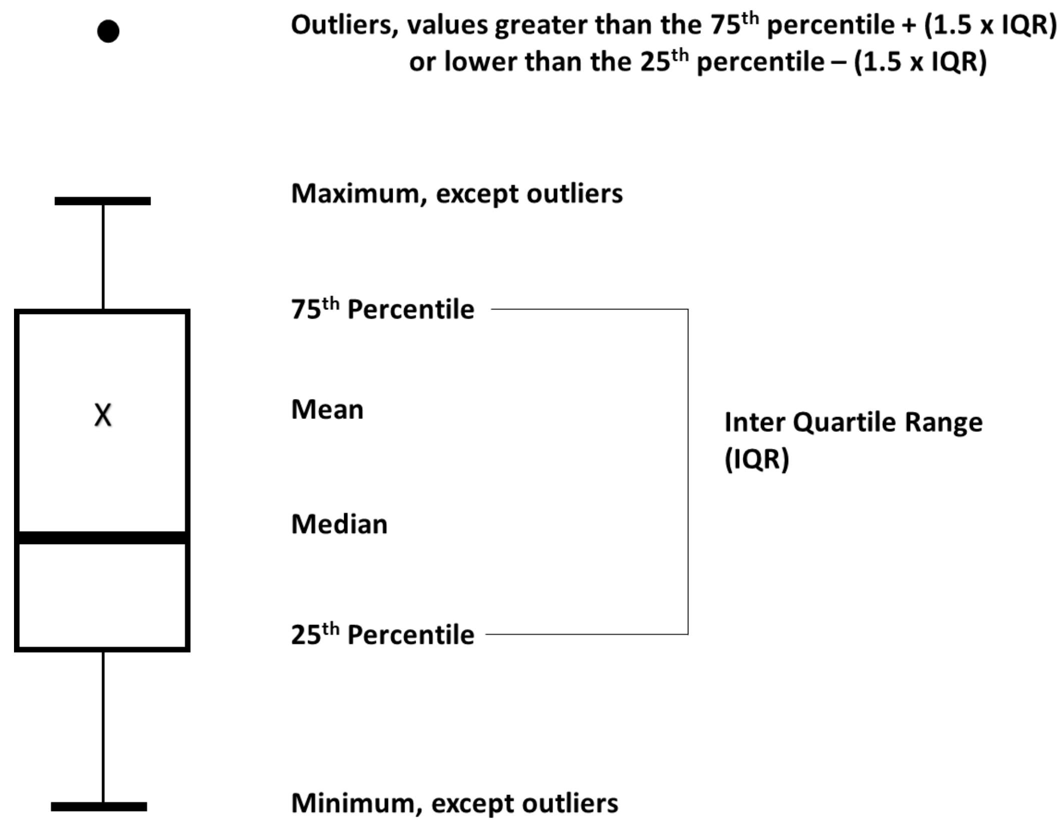

Figure 4: Boxplot Key

6 RESERVOIR WATER QUALITY

Since the 1970s, CWD has monitored seasonal thermal stratification, which occurs in all three reservoirs and has implications on water quality. In the spring, surface water begins to warm, forming a distinct upper layer (epilimnion) of less dense water that will not mix with colder, denser bottom waters (hypolimnion). Biochemical processes in the isolated bottom waters require oxygen and can create reduced (anoxic) conditions which stress fish and other aquatic fauna. Nuisance metals, such as iron and manganese, and phosphorus bound to sediments can be released into the hypolimnion in the absence of oxygen. These metals and nutrients are then mixed throughout the water column during fall “turn over,” the mixing of layers as surface water cools and water temperature becomes homogeneous throughout the reservoir depth profile.

The following sections describe water quality in the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs throughout all seasons in 2017. Water quality results are also compared to the Class A water quality standards, MCL and SMCLs, ORS Guidelines, and EPA nutrient criteria.

6.1 RESERVOIR WATER QUALITY PROFILES

6.1.1 Temperature and Dissolved Oxygen (DO) Profiles

In 2017, water column temperatures at Hobbs Brook, Stony Brook, and Fresh Pond reservoirs increased throughout the spring and summer, peaking in July and August (Figures 5 and 6). Water column temperatures began to cool in September and consistently dropped through the end of November when the last profiles of 2017 were collected. Because warm water holds less oxygen than colder water, DO levels showed the opposite trend of temperature. Overall DO concentrations were highest when water temperatures were lowest (January – May, October, and November).

The deep hole sites at all three reservoirs exhibited the expected behavior of thermal stratification during the spring and summer months, followed by fall mixing (Figure 5). Unlike the deep hole sites where stratification was apparent in April and May, profiles from the intake and FP @ Cove sites did not become strongly stratified until June (Figures 5 and 6). The intake and FP @ Cove sites also underwent fall turnover a month earlier than the deep hole sites, likely due to their shallowness (Figure 6). Profiles were not collected from SB @ Intake until July due to an inaccessible mooring buoy which was needed to secure the boat when collecting the profiles.

All three reservoirs experienced reduced DO levels in the hypolimnion during periods of thermal stratification. All deep hole sites were hypoxic (DO below 2 mg/L) in the hypolimnion during July and August (Figure 6; Rounds and Wilde, 2013). However, likely due to an aeration system that ran continuously throughout the year at Fresh Pond Reservoir, only HB @ DH and SB @ DH experienced hypoxic conditions during the June profile. In addition, none of the FP @ DH profiles had anoxic conditions (DO below 0.5 mg/L) whereas HB @ DH and SB @ DH were anoxic in the bottom depths in June, July, and August (Figure 6; Rounds and Wilde, 2013). Of the shallower sites, only HB @ Intake experienced summer hypoxic and anoxic conditions. Interestingly, the FP @ Intake April profile had higher DO in the bottom of the water column than in the surface layers. It is possible that a subsurface algal bloom caused this

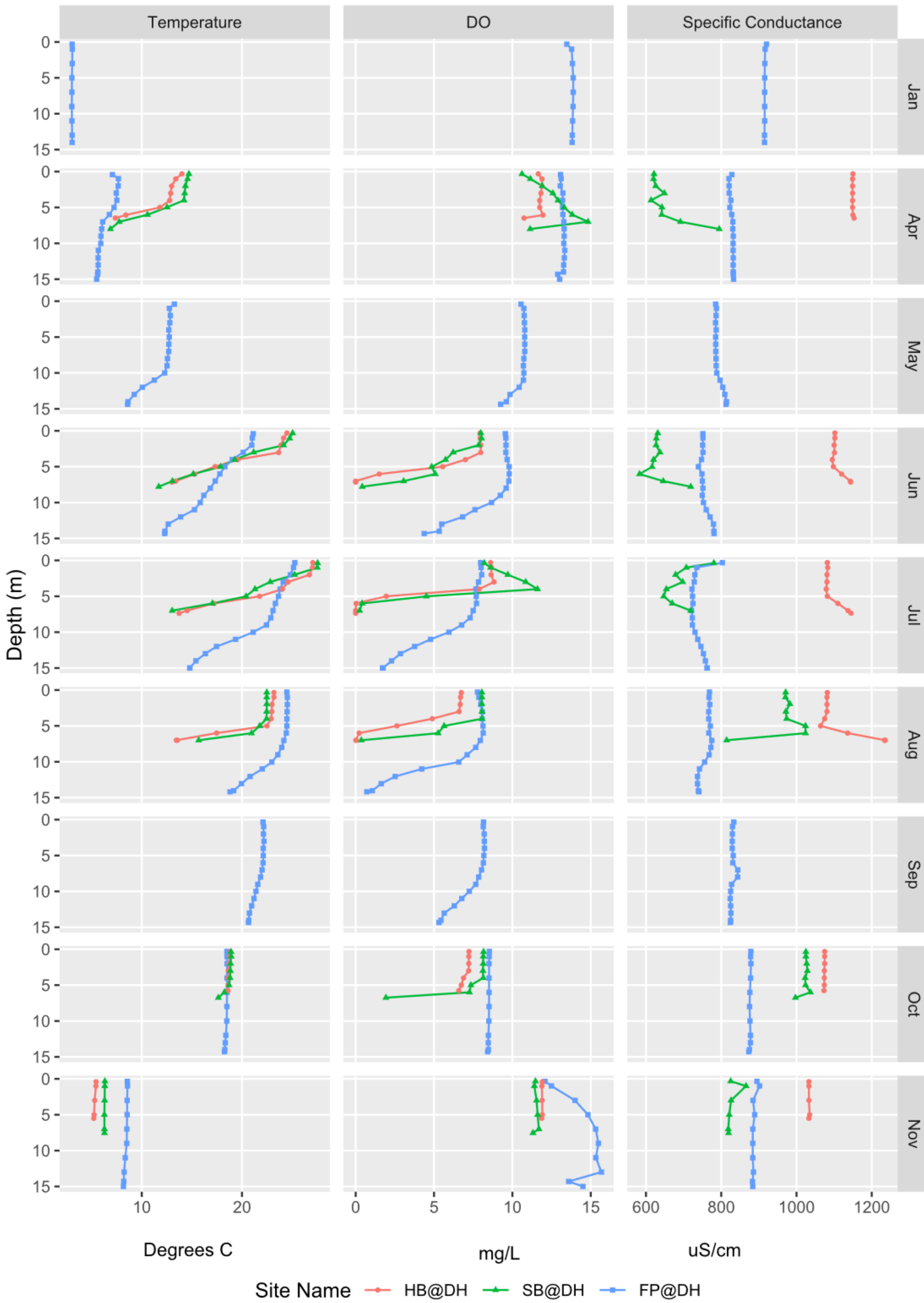

Figure 5: Reservoir Deep Hole Temperature, DO, and Specific Conductance Profiles, 2017

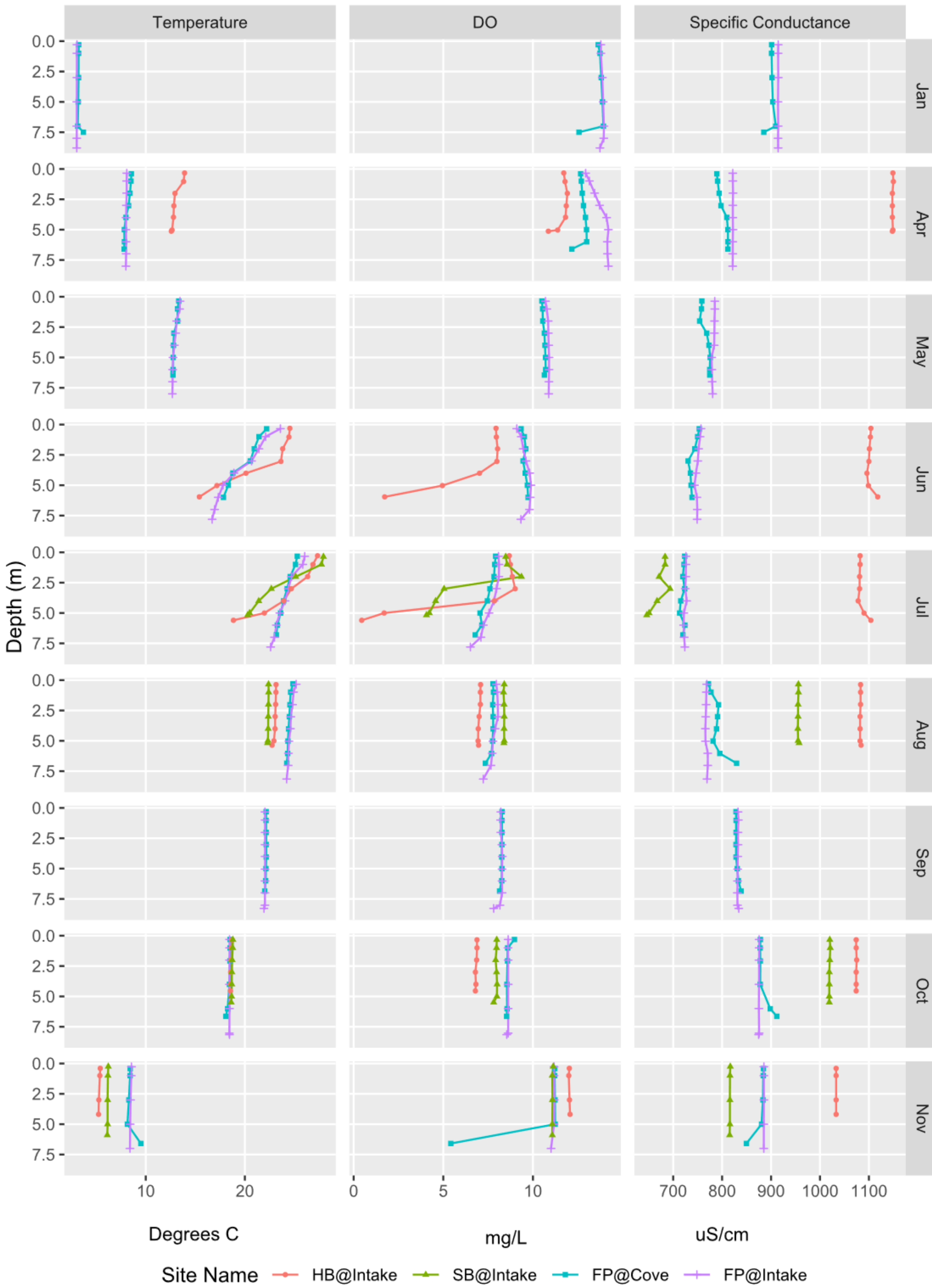

Figure 6: Reservoir Intakes and FP @ Cove Temperature, DO, and Specific Conductance Profiles, 2017

inversion by producing oxygen through photosynthesis. However, elevated pH, a sign of algal activity, was not found throughout the profile, although pH did increase slightly with depth (pH range of 7.44-7.46) (see section 6.2.1, Figure 8).

6.1.2 Specific Conductance Profiles

Specific conductance in the Hobbs Brook Reservoir is heavily influenced by road salt impacts from Interstate 95 and Route 2 as well as from a historic groundwater salt plume from the District 4 Massachusetts Department of Transportation (MassDOT) salt storage facility (Geotechnical Engineers Inc., 1985). Specific conductance in Cambridge watershed tributaries tends to be higher in base-flow samples than in stormflow composite samples due to dilution during storm events (Smith, 2017). However, acute spikes in specific conductance do occur during winter runoff events and can be orders of magnitude higher than base-flow specific conductance (Smith, 2017). Water stored in the Hobbs Brook Reservoir during the wet winter and spring months is released during the drier summer and fall months to supplement inflow to the Stony Brook Reservoir and meet water demand at Fresh Pond Reservoir in Cambridge. Therefore, the specific conductance at Hobbs Brook Reservoir influences the specific conductance downstream at the Stony Brook Reservoir. Because the reservoirs are located in succession, water released from Hobbs Brook Reservoir into Stony Brook Reservoir affects water quality at Fresh Pond Reservoir too.

In 2017, overall specific conductance at Hobbs Brook Reservoir decreased slightly throughout the year (Figures 5 and 6). Specific conductance at HB @ DH and HB @ Intake during the April profiles was approximately 1150 uS/cm. By November, the concentration had dropped by over 100 uS/cm to 1,033 uS/cm. The observed decrease is likely due to the flushing of salt impacted base-flow with increased stormflow following the end of a drought which officially began July 1, 2016 and ended on April 30, 2017 (Massachusetts Executive Office of Energy and Environmental Affairs, 2017).

In 2017, annual water releases from Hobbs Brook Reservoir to supplement flows into Stony Brook Reservoir began in mid-July and ceased at the end of October. The influence of water released from Hobbs Brook Reservoir on Stony Brook Reservoir water quality was apparent in the specific conductance profiles (Figures 5 and 6). In the April profile, prior to the release of water from Hobbs Brook Reservoir, the SB @ DH surface specific conductance was 621 uS/cm, more than 500 uS/cm lower than HB @ DH (1,150 uS/cm) on the same date (Figure 5). By October, specific conductance at the surface of SB @ DH had increased to 1,025 uS/cm, within 50 uS/cm of the concentration at Hobbs Brook Reservoir (1,075 uS/cm). Following the cessation of water releases from Hobbs Brook Reservoir at the end of October, the surface specific conductance level at SB @ DH dropped by 200 uS/cm to 825 uS/cm in the November profile, while the HB @ DH level remained elevated at 1,033 uS/cm.

At Fresh Pond, specific conductance profiles demonstrated a decreasing trend from January through July (Figures 5 and 6). Concentrations stabilized in August, and then increased slightly in the September and October profiles before stabilizing again in November. The decrease in specific conductance between January and July was likely due to the continued flushing of salt impacted water that had entered Fresh Pond from Hobbs Brook Reservoir water releases during the 2016-2017 drought. However, once summer releases of water from the Hobbs Brook Reservoir began again in July of 2017, the decreasing trend began to reverse, with specific conductance at Fresh Pond increasing from August through October before stabilizing in November.

There was approximately a one-month delay between the start of water releases from Hobbs Brook Reservoir and a change specific conductance at Fresh Pond Reservoir. By contrast, the water quality impact of Hobbs Brook Reservoir water releases was more immediate at Stony Brook Reservoir. For example, specific conductance remained very similar at Fresh Pond Reservoir between July and August, whereas specific conductance at Stony Brook Reservoir increased between the July and August profiles by 200 uS/cm - 300 uS/cm, depending on the depths compared.

In addition to a temporal difference in the timing of water quality impacts, the magnitude of change in specific conductance was greater at Stony Brook Reservoir than at Fresh Pond. The highest specific conductance levels measured at Stony Brook Reservoir during 2017 exceeded peak levels at Fresh Pond, and the lowest specific conductance readings at Stony Brook Reservoir were lower than at Fresh Pond. These differences in the timing and magnitude of change of specific conductance is likely explained by the difference in flushing rates and retention times between Stony Brook and Fresh Pond reservoirs. The flushing rate at Stony Brook Reservoir is higher than Fresh Pond Reservoir, with a retention time in 2017 of only 18 days at Stony Brook Reservoir versus 3.8 months at Fresh Pond (see section 10.2 *Reservoir Retention Times*).

6.2 Class A Water Quality Results

6.2.1 Reservoir *E. coli*, DO, pH, and Temperature

All three reservoirs had excellent water quality as evaluated by the Class A water quality standards for DO, temperature, pH, and *E. coli* (Figures 7 – 10). Fresh Pond Reservoir is the terminal reservoir in the Cambridge water supply and, therefore, is the most important in terms of water quality. Surface water quality probe readings of pH, temperature, and DO at FP @ Cove, FP @ DH, and FP @ Intake were all within the Class A bounds (Figure 8). In addition, all FP @ Intake surface *E. coli* results were below the 235 MPN/100 ml Class A standard (Figure 7).

In addition to surface samples, water quality probe measurements at Fresh Pond Reservoir met the Class A standards for temperature and pH at every depth in the profile (Figure 8). At FP @ DH, thermal stratification of the water column in the spring and summer prevented oxygen-rich water in the epilimnion from mixing with the hypolimnion. This presumably led to oxygen depletion in the lower depths of the reservoir, where DO levels dropped below the Class A standard of 5 mg/L despite continuous operation of the aeration system (Figure 8 and Appendix D). During the June profile, only the last meter of the water column at FP @ DH had dropped below 5 mg/L. As thermal stratification continued in July and August, the zone of oxygen depletion (DO below 5 mg/L) expanded from the bottom meter up to 10 meters in depth (Figure 8). The FP @ Intake and FP @ Cove sites were shallower than 10 meters and remained above the 5 mg/L threshold throughout the year.

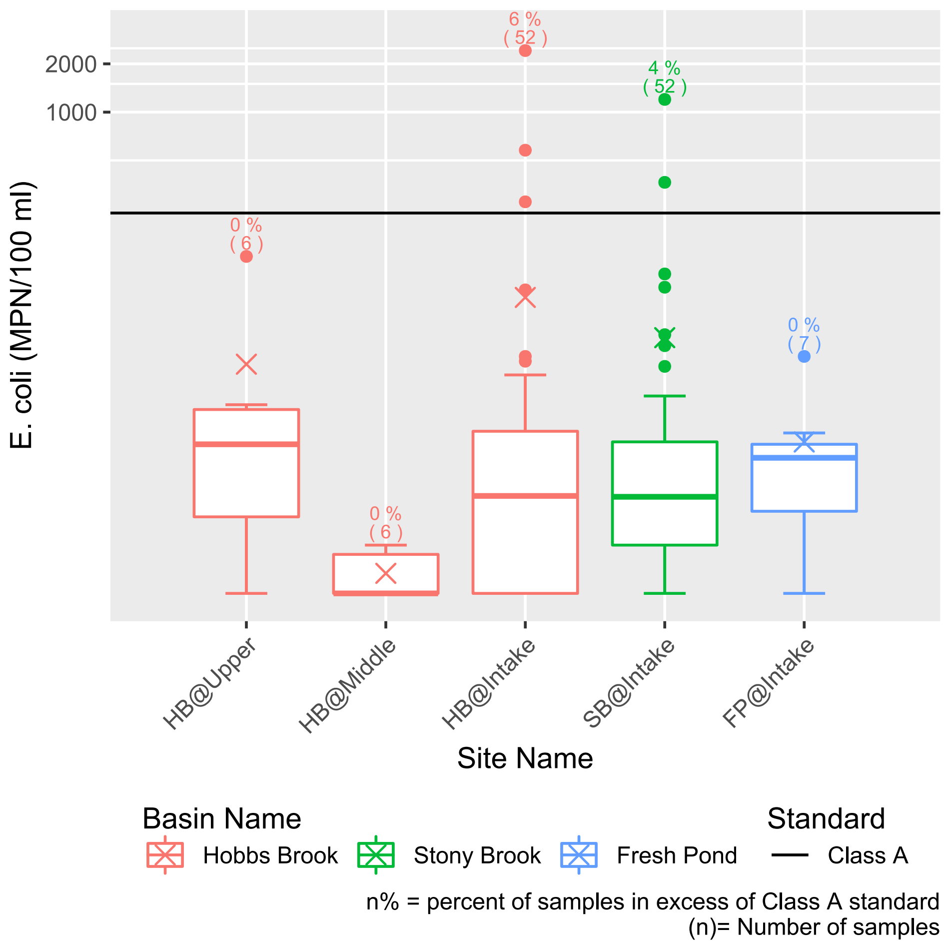

Figure 7: Reservoir E. coli, 2017

Water quality at Hobbs Brook Reservoir and Stony Brook Reservoir also largely met the Class A standards in 2017. Hobbs Brook Reservoir and Stony Brook Reservoir met the Class A water quality criteria for pH at all depths, except for one *in situ* water quality probe reading at HB @ Upper on December 14, 2017 (Figures 9 and 10; Appendix D). This measurement (8.32) exceeded the upper bound of the Class A pH standard (8.3). However, a water quality sample collected simultaneously and analyzed in the CWD laboratory was much lower (6.95) and within the acceptable Class A bounds for pH. The discrepancy between the two pH readings could be caused by ice cover at the site; CWD staff broke through a layer of ice to collect the sample and take the probe reading. The ice may have prevented atmospheric carbon dioxide (CO_2) from mixing with the water (H_2O), thereby reducing the concentration of bicarbonate (HCO_3^-) and hydrogen (H^+) molecules and driving up the pH. The laboratory pH measurement could be lower (higher hydrogen ion concentration) due to atmospheric mixing of carbon dioxide with water to form hydrogen ions and bicarbonate.

All six base-flow samples from HB @ Upper and HB @ Middle samples collected in 2017 met the *E. coli* Class A criterion (Figure 7). Three *E. coli* samples collected at HB @ Intake and two samples from SB @ Intake were above the Class A standard of 235 MPN/100 ml (Figure 7 and Appendix D). The exceedances at both reservoirs occurred on April 6th and September 21st, with an additional exceedance at HB @ Intake on September 7th. A 1-inch rain event occurred within 72 hours of the April 6th weekly sample, so the elevated *E. coli* could have been a result of pollutants entering the reservoirs after the storm. A negligible amount of rain occurred prior to the September 21st event, so stormwater runoff is an unlikely explanation for the exceedance. The September 7th weekly sample was collected during the tail end of a 24-hour 1-inch rain event, so stormwater runoff is a possible explanation for the *E. coli* exceedance at Hobbs Brook Reservoir. With 52 samples collected from HB @ Intake and SB @ Intake during 2017, the Class A exceedance rate for *E. coli* was 6 percent and 4 percent, respectively (Appendix D). This indicates that *E. coli* is not a significant water quality issue at either reservoir.

Hobbs Brook and Stony Brook reservoirs also met the DO and temperature Class A standards for warm water fisheries (5 mg/L and 28.3 degrees C) in all surface measurements collected by CWD in 2017 (Figures 9 and 10). Neither reservoir exceeded the warm water fisheries temperature at any depth. In addition, the USGS maintains a continuous water quality probe at the Hobbs Brook Reservoir gatehouse (station 01104430). The maximum temperature recorded by the USGS probe in 2017 was 24.6 degrees C, well below the 28.3 degrees C Class A standard.

However, during thermal stratification, both reservoirs dropped below the warm water fisheries DO standard in the lower depths of the water column (Figures 9 and 10; Appendix D). In June, DO at Hobbs Brook Reservoir was less than the Class A standard after 5 meters in depth (Figure 9). The zone of oxygen depletion expanded slightly in July to include all depths below 4 meters. In August, HB @ Intake was thermally mixed and fully oxygenated at all depths while HB @ DH remained oxygen deficient below 4 meters. Both HB @ DH and HB @ Intake had mixed by October and had sufficient DO at all depths.

Similarly, SB @ DH DO fell below the 5 mg/L warm water fisheries Class A standard after approximately 5 meters in depth in June and July, before improving slightly in August to include only depths below 6 meters (Figure 10). Unlike at HB @ DH, the bottom meter of the SB @ DH profile remained below 5 mg/L in October. A water quality profile was not collected at SB @ Intake in June, although the July profile showed that DO was also below the Class A warm water fisheries standard after only 3 meters in depth. However, the SB @ Intake water column had mixed by the following month, with DO above 5 mg/L in the August, October, and November profiles.

Despite being an impoundment, the Stony Brook Reservoir is classified as a CFR.[12] As such, temperature and DO were also compared against the CFR Class A standards, which are more stringent than the warm water fishery standards. The Class A temperature standard for CFRs is defined in 314 CMR 4.00 as below 20 degrees C for the seven-day average maximum daily temperature unless naturally occurring. Continuous temperature data were not collected at Stony Brook Reservoir in 2017, so the discrete temperature measurements recorded during sampling events were used instead.[13]

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12 See footnotes 1 and 2, page 2.

13 According to the 2016 CALM manual, small datasets with only instantaneous measurements should never exceed, or only rarely exceed, the 20 degrees C Class A standard. However, a dataset containing only infrequent discrete/instantaneous measurements would not be sufficient to classify a waterbody as impaired.

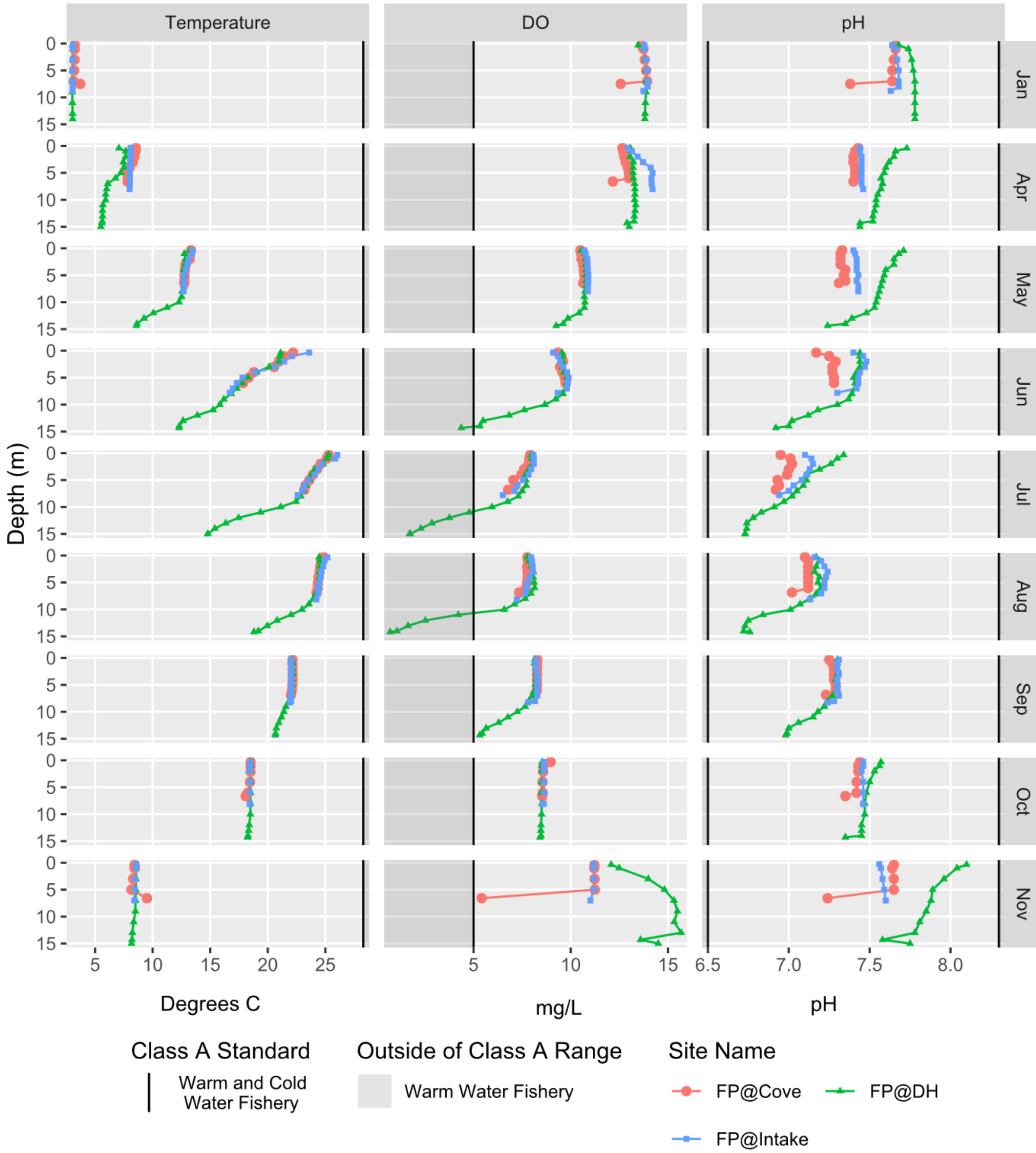

Figure 8: Fresh Pond Reservoir Class A Water Quality Probe Results, 2017

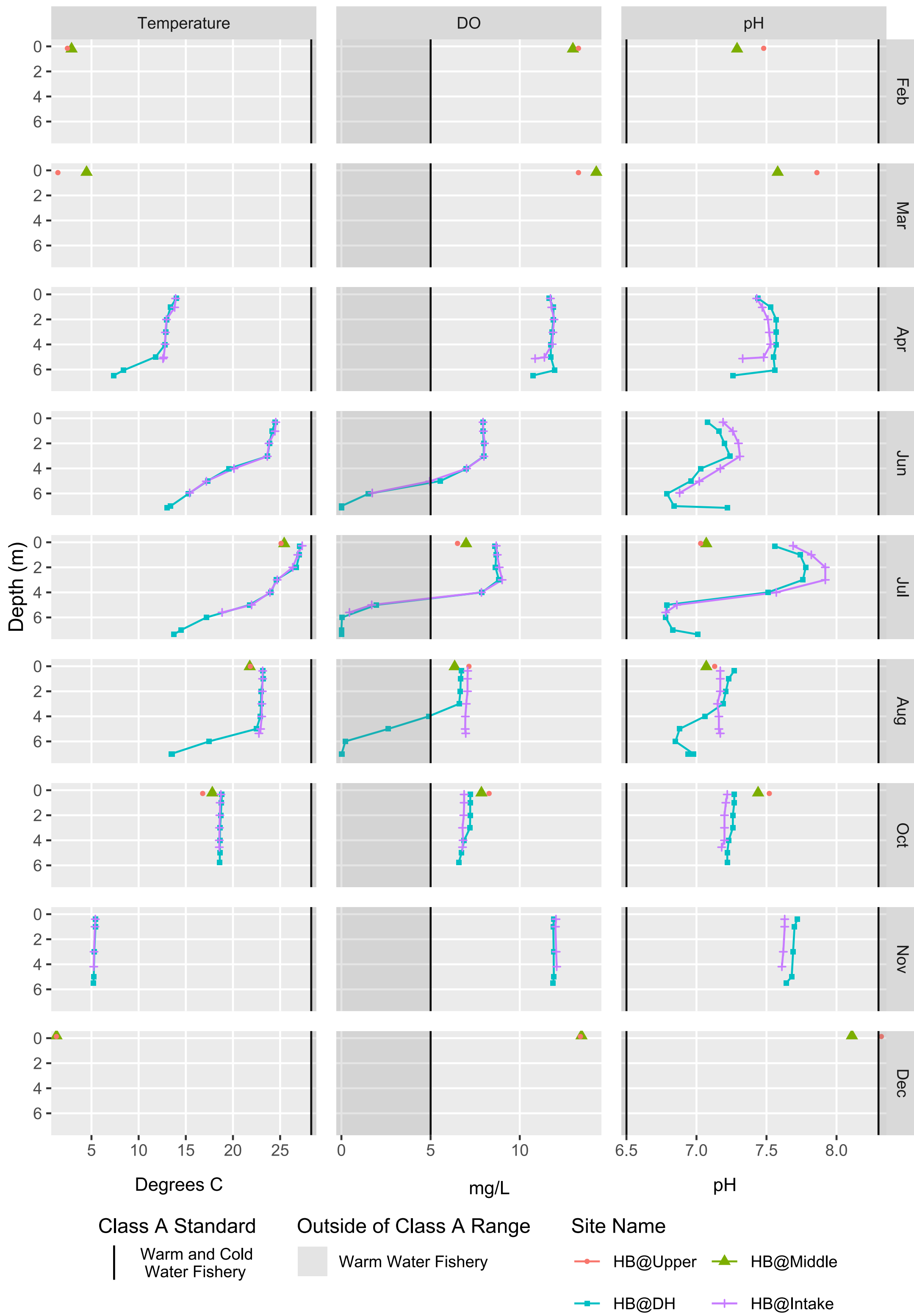

Figure 9: Hobbs Brook Reservoir Class A Water Quality Probe Results, 2017

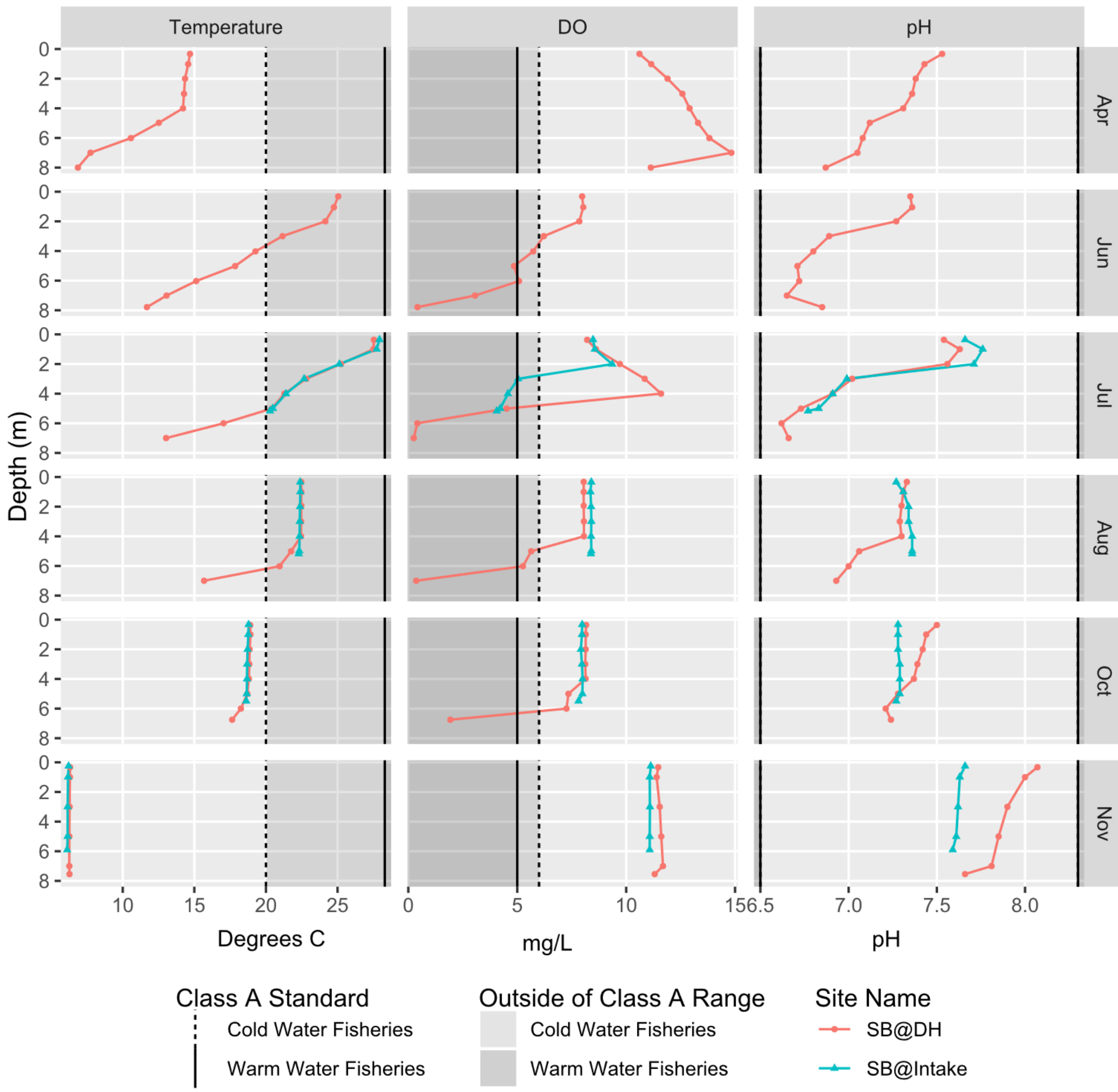

Figure 10: Stony Brook Reservoir Class A Water Quality Probe Results, 2017

When using the more stringent 6 mg/L Class A DO standard for CFRs, the portion of the water column at SB @ DH and SB @ Intake that met the Class A criterion decreased by one meter or less (Figure 10). A more extensive portion of the reservoir exceeded the CFRs temperature standard, with the top 4 to 6 meters of the water column warmer than 20 degrees C in June, July, and August. By contrast, there were no exceedances of the warm water fisheries temperature standard. These 2017 temperature exceedances did not appear to be an anomaly, with discrete surface temperature measurements collected between June and September regularly exceeding 20 degrees C (Figure 11).

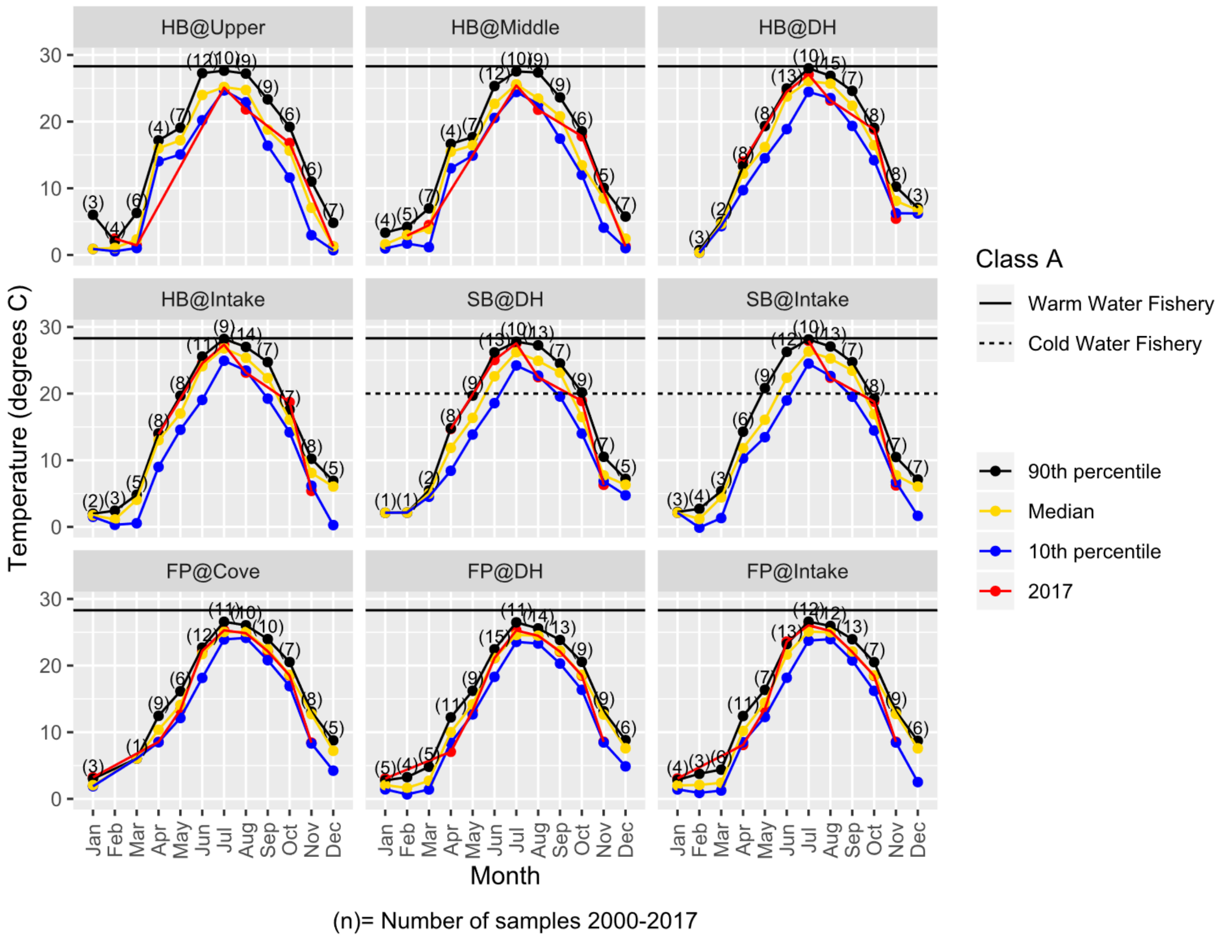

Figure 11: Reservoir Monthly Temperatures, 2000-2017

Like in other reservoir impoundments, water in the Stony Brook Reservoir likely exceeded the CFR temperature standard due to surficial heating of dammed water. Water sitting in an open reservoir is more prone to heating than moving water in a shaded stream. However, inflows to the Stony Brook Reservoir at RT 20 (Figure 3) regularly exceeded the CFR temperature standard between June and September (see section 7.7.1, Table 8).

6.2.2 Nutrients

See section 6.4 for a discussion of nutrient results compared against select 2016 CALM Primary Producer Biological and Physico-chemical Screening Guidelines. This report does not perform a comprehensive analysis of whether Cambridge reservoirs supported the Aquatic Life use for Class A waters. However, where data were available, 2017 water quality results were compared against the 2016 screening guidelines for nutrient impairment as well as the EPA nutrient criteria.

6.3 Reservoir Maximum and Secondary Maximum Contaminant Levels (MCLs and SMCLs) and ORS Guidelines

The ORS Guideline for sodium and the SMCL standards for manganese, iron, chloride, and TDS were exceeded more frequently than the Class A ambient (environmental) water quality standards (Figures 12 – 21; Appendix D). SMCL standards are primarily for aesthetic, not health, purposes and apply to treated drinking water. However, the SMCL standards are still a useful metric for evaluating source water quality in the Cambridge watershed. Nitrate and nitrite nitrogen concentrations are discussed in section 6.4 in relation to the EPA nutrient criterion. However, all reservoir nitrate and nitrite samples were under 1 mg/L, which is well below the 10 mg/L MCL set to protect human health.

6.3.1 Iron and Manganese

6.3.1.1 Surface Samples

When compared against the SMCL standards for iron and manganese, Fresh Pond Reservoir had the best water quality of the three reservoirs in 2017 (Figure 12). The Fresh Pond SMCL exceedance rates for iron

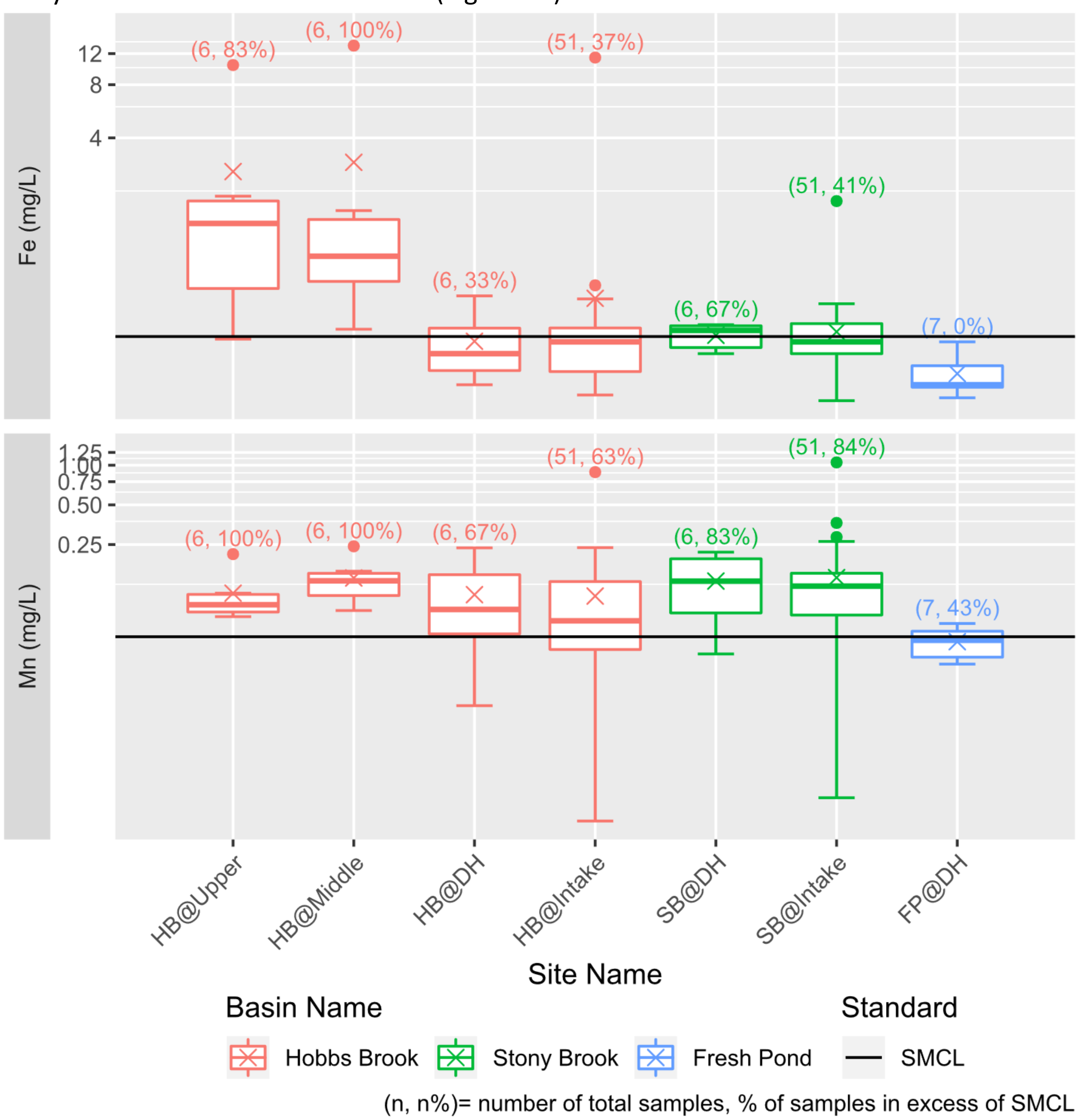

Figure 12: Reservoir Surface Iron and Manganese, 2017

and manganese were the lowest of the three reservoirs (Figure 12 and Appendix D). No Fresh Pond surface samples exceeded the iron SMCL. Three out of seven samples exceeded the manganese SMCL (43 percent exceedance rate), although the median concentration (0.047 mg/L) was below the 0.05 mg/L SMCL (Figure 12). By contrast, the SMCL exceedance rate for manganese at Hobbs Brook and Stony Brook reservoirs ranged from 63 percent to 100 percent of samples (Figure 12). The iron SMCL exceedance rate at Hobbs Brook and Stony Brook reservoirs ranged from 33 percent (HB @ DH, two out of six samples) to 100 percent (HB @ Middle, six samples) (Figure 12).

6.3.1.2 *Bottom Samples*

Iron and manganese are typically in a solid state and precipitate out of the water column when oxygen is abundant. In the absence of oxygen, redox reactions convert iron and manganese in solid compounds into reduced, aqueous ions which increases their concentration in the water. Therefore, manganese and iron concentrations are typically lower in high oxygen conditions. Iron and manganese concentrations at HB @ DH and SB @ DH increased by an order of magnitude or more in bottom samples, which were collected during periods of thermal stratification (low DO) (Figures 5 and 13; Table 3). For example, the annual median surface manganese concentration at HB @ DH was 0.081 mg/L compared to the median bottom concentration of 3.89 mg/L. For iron, the annual median surface concentrations at HB @ DH and SB @ DH were 0.24 mg/L and 0.33 mg/L; the median concentrations for bottom samples at the two sites were 1.49 mg/L and 1.00 mg/L, respectively.

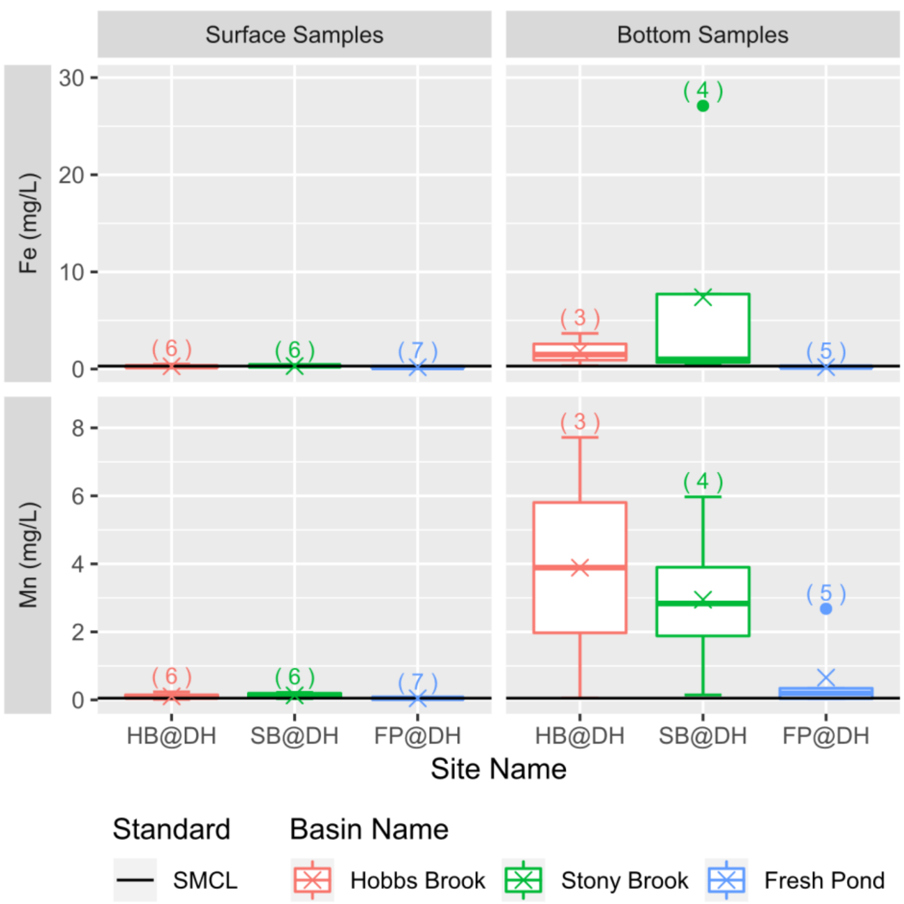

Figure 13: Reservoir Iron and Manganese Surface and Bottom Comparison, 2017 (n)= Number of samples

FP @ DH also experienced elevated manganese at the reservoir bottom during stratification, although difference in concentration was less extreme than at HB @ DH and SB @ DH. The surface median manganese concentration at FP @ DH was 0.047 mg/L and the median bottom concentration was 0.195 mg/L (Figure 13). The difference between median iron concentrations in the surface and bottom of the reservoir was even less, with the bottom median concentration only 0.04 mg/L lower than the surface. All 2017 FP @ DH surface and bottom iron samples were less than the 0.3 mg/L SMCL (Figure 13; Appendix D). The continuous running of the aeration system, although not sufficient to prevent DO concentrations in the hypolimnion from dropping below the Class A 5 mg/L threshold during June, July, and August, may have been sufficient to slow the reduction of iron and manganese in the reservoir bottom sediments.

6.3.2 Sodium and Chloride

6.3.2.1 Surface Samples

As discussed in section 6.1.2, Hobbs Brook Reservoir is vulnerable to sodium and chloride pollution from road salts used for deicing on state and federal highways. Hobbs Brook Reservoir is also subject to groundwater salt loads from a historic salt plume due to a previously unprotected MassDOT salt storage (Geotechnical Engineers Inc., 1985). Bordered by interstate 95, Stony Brook Reservoir is also affected by sodium and chloride pollution from deicing. However, drainage from less developed catchment areas, such as the SB @ Viles and Summer St catchments, help to dilute higher-salt inflows (Appendix D). Because the reservoirs are located in succession, releases of water from Hobbs Brook Reservoir during the summer and fall months increase the sodium and chloride concentrations downstream at Stony Brook Reservoir and Fresh Pond Reservoir (Figure 14).

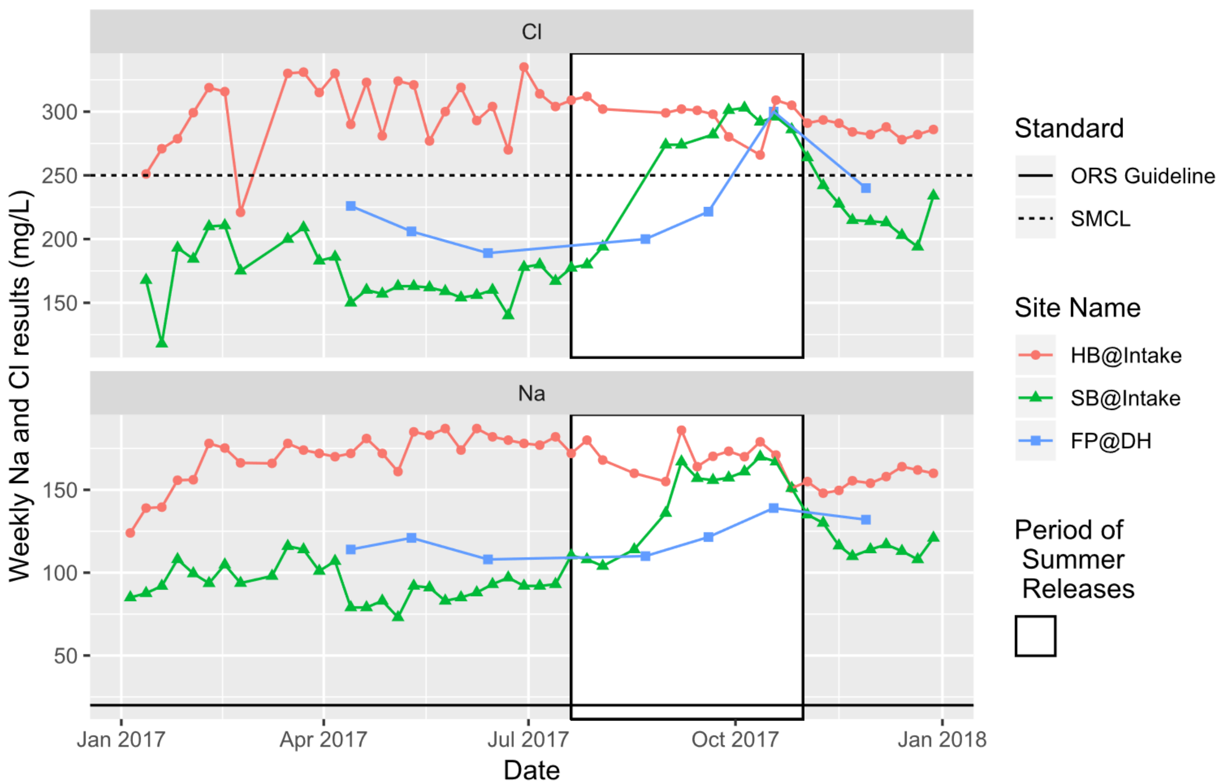

Figure 14: Reservoir Chloride (Cl) and Sodium (Na), 2017

Prior to the start of water releases in 2017, concentrations of sodium and chloride were generally higher at HB @ Intake than at SB @ Intake and FP @ DH (Figure 14). Shortly after the start of water releases in July, salt concentrations at SB @ Intake and HB @ Intake became similar, likely due to the short retention time at Stony Brook Reservoir (see section 10 *Reservoir Retention Time*). Due to the longer retention time at Fresh Pond, concentrations of sodium and chloride were slower to respond to releases of salt-impacted water from Hobbs Brook Reservoir, but did increase throughout the summer and early fall, peaking in October shortly before the end of the summer water release regime. Once water releases ended for the year, sodium and chloride concentrations dropped at both Stony Brook and Fresh Pond reservoirs.

In 2017, Hobbs Brook Reservoir chloride concentrations exceeded the SMCL in 98 percent of weekly intake samples (Figures 14 – 16; Appendix D). All six samples from HB @ DH exceeded the 250 mg/L SMCL as

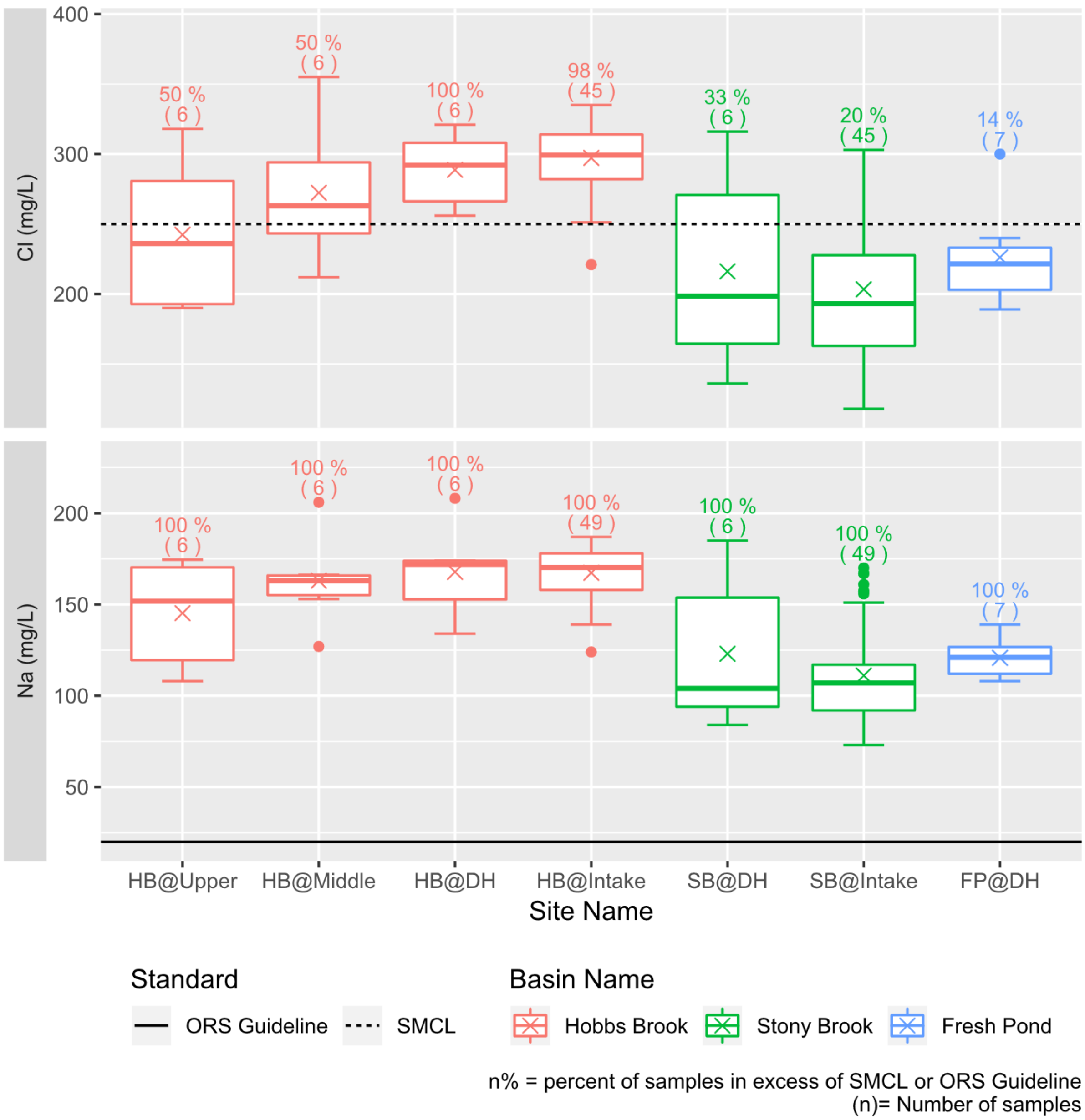

Figure 15: Reservoir Surface Chloride (Cl) and Sodium (Na), All Sites, 2017

well (Figure 15 and Appendix D). HB @ Upper and HB @ Middle had slightly lower exceedance rates (50 percent each, or three of six samples). The HB @ Upper site borders Route 2 and receives runoff from tributaries that drain interstate 95 or are otherwise salt impacted, such as Lex Brook and Salt Depot (Figures 2 and 3). However, the largest catchment area draining to HB @ Upper is the HB @ Mill St catchment, which is over 75 percent forest and forested wetland and had some of the lowest sodium and chloride concentrations in the Cambridge watershed (Appendix A and Figure 36). The Mill St catchment area may help dilute salt loads from the Salt Depot and Lex Brook catchments.

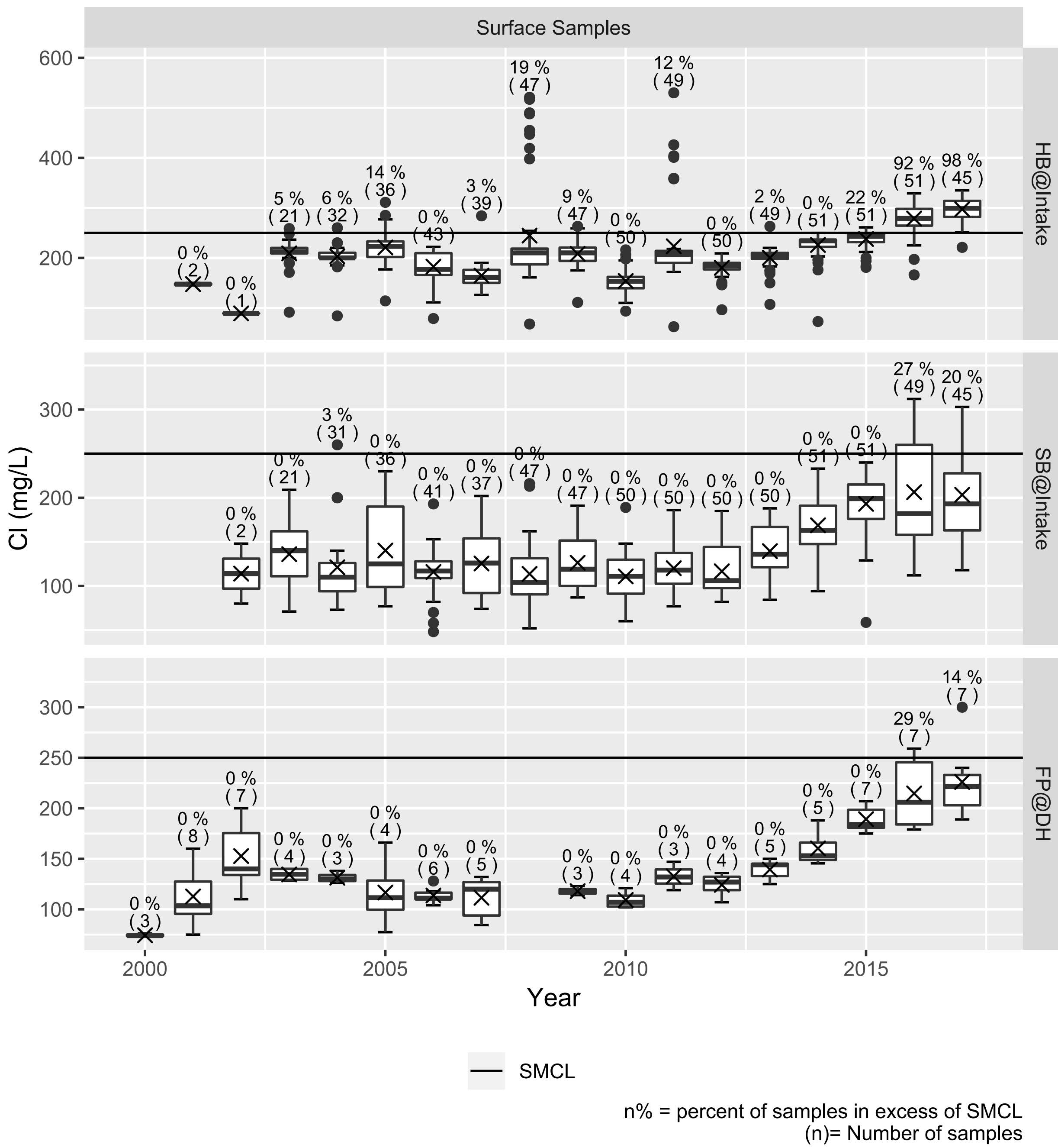

Figure 16: Reservoir Surface Chloride, 2000-2017

Chloride concentrations in the Hobbs Brook reservoir increased dramatically between 2014 and 2017 (Figure 16). In 2014, no weekly intake sample exceeded the 250 SMCL. By 2015, 22 percent of samples exceeded the standard, skyrocketing to 92 percent and 98 percent of samples in 2016 and 2017 (Figure 16). Prior to 2014, no more than 19 percent of HB @ Intake chloride samples exceeded 250 mg/L and there were only five years with more than 5 percent of samples exceeding the SMCL.

Twenty percent of SB @ Intake weekly samples exceeded the chloride SMCL in 2017 at SB @ Intake, although all exceedances occurred during the period of water releases from Hobbs Brook Reservoir (Figures 14 – 16; Appendix D). The SB @ Intake chloride SMCL exceedance rate in 2016 (27 percent) was similar to 2017 (20 percent), both of which represented a large increase compared to previous years (Figure 16). Before 2016, only one outlier sample had ever exceeded the SMCL (Figure 16). Similarly, the only exceedances of the chloride SMCL at FP @ DH occurred in 2016 and 2017. In 2017, the exceedance (300 mg/L) occurred on October 18th after months of recharging with salt impacted water from the upstream reservoirs (Figures 14 – 16; Appendix D).

While the increase in chloride concentrations between 2014 and 2015 – 2017 may seem alarming, it is likely due to drought conditions, when less stormflow was available to dilute salt-impacted base-flow. The Massachusetts Drought Management Taskforce officially declared a drought beginning on July 1, 2016 and ending on April 30, 2017 (Massachusetts Executive Office of Energy and Environmental Affairs, 2017). However, the Hobbs Brook Reservoir volume was near a 10 year low at the end 2015 and began its recharge cycle later in the year than is typical (Figure 17). This indicates that the effects of the drought were already taking place in terms of reduced inflows to the reservoir before the official start of the drought.

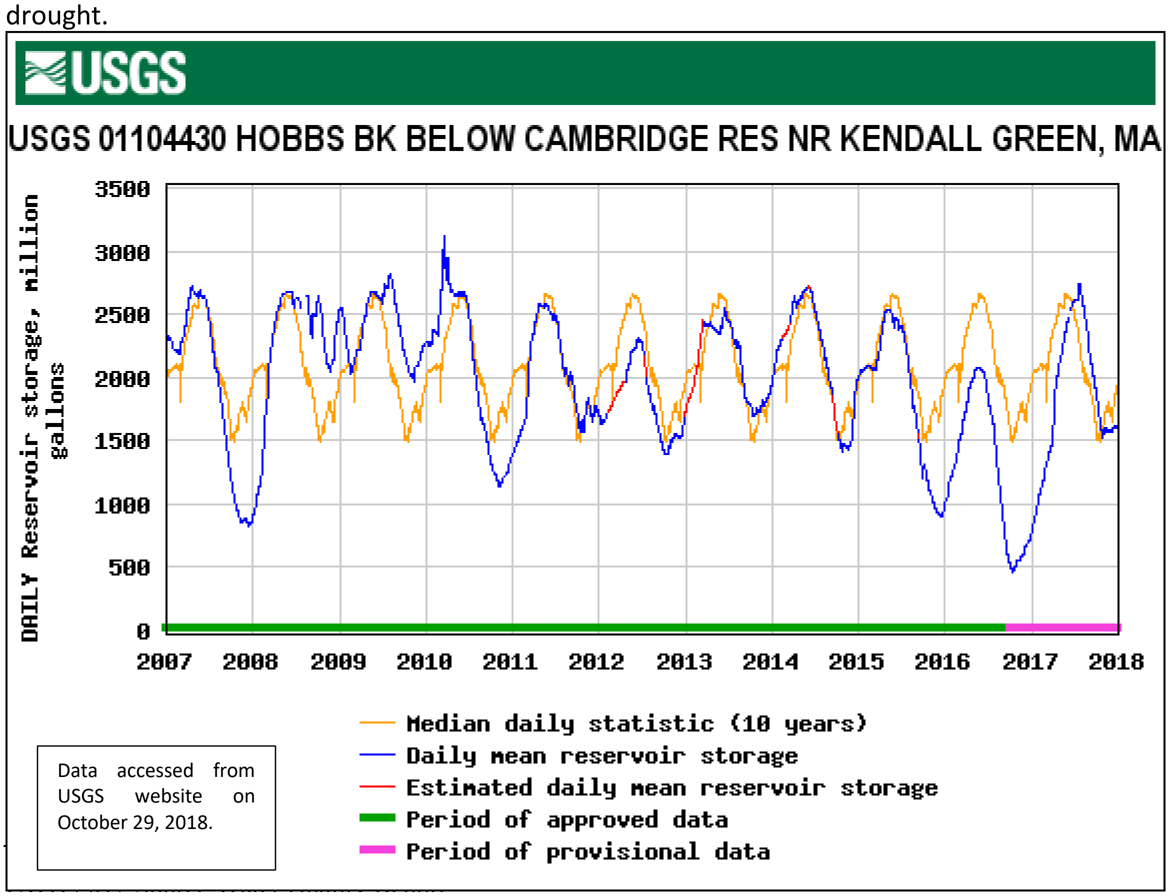

Figure 17: Hobbs Brook Reservoir Daily Storage 2007-2017

The ORS Guideline for sodium is a much lower concentration than the SMCL for chloride (20 mg/L compared to 250 mg/L). All samples at all reservoirs exceeded ORS Guideline in 2017, with concentrations ranging from 73 mg/L (SB @ Intake) to 208 mg/L (HB @ DH) (Figure 18 and Appendix D). Sodium concentrations in all three reservoirs have been elevated since at least the early 2000s, with nearly all sodium samples collected by CWD during that time greater than 20 mg/L. Similar to chloride, sodium concentrations have increased since 2014, although that increase is likely due to diminished inflows during drought conditions.

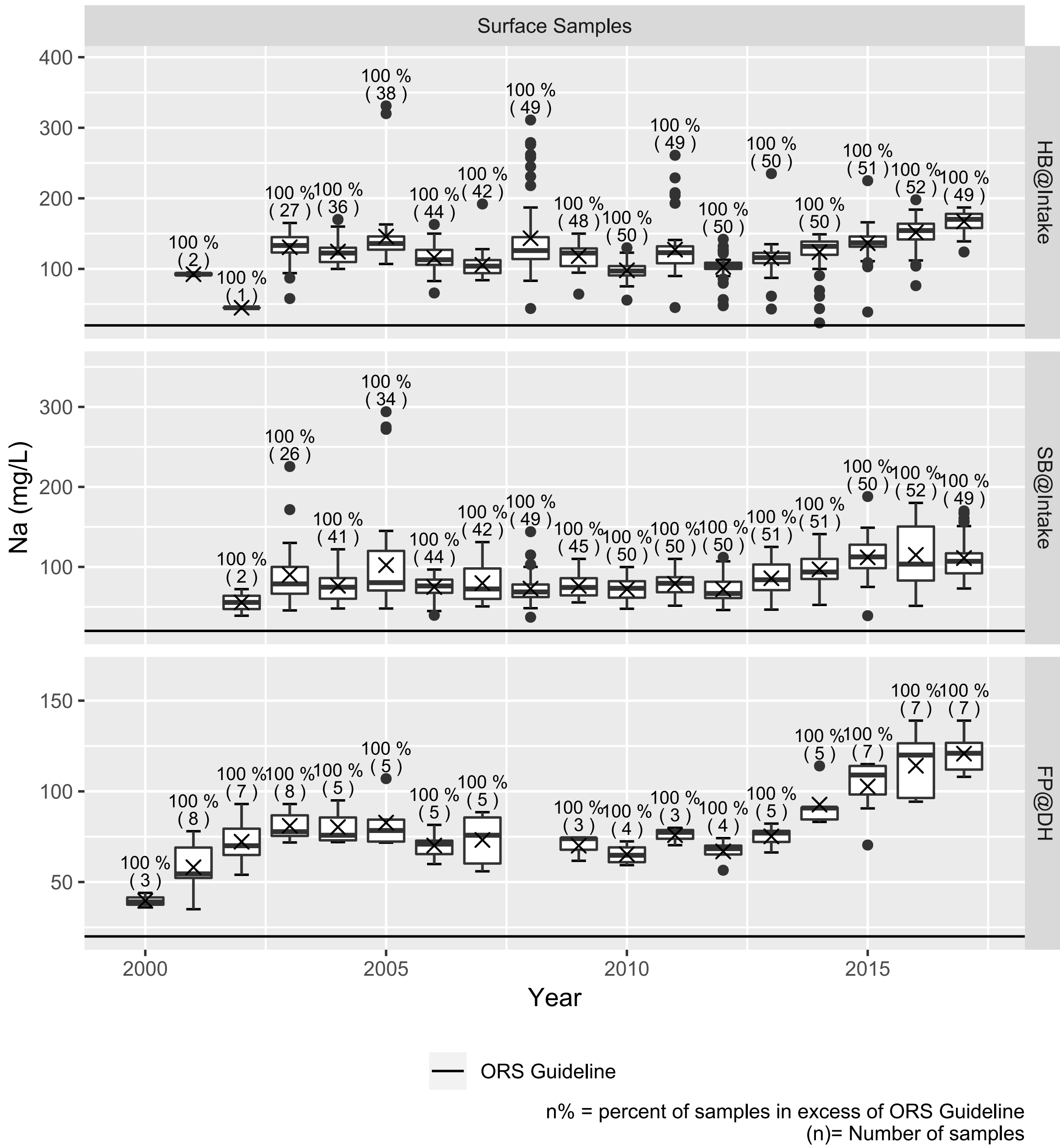

Figure 18: Reservoir Sodium, 2000-2017

6.3.2.2 Bottom Samples

Sodium and chloride are dissolved ions and not typically governed by redox reactions. Therefore, the difference between surface and bottom concentrations in the reservoirs would not be expected to change in response to diminished DO levels. However, the potential exists for the formation of a chemocline, whereby more dense, salty water sinks to the bottom of the reservoir and less dense, lower salt water rises to the surface of the reservoir. Differences between surface and bottom water chemistry could also be explained by reservoir inflows with higher or lower salt concentrations than the receiving water, which may create a layer of water with different sodium and chloride concentrations.

At HB @ DH and SB @ DH, median sodium and chloride concentrations were greater in the bottom samples than in surface samples, although the IQRs of the surface and bottom samples overlapped at both sites (Figure 19). At SB @ DH, the difference between mean and median chloride in surface and

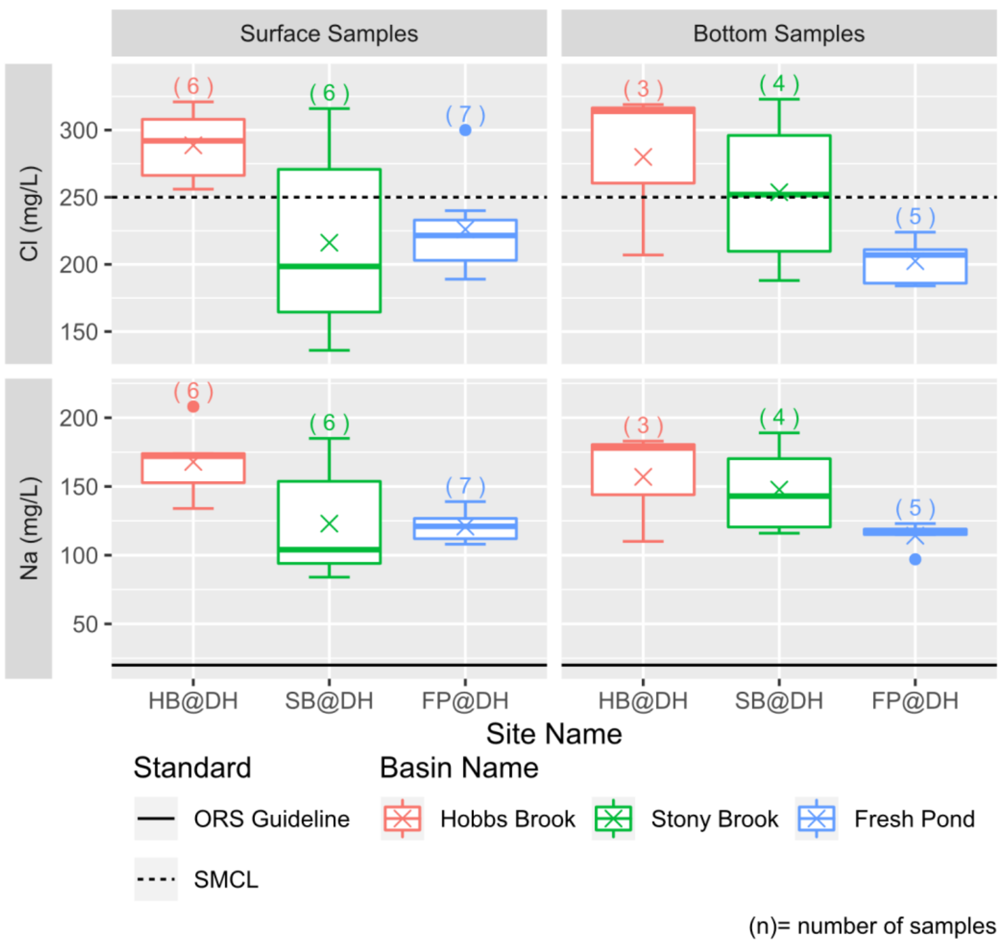

Figure 19: Reservoir Sodium and Chloride Surface and Bottom Comparison, 2017

bottom samples was more pronounced than at HB @ DH, with both the mean and median concentrations at SB @ DH less than the 250 mg/L SMCL in surface samples and exceeding the SMCL in bottom samples (Figure 19). This difference is reflected in the specific conductance profiles at SB @ DH, which showed chemical stratification of the reservoir in April and June (Figure 5). Although the SB @ DH August profile showed that the specific conductance in the bottom meter of the reservoir was nearly 200 uS/cm lower than the surface (a concentration similar to the July, indicating incomplete flushing of the water column), the August chloride and sodium results showed the opposite, with salt concentrations slightly higher in the bottom of the water column than in the surface (323 mg/L versus 316 mg/L for chloride and 189 versus 185 mg/L of sodium) (Figure 5). This discrepancy between the specific conductance and sodium and chloride at the bottom of SB @ DH during the August sampling event indicates that the samples were collected from slightly above the last meter of the water column.

6.3.3 Total Dissolved Solids (TDS)

TDS is a measure of dissolved ions and organic matter in water and is often closely related to specific conductance. In 2017, TDS was quantified using a water quality probe that estimated TDS based on specific conductance. The Hobbs Brook Reservoir deep hole, intake, and middle basin sites exceeded the SMCL standard of 500 mg/L in all measurements collected in 2017. As with specific conductance, HB @ DH and HB @ Intake concentrations decreased slightly throughout the year, but overall concentrations stayed relatively constant (Figure 20).

Hobbs Brook Reservoir also had the highest TDS concentrations of the three reservoirs, with maximum TDS levels at HB @ Middle, HB @ DH, and HB @ Intake of 800, 792, and 736 mg/L, respectively (Figure 20). The maximum TDS concentration at HB @ Upper was slightly lower at only 656 mg/L. Interestingly, TDS at HB @ Upper and HB @ Middle differed by approximately 300 mg/L in February and March, with the difference dropping to less than 200 mg/L in July. In August, TDS at the two sites was similar, with HB @ Middle having decreased and HB @ Upper having increased in concentration. In October, both sites increased from August, and by December the TDS concentrations were nearly identical (658 and 654 mg/L). The December concentrations at HB @ Upper and HB @ Middle matched the TDS levels from the November profiles at HB @ Intake and HB @ DH.

Except for a single reading at the bottom of SB @ DH during the April profile, TDS at Stony Brook Reservoir was below the 500 mg/L SMCL prior to the start of water releases from Hobbs Brook Reservoir (Figure 21 and Appendix D). In August, after water releases began for the year, TDS concentrations at Stony Brook Reservoir were all above the 500 mg/L. The influence of the higher TDS water from Hobbs Brook continued in the October profile, with all TDS readings above 500 mg/L. The November profile, collected on November 30th, approximately one month after water releases ended at Hobbs Brook Reservoir, was still above the SMCL but was lower than in October.

As with specific conductance, TDS at Fresh Pond Reservoir decreased from January through July and increased from August through October due to the influence of water releases from Hobbs Brook Reservoir (Figure 22). This decrease in the first half of the year was presumably the result of flushing the higher TDS water, which dominated recharge at Fresh Pond Reservoir during the 2016-2017 drought, with water from the Stony Brook Reservoir subbasin. Fresh Pond Reservoir TDS exceeded the SMCL in January and April (Figure 22 and Appendix D). As TDS concentrations continued to decrease, FP @ DH was still above the SMCL in May, although the FP @ Cove site and lower portion of the FP @ Intake site were below the SMCL. By June and July, all three sites were below the SMCL except for a single surface reading at FP @ DH in July. FP @ DH and FP @ Intake remained below the SMCL in August, although the majority of the

FP @ Cove profile exceeded the 500 mg/L SMCL. FP @ Cove is closest to where water transferred from Stony Brook Reservoir enters Fresh Pond, which may explain why changes in TDS water chemistry due to releases of water from Hobbs Brook Reservoir by way of Stony Brook Reservoir first appeared at FP @ Cove. All 2017 profiles after August at Fresh Pond Reservoir were above the TDS SMCL.

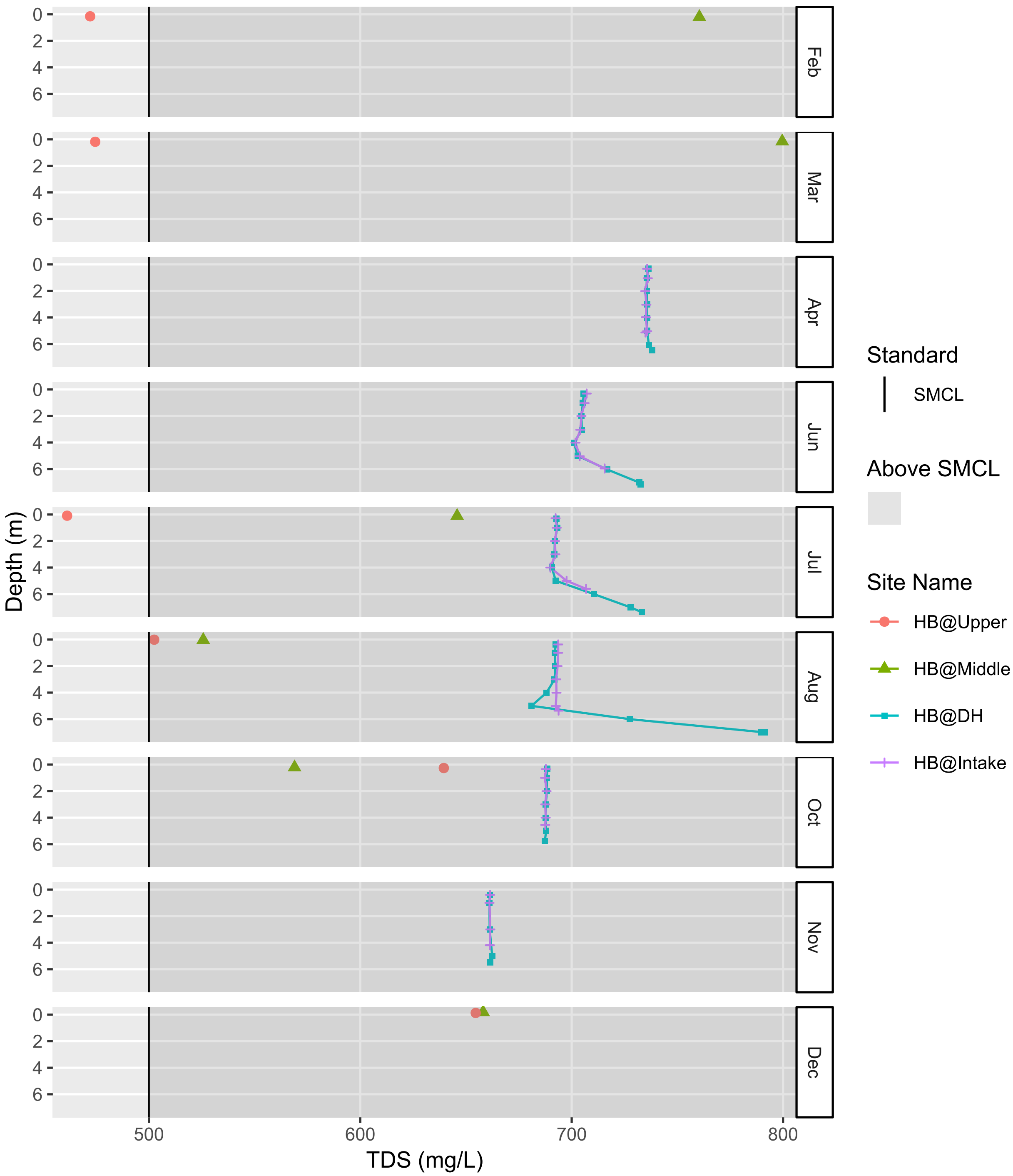

Figure 20: Hobbs Brook Reservoir TDS Water Quality Probe Results, 2017

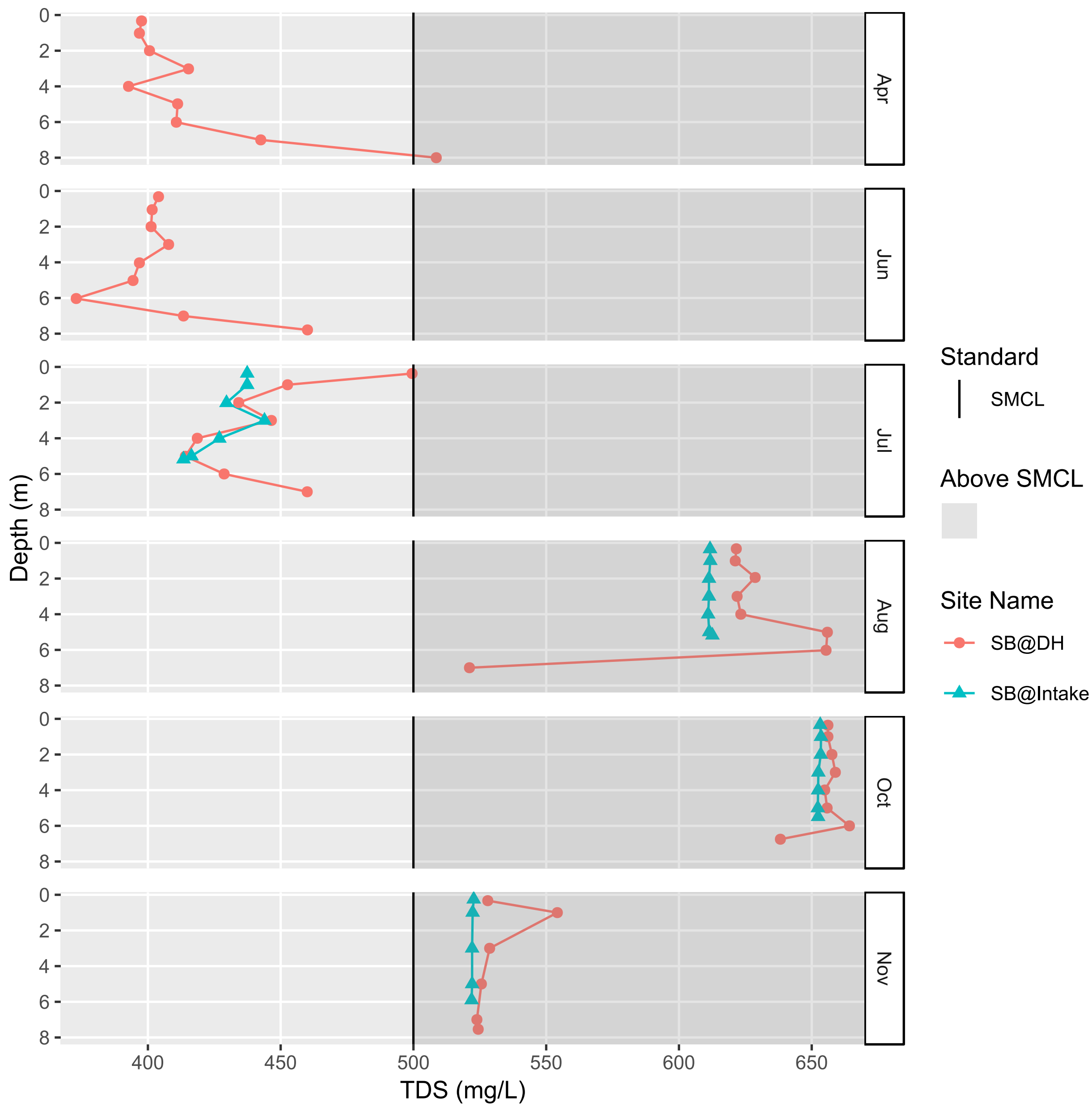

Figure 21: Stony Brook Reservoir TDS Water Quality Probe Results, 2017

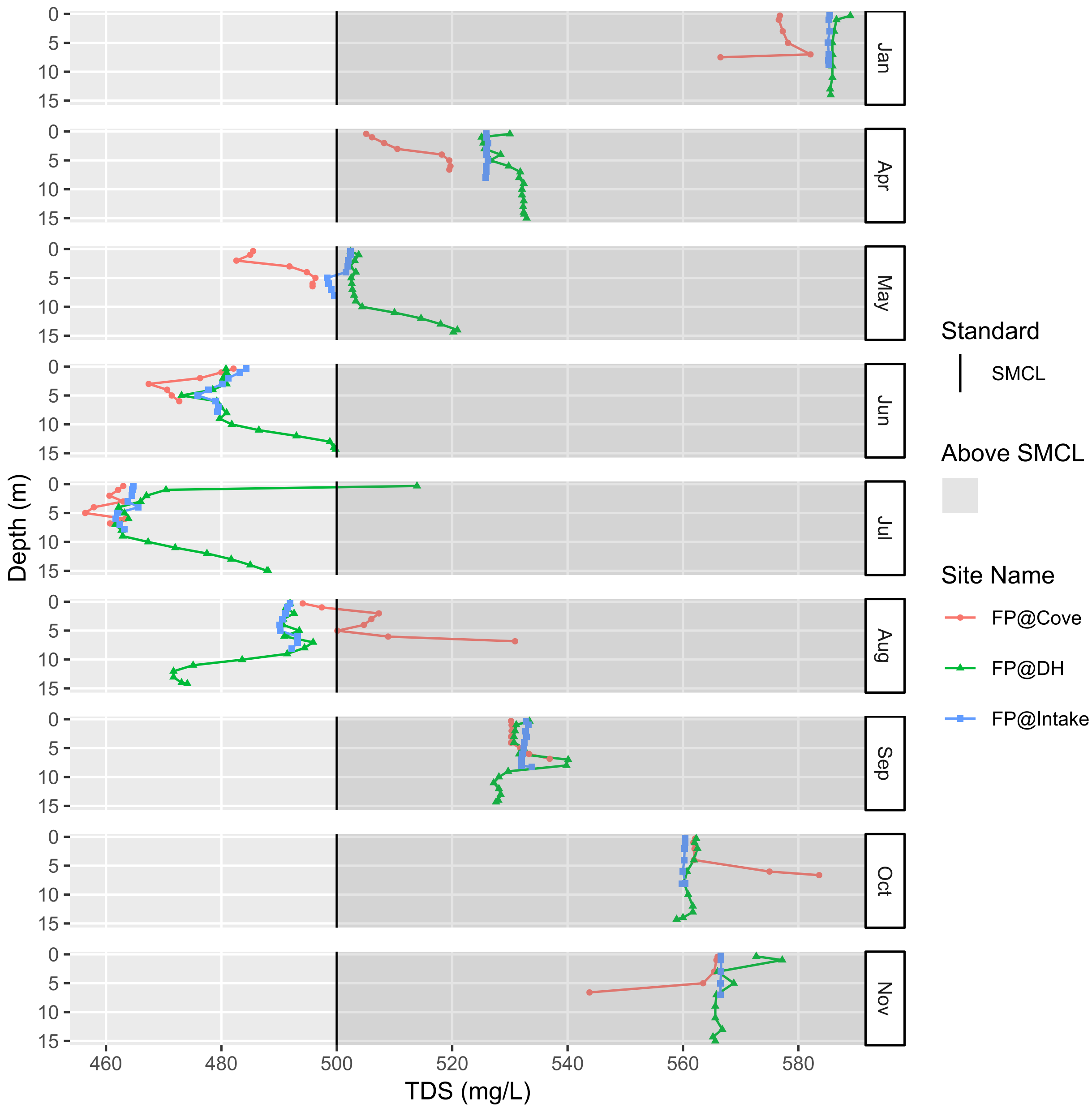

Figure 22: Fresh Pond Reservoir TDS Water Quality Probe Results, 2017

6.4 Nutrient Enrichment Indicators and TOC Results

6.4.1 Surface Samples

According to the CALM 2016 manual, a lake is considered impaired for the Aquatic Life use if "there is more than one nutrient enrichment indicator present more than once during the survey season." While not all enrichment indicators listed in the CALM 2016 manual were analyzed by CWD, measurements of chl-*a*, TP, and Secchi depth[14] were collected at each reservoir in 2017 (Figures 23 and 24). Surface water quality as assessed by these three parameters improved as water moved between the upper and lower basins of Hobbs Brook Reservoir, through the Stony Brook Reservoir, and into Fresh Pond (Figure 23).

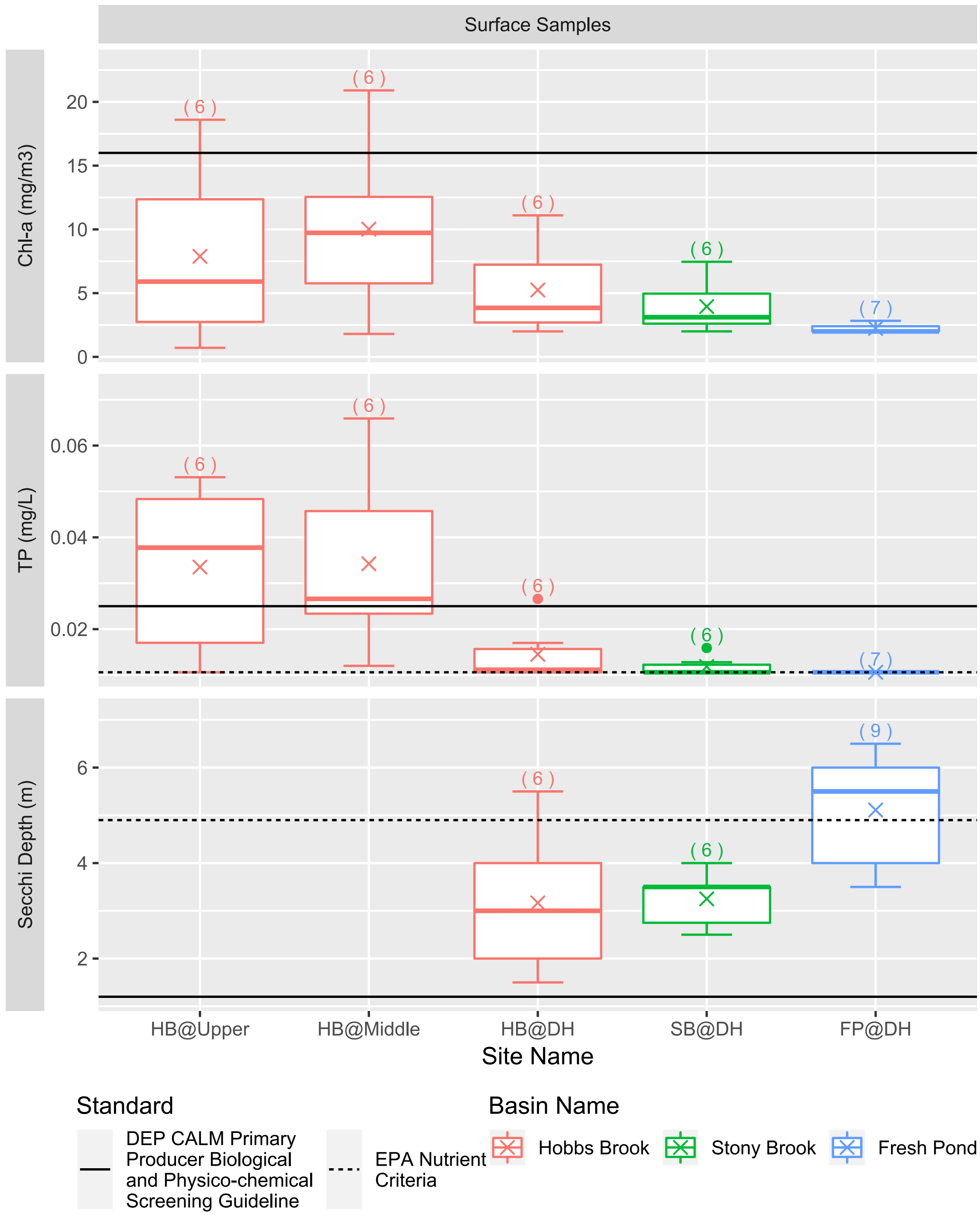

Figure 23: Reservoir Chl-a, TP, and Secchi Depth (without aquascope), 2017

Mean and median surface TP and chl-*a* concentrations decreased as water traveled between the reservoirs while transparency increased (Figures 23 and 24). This indicates a reduction in primary productivity as water traveled from Hobbs Brook Reservoir to Fresh Pond Reservoir. Although TOC and color were higher at Stony Brook Reservoir than at Hobbs Brook Reservoir lower basin (HB @ DH and HB @ Intake) and Fresh Pond, turbidity maintained the downward trend between the reservoirs, supporting the conclusion of reduced productivity (Figure 24). The elevated TOC and color at Stony Brook Reservoir are likely due to external inputs, such as organic matter from leaves and the surrounding natural landscapes, rather than primary production of algae within the reservoir. Secchi disk transparency was greater than the 1.2 meter minimum transparency 2016 CALM guideline at all sites, although FP @ DH and FP @ Intake were the only sites with mean and median transparencies greater than the 4.9 meter EPA nutrient criterion (Figure 24). Every site fell short of the more stringent EPA nutrient criterion transparency minimum at least once in 2017 (Figure 24 and Appendix D). [15]

Fresh Pond had the lowest concentrations of chl-*a* and TP and the greatest transparency as measured by Secchi depth. No samples from Fresh Pond exceeded the DEP screening guidelines for chl-*a*, TP, or Secchi depth (Figures 22 and 23). [16] Fresh Pond surface samples were also below the TP EPA nutrient criterion in 2017.[17] However, approximately half of Secchi disk readings at Fresh Pond were less transparent than the more stringent 4.9 meter EPA nutrient criterion (Figures 23 and 24; Appendix D).

Hobbs Brook Reservoir, especially at the HB @ Upper and HB @ Middle locations, was the only reservoir to exceed the CALM 2016 screening guidelines for chl-*a* and TP. HB @ Upper and HB @ Middle were both above the 16 mg/m^3 chl-*a* guideline on October 3, 2017 and annual mean and median TP concentrations were above both the EPA nutrient criterion and the DEP CALM screening guideline (Figure 23). Water quality improved considerably after entering the larger lower basin of Hobbs Brook Reservoir; surface TP and chl-*a* concentrations decreased along with corresponding decreases in color, TOC, and turbidity (Figures 23 and 24). These changes indicate reduced productivity, likely due to settling of organic matter and dilution of TP inputs in the lower basin.

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[14] Secchi depth disk readings reported Figures 23 and 24 were observed without the aid of an aquascope, a viewing device used to reduce surface glare to improve readings. See Appendix D for a comparison of Secchi depths below the minimum EPA nutrient criteria transparency observed with and without an aquascope.

[15] Samples from HB @ Upper and HB @Middle were shoreline grab samples, so no Secchi depth readings were collected these sties.

[16] The CALM 2016 manual TP screening guideline is specific to the mean concentration for the sampling season. In this report, the sampling season was the 12 month period between January 1st and December 31st of 2017. This may differ from the sampling season duration recommended by MA DEP.

[17] The detection limit for TP was 0.0106 mg/L, which is above the EPA nutrient criteria of 0.008 mg/L. For the purposes of this analysis, it was assumed that sample results below the detection limit were below the EPA nutrient criteria.

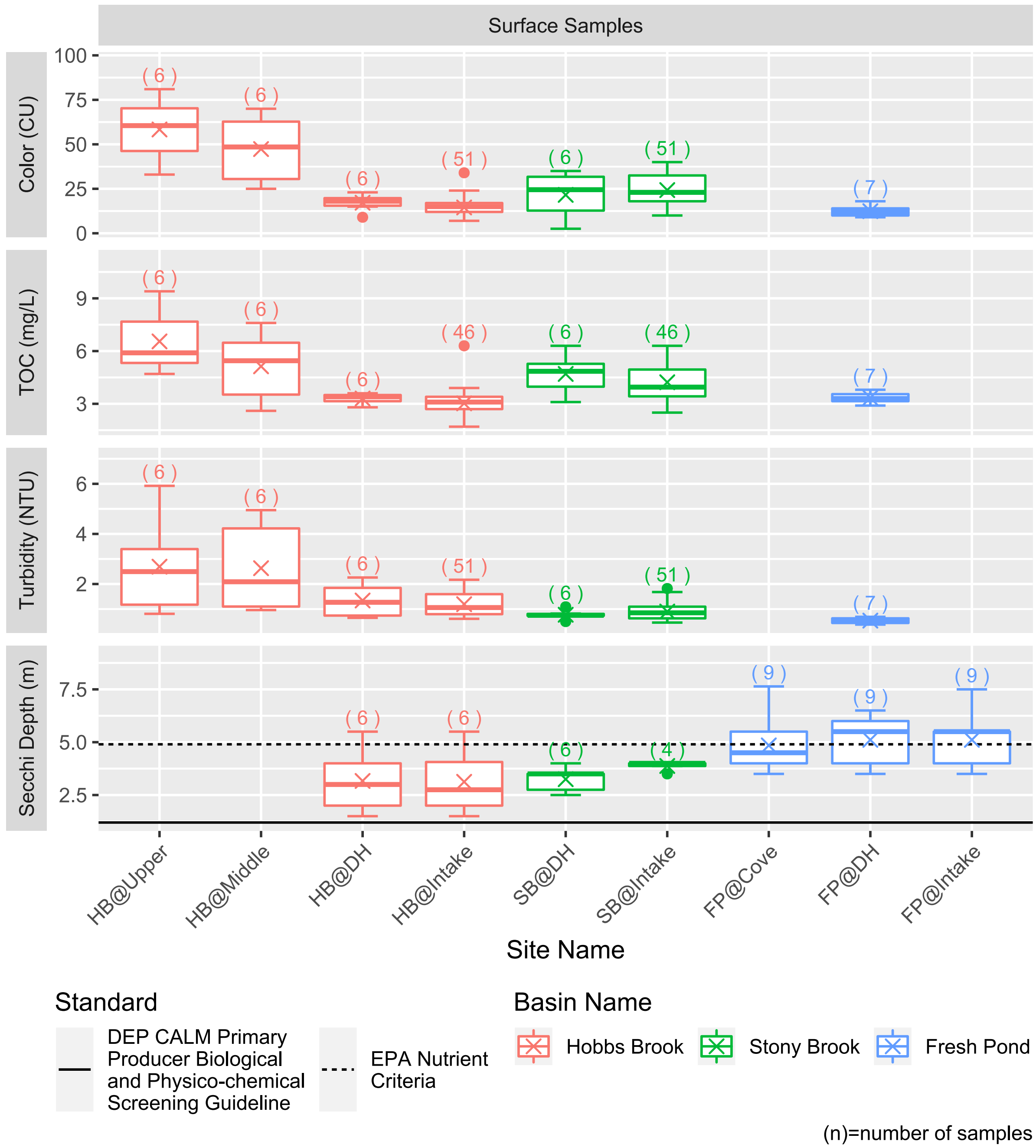

Figure 24: Reservoir, Color, TOC, Turbidity, and Secchi Depth (without aquascope), 2017

Nitrate and nitrite are forms of nitrogen commonly found in oxidized environments. Sources of nitrate and nitrite include fertilizer runoff and septic system leachate. Nitrate and nitrite nitrogen levels were highest at Stony Brook and Fresh Pond reservoirs and lowest in Hobbs Brook Reservoir, likely due to the land use differences in the watershed subcatchments (Figure 25). The Stony Brook Reservoir drainage area includes a golf course and more low density residential areas than the Hobbs Brook Reservoir watershed. In addition, Stony Brook Reservoir subcatchments in Weston and Lincoln are primarily served by septic systems, whereas most homes and businesses in the Hobbs Brook Reservoir subcatchments are served by sewer systems. Widespread use of septic systems, as well as probable fertilizer use on lawns and golf courses, may explain the difference in nitrate and nitrate nitrite concentrations between Hobbs Brook Reservoir and Stony Brook and Fresh Pond reservoirs. While all reservoirs exceeded the 0.05 mg/L EPA nutrient criterion threshold for nitrate and nitrite nitrogen (Appendix D), all samples were well below the 10 mg/L drinking water MCL necessary to protect human health (Figure 25).

TKN and ammonia (TKN is the sum of ammonia-nitrogen and organic nitrogen) showed the opposite trend of nitrate and nitrite, decreasing between Hobbs Brook, Stony Brook, and Fresh Pond reservoirs (Figure 25). TKN decreased more than ammonia between the basins, showing the largest drop in median concentrations between the Hobbs Brook upper, middle, and lower basins. This is likely due to the settling of organic particles, and corresponds to a similar pattern of decreasing TOC, turbidity, color, and chl-*a* as water moved between the three Hobbs Brook Reservoir basins (Figures 23 through 25). HB @ Upper, HB @ Middle, and HB @ DH all had median TKN concentrations above the EPA nutrient criterion, while the SB @ DH median concentration was at the 0.43 mg/L nutrient criterion threshold, and the median TKN concentration at Fresh Pond was below the threshold.

When compared to the EPA nutrient criterion for TN (the sum of TKN and nitrate and nitrite nitrogen), all sampling sites had median values above the 0.48 mg/L criterion (Figure 25). The median TN concentration HB @ DH was the lowest of the reservoir sites (0.54 mg/L). Median TN concentrations were similar between HB @ Upper, HB @ Middle, SB @ DH, and FP @ DH, ranging from 0.77 mg/L at FP @ DH to 0.83 mg/L at HB @ Upper. However, at HB @ Upper and HB @ Middle, TKN (presumably due to organic nitrogen in the water column) had the most influence over TN levels whereas nitrate and nitrite contributed more to TN at FP @ DH.

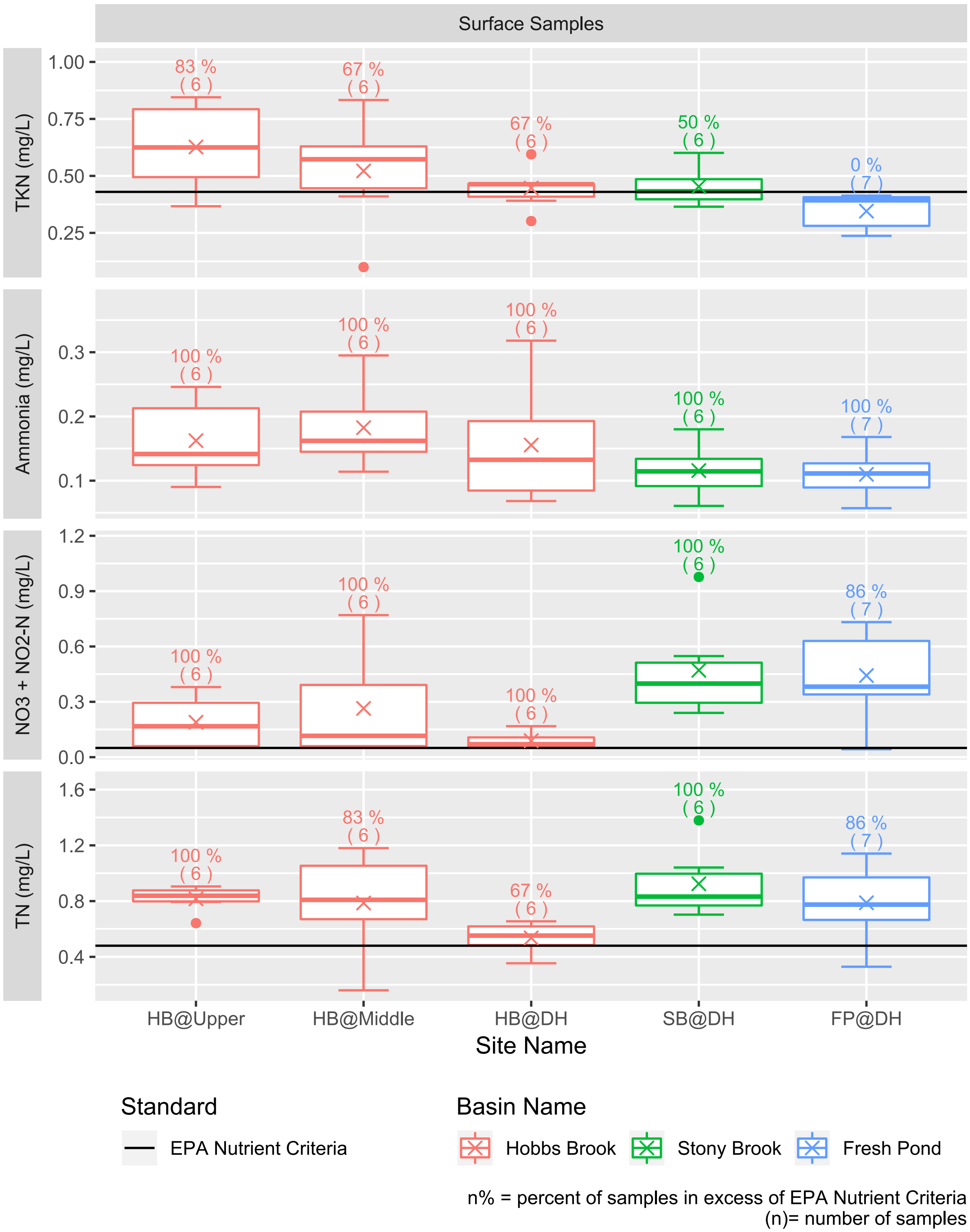

Figure 25: Reservoir Surface Nitrogen, 2017

6.4.2 Bottom Samples

At Hobbs Brook and Stony Brook Reservoirs, concentrations of nutrients common in low oxygen, reducing aquatic environments, such as TP, TKN, and ammonia, were higher in bottom samples collected during periods of thermal stratification than in surface samples (Figure 26). HB @ DH bottom samples also had elevated chl-*a*, TOC, color, and turbidity compared to surface samples (Figures 26 and 27). These elevated parameters indicate a subsurface algal or aquatic plant growth.

Although SB @ DH had elevated concentrations of nutrients in the hypolimnion compared to the epilimnion during thermal stratification, a coincident spike in chl-*a* was not as pronounced as at HB @ DH. This could be due to relatively lower TP concentrations in the SB @ DH hypolimnion during the August sampling event, when chl-*a* at the HB @ DH bottom was highest. During the August 30th sampling event, TP at HB @ DH bottom was 0.051 mg/L and the chl-*a* concentration was 87 mg/m^3 (Figure 26 and Appendix D). The SB @ DH bottom sample on the same date had less than half the concentration of TP (0.0202 mg/L) and a chl-*a* concentration of only 15 mg/m^3.

Despite elevated levels of nutrients, turbidity, and chl-*a* at the bottom of Hobbs Brook Reservoir during spring and summer stratification, and to a lesser extent at Stony Brook Reservoir, the consistent year-round concentrations in surface samples indicate that overall reservoir water quality was not significantly impacted by mixing in the late fall. However, given the difference in water quality between the surface and bottom layers of the reservoirs, dam releases for water supply purposes drew from the surface and middle layers of the Stony Brook and Hobbs Brook Reservoirs.

Fresh Pond notably did not have concentrations of iron or TP that were elevated compared to surface samples (Figure 13 and Figure 26). In well oxygenated lakes, phosphorus is typically sorbed to solid iron compounds in the benthic sediments. Under low DO conditions, redox reactions convert iron into its reduced, aqueous form which releases the previously sorbed phosphorus into the water column. Perhaps due to the Fresh Pond aeration system, hypolimnion iron remained in solid form, helping to minimize internal phosphorus loading. Chl-*a* concentrations at FP @ DH bottom were near or below the test detection limit (<2 mg/m^3) except for the bottom sample on August 22nd (19 mg/m^3). Phosphorus is typically the limiting nutrient for lake productivity, so it was unsurprising that low TP levels were found in concert with low chl-*a* concentrations, although the TP was below the detection limit (<0.0106 mg/L) during the August sampling event when chl-*a* was elevated.

Median concentrations of nitrate and nitrite nitrogen at HB @ DH were the same for bottom and surface samples (0.07 mg/L), just above the EPA nutrient criterion of 0.05 mg/L (Figure 26). At SB @ DH, overall nitrate and nitrite nitrogen concentrations were higher than HB @ DH presumably due to land use differences in the respective drainage areas. However, median nitrate and nitrite nitrogen concentrations in SB @ DH bottom samples were lower than in surface samples (0.18 mg/L versus 0.40 mg/L) (Figure 26). Nitrate is rare in hypoxic and anoxic environments, where bacterially driven redox reactions convert nitrate into reduced forms of nitrogen, such as nitrogen gas or ammonia, which likely happened here (Figures 26). Median nitrate and nitrite nitrogen concentrations at FP @ DH were also higher in bottom samples (0.47 mg/L) than in surface samples (0.38 mg/L), although the discrepancy was not as large as at SB @ DH. This could be attributable to oxygen supplied by the aeration system, which may have prevented the nitrate load from fully converting into reduced forms of nitrogen during stratification.

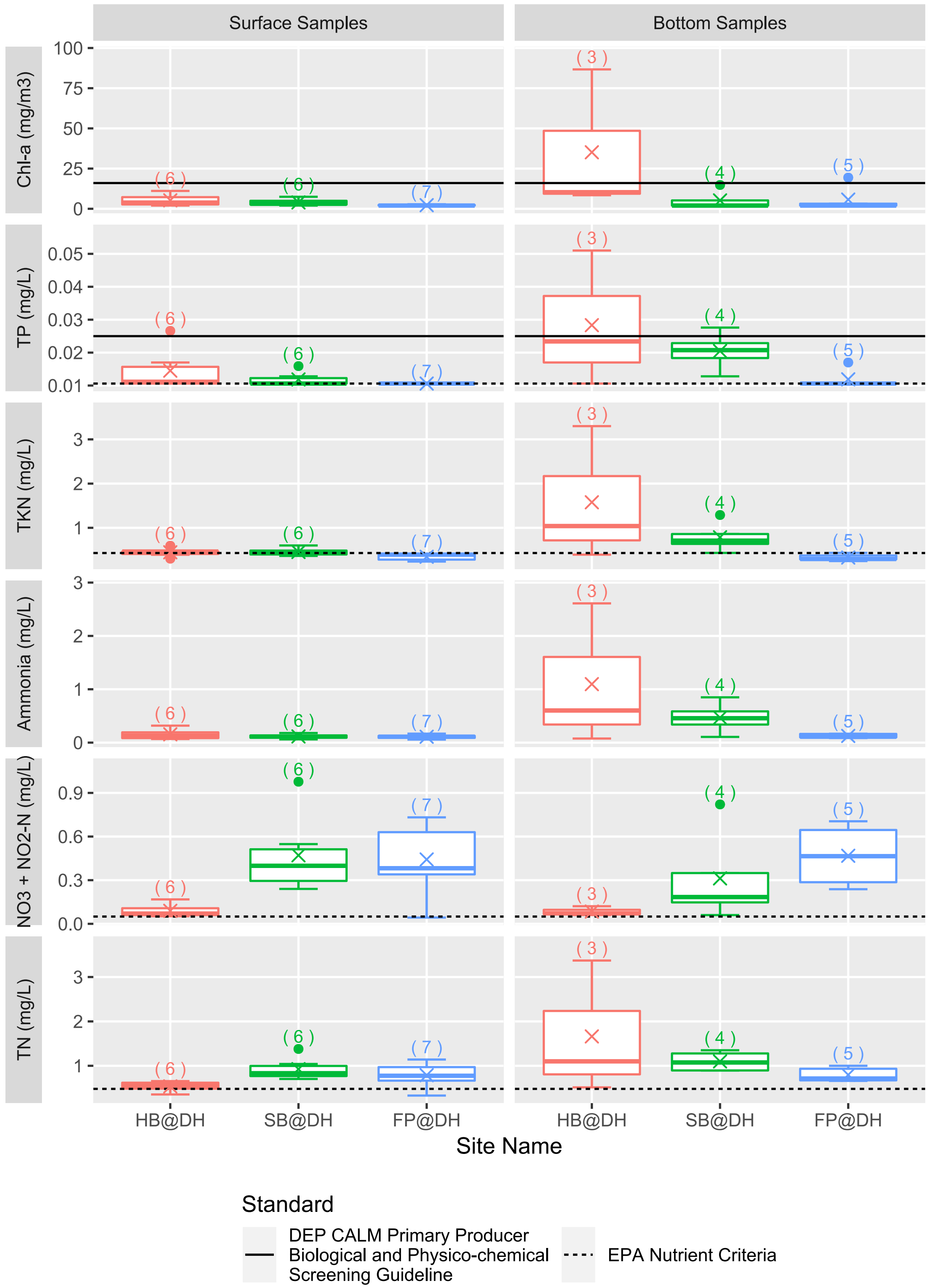

Figure 26: Reservoir Nutrient and Chl-a Surface and Bottom Sample Comparison, 2017

(n)=number of samples

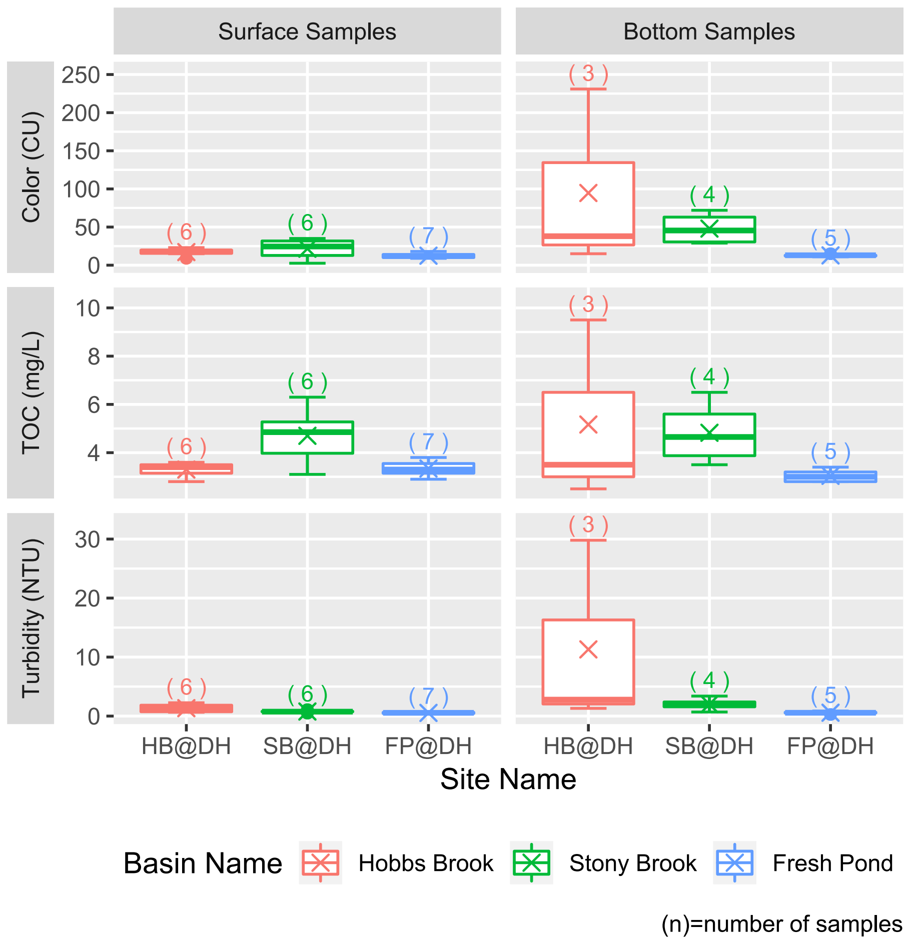

Figure 27: Reservoir Color, TOC, and Turbidity Surface and Bottom Sample Comparison, 2017

Although HB @ DH surface had the lowest surface TN levels of the three reservoirs, it had the highest bottom concentrations due to elevated TKN. The elevated TKN was likely due to benthic algae or plant growth and decomposition, as indicated by elevated bottom chl-*a* and turbidity (Figures 25 and 26). There was less of a discrepancy between TN concentrations in surface and bottom samples at SB @ DH and FP @ DH due to lower bottom concentrations of TKN and ammonia.

TOC, which can react with chlorine during the treatment disinfection process to form harmful byproducts, ranged between 1.7 mg/L and 6.3 mg/L in surface samples and 2.5 mg/L and 9.5 mg/L in bottoms samples from the three reservoirs (Figure 27). TOC was relatively homogenous between the surface and bottom of the water column at Stony Brook and Fresh Pond Reservoir but was higher in HB @ DH bottom samples compared to HB @ DH surface samples. The higher TOC at the bottom of HB @ DH could be reflective of the higher productivity in the bottom stratum of the reservoir as indicated by elevated chl-*a* (Figures 26 and 27).

Median surface and bottom TOC concentrations were highest at SB @ DH (4.9 mg/L and 4.7 mg/L, respectively), although the highest single TOC result occurred in the HB @ DH bottom sample on August

30th (9.5 mg/L) and was coincident with elevated chl-*a* (Figure 27). FP @ DH had the lowest median surface and bottom concentrations (3.3 mg/L and 3.0 mg/L, respectively) of the three reservoirs. It is possible that the longer retention time at Fresh Pond allowed suspended organic particles to settle, thereby reducing the concentration of TOC in the water (see section 10.2 *Reservoir Retention Times*).

6.5 RESERVOIR TROPIC STATE INDEX

6.5.1 Surface Samples

According to Carlson's trophic state index (TSI),[18] productivity dropped as water moved throughout the reservoir system (Figure 28). HB @ Upper and HB @ Middle were the most productive reservoir surface sampling locations. The median TSI for HB @ Upper fell within in the mesotrophic zone and the median TSI at HB @ Middle was in the eutrophic range. However, both sites had chl-*a* results resulting in mesotrophic and eutrophic categorizations throughout the year. Median surface TSI dropped by 9 points between the middle basin HB @ Middle sampling site and HB @ DH in the lower basin. The drop in TSI between the basins indicates an improvement in water quality, likely due to dilution and settling of organic matter and nutrients in the larger lower basin. Median surface TSI continued to drop at SB @ DH, although both HB @ DH and SB @ DH site medians were mesotrophic.

Fresh Pond had the lowest productivity of the three reservoirs, with median TSI for both surface and bottom samples in the oligotrophic range (Figure 28). The improvement in water quality between Stony Brook Reservoir and Fresh Pond Reservoir may be attributable to the aeration system, low iron and TP, and increased capacity for dilution and settling given the larger reservoir size (1.5 billion gallons of storage at Fresh Pond versus only 418 million gallons at Stony Brook Reservoir). The decrease in surface sample productivity between the upper basins of Hobbs Brook Reservoir to Fresh Pond Reservoir as indicated by TSI (calculated using chl-*a*), is confirmed by a similar decreasing trend in TP and an increasing trend in Secchi depth (which indicates increased transparency due to reduced algal and plant growth).

6.5.2 Bottom Samples

Productivity during thermal stratification at the bottom of the three reservoirs was highest at HB @ DH, which had the highest summer chl-*a* levels (Figure 29). Median bottom TSI at HB @ DH was in the eutrophic range, while median TSI at both SB @ DH and FP @ DH was in the oligotrophic range. SB @ DH median bottom TSI was lower than the surface TSI. This is due to samples collected during the April and June profiles, when chl-*a* was higher in surface samples than bottom samples, indicating spring algal activity in the surface layer of the reservoir.

[18] Carlson's TSI was calculated using chl-*a* (see section 5.2.4 Other Parameters). The reporting limit for chl-*a* was 2 mg/m^3 except for samples collected at HB @ Upper and HB @ Middle on March 21, 2017. On this date, the reporting limit was 0.27 mg/m^3 and both sample results were above this limit. To calculate TSI, it was assumed that all test results below the reporting limit were equivalent to 2 mg/m^3. This placed a floor on TSI of 37 for all samples except for the March 21st samples. As such, TSI statistics for sites with sample results below the reporting limit may be artificially high. In 2017, the following sites had at least one chl-*a* result of <2 mg/m^3: HB @ Upper, HB @ DH surface, SB @ DH surface and bottom, and FP @ DH surface and bottom.

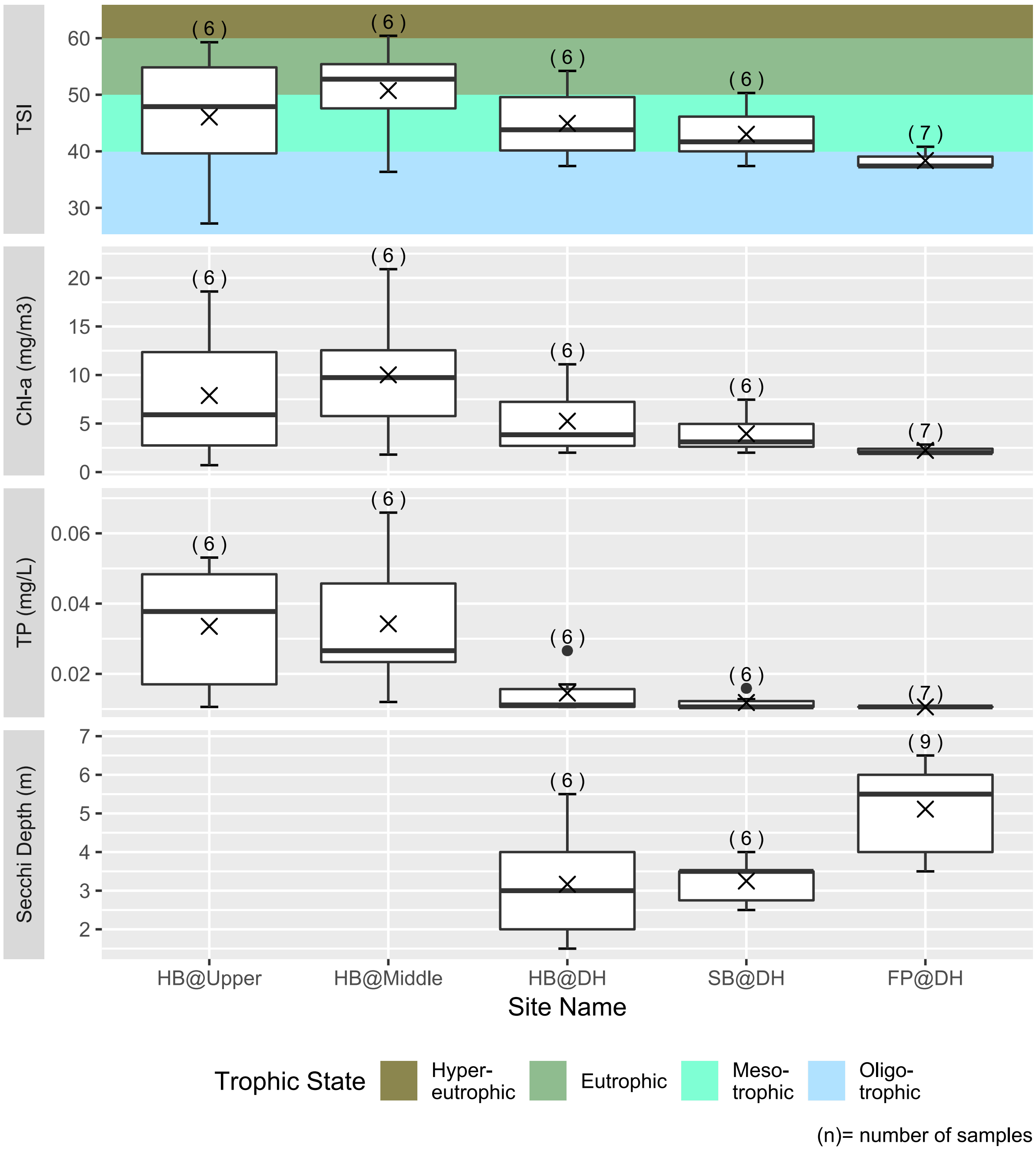

Figure 28: Reservoir TSI, Chl-a, TP, and Secchi Depth (without aquascope), 2017

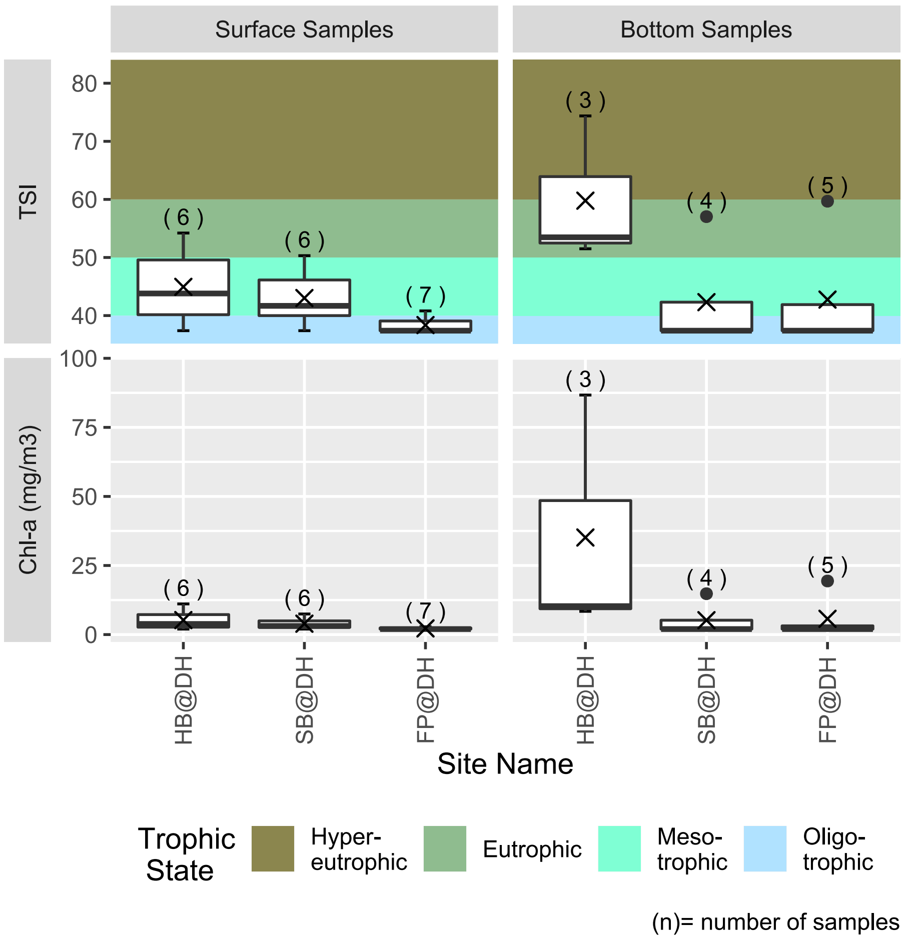

Figure 29: Reservoir TSI and Chl-a Surface and Bottom Sample Comparison, 2017

7 Tributary Base-flow Water Quality

The following section highlights results from the 12 tributary base-flow water quality monitoring stations sampled by CWD in 2017 (Figure 3). Results are compared to Class A water quality standards, MCL and SMCL standards, ORS Guidelines, and EPA nutrient criteria.

7.1 Tributary Class A Water Quality Results

7.1.1 Tributary E. coli, DO, pH, and Temperature

When compared against the Class A water quality standards for *E. coli*, DO, pH, and temperature, tributary water samples in 2017 were overall of good quality. However, exceedances of each parameter occurred at multiple sites.

For *E. coli*, tributaries draining to the Hobbs Brook Reservoir exceeded the Class A 235 MPN/100 ml standard more frequently than tributaries in the Stony Brook Reservoir basin, although *E. coli* from the outlet of Hobbs Brook Reservoir (HB Below Dam) was the lowest of all 12 tributary sites (Figure 30 and Appendix D).

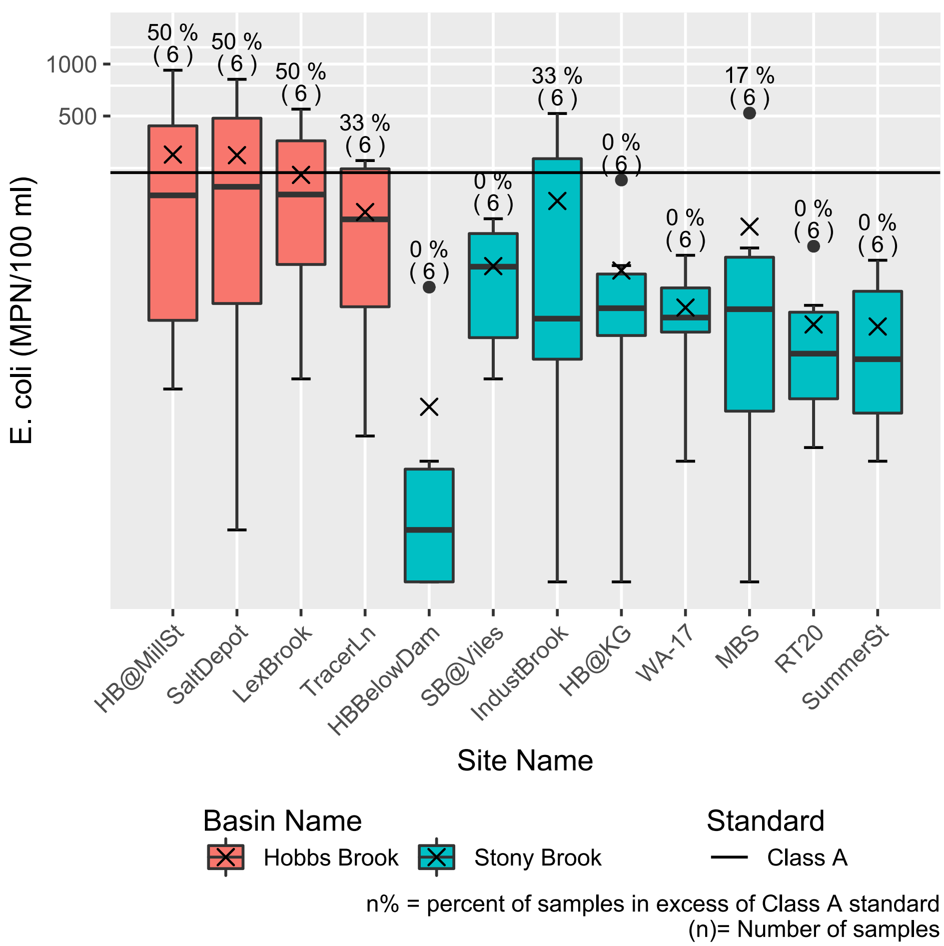

Figure 30: Tributary Base-flow E. coli, 2017

In the Hobbs Brook Reservoir basin, 50 percent of samples (three of six) exceeded the standard at HB @ Mill St, Salt Depot, and Lex Brook. One third of samples (two of six) exceeded 235 MPN/100 ml at Tracer Ln. In the Stony Brook basin, only Indust Brook (two of six samples, 33 percent) and MBS (one of six samples, 17%) had *E. coli* samples above the Class A standard (Figure 30). These exceedances could be the result of septic system leachate or leaking sewer lines. The exceedances could also be due to animal sources, such as geese and beavers. HB @ Mill St and MBS were among the least developed catchments in the Cambridge watershed, but had active beaver populations near the sampling locations. Geese are also frequently near MBS site. Despite exceedances of *E. coli*, median concentrations were below the Class A standard at all sites.

HB @ Mill St, MBS, and Tracer Ln were the only sites with pH measurements outside the pH Class A range of 6.5 and 8.3 (Figure 31 and Appendix D). No site exceeded the upper limit of the pH standard, but all three had readings below 6.5. pH was measured at each sampling location with a water quality probe (*in situ*) and was also measured in water samples brought back to the CWD laboratory (lab). Both the *in situ* and lab pH measurements were below 6.5 for MBS on August 15th and HB @ Mill St on November 2nd. The lab pH reading also registered below 6.5 at HB @ Mill St on January 1st (6.42), but this finding was not supported by the higher *in situ* probe reading of 6.99. Similarly, at MBS, the June 27th the *in situ* probe reading was 6.40 but the laboratory was acceptable by the Class A standards at 6.6. Tracer Ln had one *in*

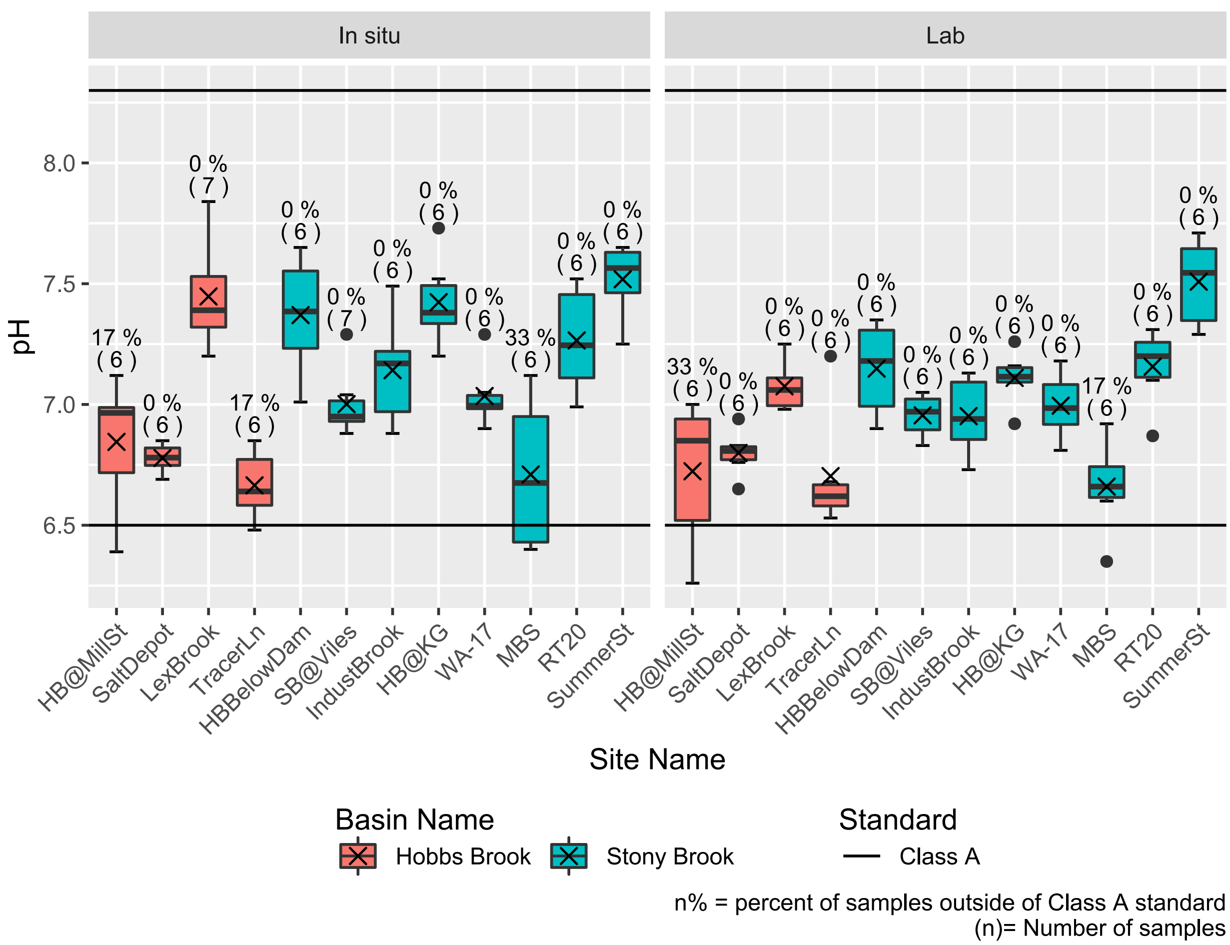

Figure 31: Tributary Base-flow pH Water Quality Probe Results Measured In Situ and in the CWD Laboratory, 2017

situ pH measurement just below the Class A standard at 6.48. However, the lab reading from the same date was 6.61.

HB @ Mill St, Tracer Ln, and MBS were also the only three sites to drop below the minimum Class A DO concentration of 5 mg/L for warm water fisheries (Figure 32 and Appendix D). At HB @ Mill St, the DO dropped below 5 mg/L on September 27th during a period of low flow, resulting in a pool of stagnant water in the stream. The site is downstream of a wetland which exported organic matter. Oxygen in the standing water was likely consumed during the decomposition of the organic matter and was unable to sufficiently replenish due to lack of inflow. Similarly, MBS is downstream of a beaver pond, which was rich in organic matter. DO readings from June through November were less than 5 mg/L, presumably due to the high organic matter load. Tracer Ln was also downstream of a wetland and was adjacent to interstate 95. Both the wetland and the highway may have been sources of organic matter, sediment, and nutrients which may have contributed to the low DO. Neither of the CFR sites (SB @ Viles and RT 20) had DO concentrations below the 6 mg/L Class A standard (Figure 32).

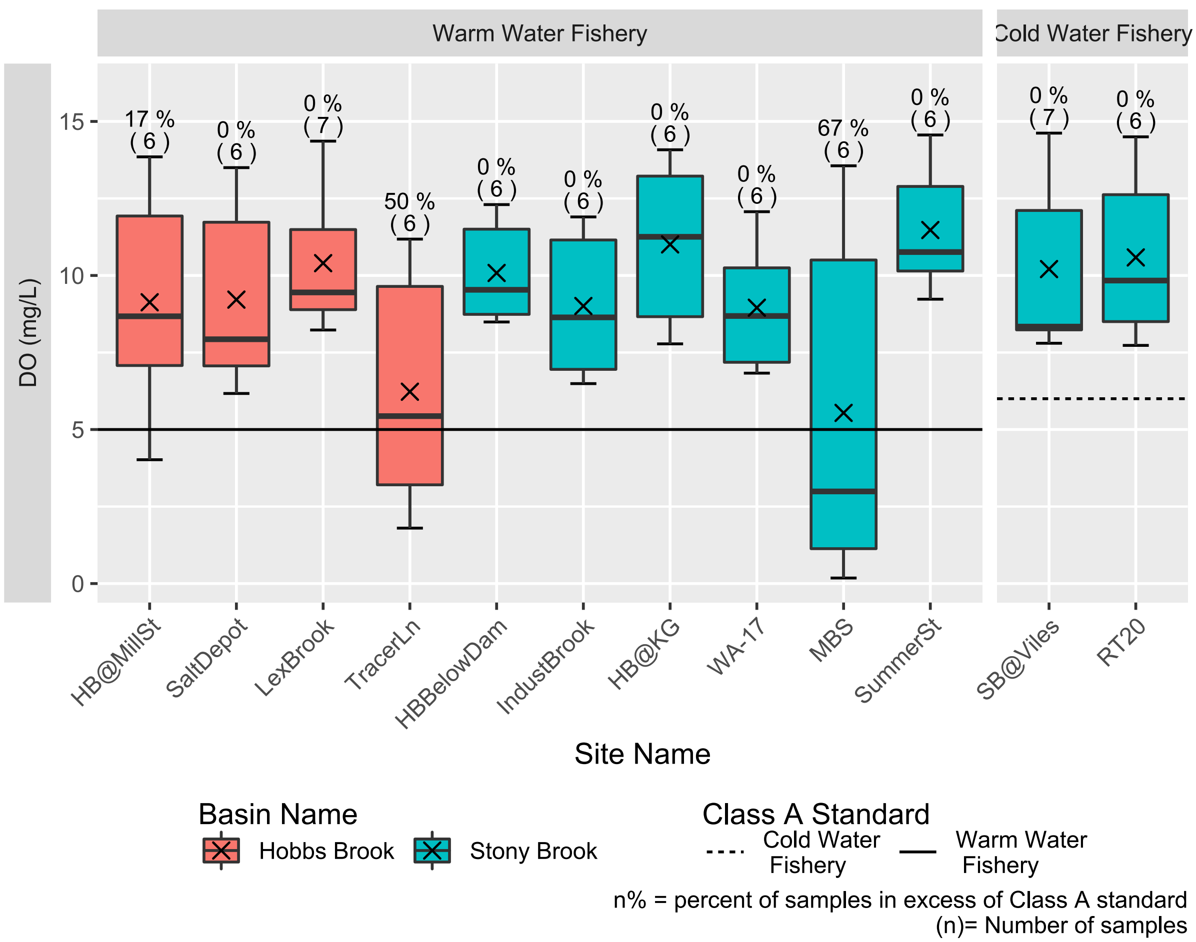

Figure 32: Tributary Base-flow DO, 2017

All warm water fishery sites were cooler than the 28.3 degree C Class A temperature standard during CWD sampling events in 2017 (Figure 33). The USGS also collected continuous temperature data at HB @ Mill

St, Salt Depot, Lex Brook, Tracer Ln, HB Below Dam, WA-17, and Summer St. USGS data confirmed CWD findings, with maximum temperatures in 2017 under 28.3 degrees C. [19]

Temperatures SB @ Viles and RT 20 were compared against the Class A standard for CFRs, defined as 20 degrees C for the seven day average maximum daily temperature unless naturally occurring. [20] CWD did not collect continuous temperature measurements so discrete readings were compared against the Class A standard. All CWD temperature measurements at SB @ Viles were below 20 degrees C (Figure 33). One measurement at RT 20, performed on August 1st, was warmer than 20 degrees C (one of six readings, or 17 percent exceedance) (Figure 33 and Appendix D).

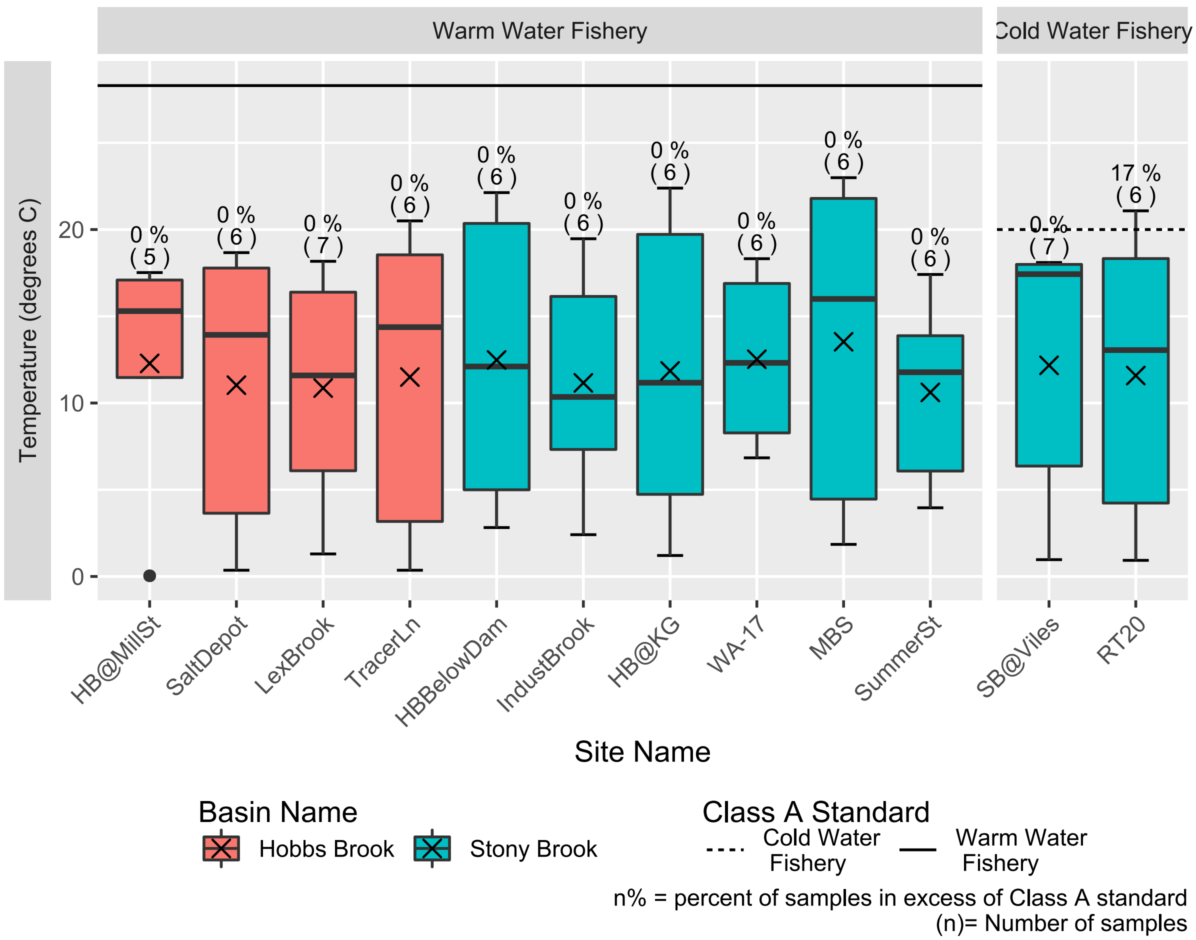

Figure 33: CWD Tributary Base-flow Temperature Results, 2017

To better assess tributary water quality against the CFR standard, CWD calculated the rolling seven day maximum daily temperature using continuous USGS data from monitoring stations 01104370 (SB @ Viles)

[19] Temperature data for 2017 included provisional data points subject to change by USGS.

[20] According to the 2016 CALM manual, small datasets with only instantaneous measurements should never exceed, or only rarely exceed, the 20 degrees C Class A standard. However, a dataset containing only infrequent discrete/instantaneous measurements would not be sufficient to classify a waterbody as impaired.

and 01104460 (RT 20). According to the USGS dataset, SB @ Viles exceeded the Class A standard 49 times in 2017, equal to 14 percent of the rolling averages (Table 8). RT 20 exceeded 20 degrees C more frequently (109 times, or 30 percent of the seven day maximum daily temperature averages). The exceedances at SB @ Viles occurred primarily in June and early August. Exceedances at RT 20 also began in June, prior to summer water releases from Hobbs Brook Reservoir. However, the exceedances continued through late September, nearly two months longer than SB @ Viles. The extended period of exceedances at RT 20 may have been attributable to water released from Hobbs Brook Reservoir. Exceedances prior to the start of Hobbs Brook Reservoir water releases in June in July were either naturally occurring or due to anthropogenic factors. Further analysis would be needed to determine the extent to which human activities such as heated pavement runoff, loss of riparian vegetation, and upstream impoundments contributed to the temperature exceedances.

Table 8: Coldwater Fish Resource Class A Temperature Results, USGS Continuous Data, 2017

Site Name	SB @ Viles	RT 20
Median	11.8	13.2
Mean	10.5	11.8
Min	0.0	0.0
Max	23.8	25.2
Number of Averages (n)	359	359
Number of Exceedances	49	109
% Exceedance	14%	30%

Data source = approved and provisional data from USGS continuous monitoring stations 01104460 (RT 20) and 01104370 (SB @ Viles); median, mean, minimum, and maximum temperatures were calculated using the complete continuous data set; n= number of rolling seven-day maximum daily temperature averages; number of exceedances= number of rolling seven-day temperature averages above 20 degrees C; % Exceedance = % of rolling seven-day maximum daily temperature averages above 20 degrees C.

7.1.2 Nutrients

Indicators of nutrient enrichment used by MA DEP to determine whether the Aquatic Life Use is supported in rivers and streams, such as algae and macrophyte growth and chl-*a*, were not assessed by CWD in tributaries. While CWD did monitor TP, the 2016 CALM methodology calls for using the summer seasonal TP average where the sample size is greater than three to evaluate TP as a cause of nutrient enrichment. However, no tributary site monitored by CWD in 2017 was sampled more than twice during the summer. As such, nutrient results from CWD tributaries only compared against EPA nutrient criteria in section 7.3.

7.2 Tributary Maximum and Secondary Maximum Contaminant Levels (MCLs and SMCLs) and ORS Guidelines

SMCLs for manganese, iron, TDS, chloride and the ORS Guideline for sodium were regularly exceeded during 2017 tributary sampling events (Figure 34 and Appendix D). It is important to note that the SMCL standards apply to treated drinking water, rather than untreated surface water. Nitrate concentrations are discussed in section 7.3 in the context of the EPA nutrient criteria. However, all tributary sites had nitrate concentrations well below the MCL of 10 mg/L in 2017.

7.2.1 Iron and Manganese

Summer St had the lowest iron and manganese exceedance rates (17 percent or one of six samples for both iron and manganese) of all 12 tributary sites and was the only tributary site with median iron and manganese concentrations below the SMCL (Figure 34 and Appendix D). SB @ Viles had the next lowest exceedance rate at 50 percent for both parameters (three of six samples). MBS exceeded the iron SMCL in 83 percent of samples but only exceeded the manganese standard in 50 percent of manganese samples. All other sites exceeded the SMCL in 67 to 100 percent of samples in 2017. Outlier spikes in iron and manganese occurred at multiple tributary monitoring sites in 2017 but were especially high in the Hobbs Brook Reservoir basin and at MBS in the Stony Brook Reservoir basin.

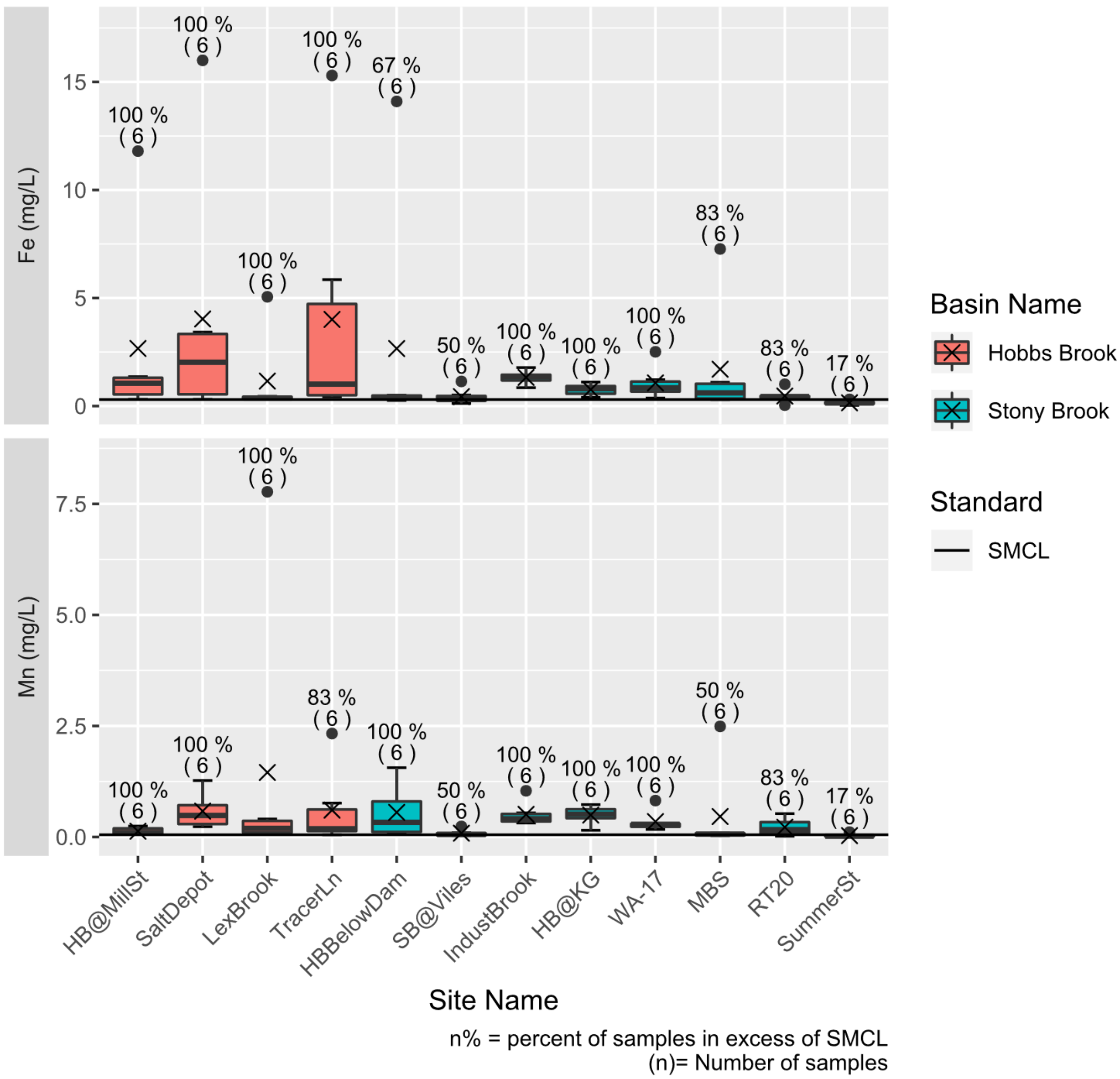

Figure 34: Tributary Base-flow Iron and Manganese, 2017

One explanation for the spikes in iron and manganese is very low flow conditions, which could more easily result in accidental contamination of the sample through the suspension of bottom sediments. It could also be due to a lack of dilution of iron and manganese loads from the sediments and parent material in the watershed. Low flow was likely a contributing factor to a spike in iron at HB @ Mill St on August 15th (11.8 mg/L) and iron and manganese at Lex Brook on October 19th (5.06 mg/L and 7.77 mg/L, respectively) (Figure 34 and Appendix D). Both sites had very low, near stagnant flows during the sampling events but DO concentrations above the 5 mg/L Class A standard (Figure 32).

Low DO and iron oxidizing bacteria are other factors that coincided with spikes in iron and manganese at Salt Depot, Tracer Ln, HB Below Dam, and MBS. On June 27th, August 15th, and September 27th, a thick orange film was observed coating the substrate at Salt Depot (Figure 35). Iron concentrations on these dates were 16 mg/L, 3.42 mg/L, and 3.09 mg/L, respectively. Salt Depot is downstream of a swamp-like habitat with ample organic matter. Although the DO was above the 5 mg/L Class A standard on all three dates, it is possible that groundwater in this habitat became anoxic after depleting oxygen during aerobic microbial respiration, resulting in the reduction of iron (converting iron into an aqueous ion) after switching to anaerobic respiration. Once the anoxic, iron-rich groundwater interacted with the oxygen-rich water from the stream, it is likely that bacteria oxidized the aqueous iron, causing the orange precipitate visible in the stream. The orange iron oxidizing bacteria slime was also observed at Tracer Ln on August 15th (iron = 5.85 mg/L and DO = 4.57 mg/L) and at HB Below Dam on August 29th (iron = 14.1 mg/L, manganese=1.56 mg/L, and DO = 8.49 mg/L) (Figure 35 and Appendix D).

A. Salt Depot stream bottom

B. Tracer Ln sampling location, looking downstream to the northwest

Figure 35: Example of Probable Iron Oxidizing Bacteria Bloom at Salt Depot and Tracer Ln, August 15, 2017

The highest concentrations of iron and manganese occurred at Tracer Ln when an orange film was not observed, but during periods of low DO, which likely resulted in the reduction of the two metals. Iron and manganese at Tracer Ln on June 27th were 15.3 mg/L and 2.3 mg/L, respectively, with a DO concentration of 1.8 mg/L. Similarly, low DO at MBS on September 27th likely resulted in the oxidation of iron and manganese from anaerobic decomposition of organic matter from the beaver pond (iron = 7.27 mg/L, manganese = 2.49 mg/L, and DO = 0.58 mg/L).

7.2.2 Sodium and Chloride

Due to proximity to highways, roadways, and impervious surfaces, road salts used for deicing have contributed to elevated concentrations of sodium and chloride in tributaries throughout the Cambridge watershed. Every sample collected in 2017 exceeded the sodium 20 mg/L ORS Guideline (Figure 36 and Appendix D). Additionally, seven sites (Salt Depot, Lex Brook, Tracer Ln, HB Below Dam, Indust Brook, HB

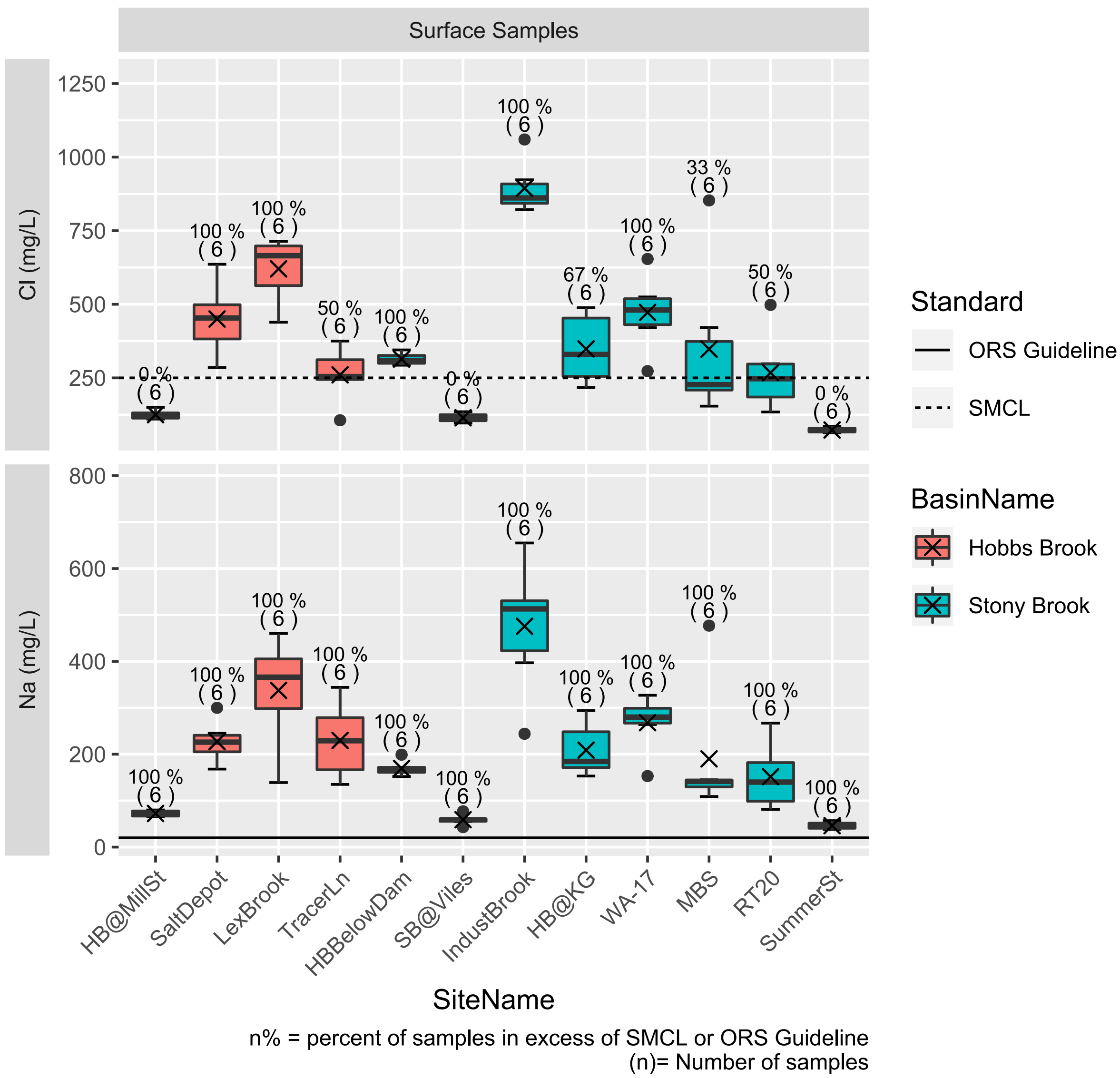

Figure 36: Tributary Base-flow Sodium and Chloride, 2017

@ KG, and WA-17) had median chloride concentrations above the 250 SMCL (Figure 36 and Appendix D). Indust Brook had by far the highest concentrations of sodium and chloride, with median concentrations of 513 mg/L and 861 mg/L. The site with the next highest median concentrations was Lex Brook at 366 mg/L (sodium) and 665 mg/L (chloride), approximately 150 to 200 mg/L lower than Indust Brook.

Indust Brook is downstream of the interstate 95 drainage system and is one of the most developed catchments in the watershed, with 67 percent of land area categorized as commercial and industrial and more than 10 percent categorized as transportation (Appendix A). Lex Brook, Tracer Ln, and WA-17 are adjacent to interstate 95 and Route 20, which likely explains the elevated salt concentrations at these sites. Even though Salt Depot receives minimal drainage from Interstate 95, it still had an elevated median chloride concentration of 454 mg/L. This was presumably attributable to a historic groundwater salt plume resulting from storage of sodium chloride by MassDOT in an uncovered garage, as well as potential spillage from current highway operations (Geotechnical Engineers Inc, 1985). The salt storage facility has since been updated to prevent road salts from leaching into the groundwater.

HB Below Dam and HB @ KG both received flows from the salt-impacted Hobbs Brook Reservoir from late July through October of 2017. RT 20 was also impacted by the high sodium and chloride water released from Hobbs Brook Reservoir. With a median chloride concentration of 247 mg/L, below the 250 mg/L SMCL, RT 20 had three samples exceed the SMCL in 2017, all of which occurred during the Hobbs Brook Reservoir water release period (Figure 36 and Appendix D).

Summer St, HB @ Mill St, and SB @ Viles had the lowest sodium and chloride concentrations of all 12 tributary sites and the only sites with median chloride concentrations below the 250 mg/L SMCL. Summer St had the overall lowest median chloride concentration (71 mg/L). These three catchments were among the least heavily developed areas in the watershed with less than a percent of land area categorized as "transportation." This means less potential exposure to road salts than more heavily developed catchments with more miles of roadways and parking lots (Appendix A).

7.2.3 TDS

TDS is a measure of total dissolved material in water, which often closely correlates with specific conductance. TDS was measured *in situ* using a water quality prove which converted specific conductance readings into TDS values. Because specific conductance is an indication of salt content, 2017 TDS results mimicked the results for sodium and chloride. As with sodium and chloride, the catchments which were not subject to Hobbs Brook Reservoir flow regulation and were least developed (HB @ Mill St, SB @ Viles St, and Summer St) were the only sites with all measurements below the 500 mg/L SMCL (Figure 37 and Appendix D). Median concentrations at all other tributary sites were above the 500 mg/L SMCL. Similar to sodium and chloride, Indust Brook had the highest median TDS concentration at 1,899 mg/L followed by Lex Brook at 1,508 mg/L.

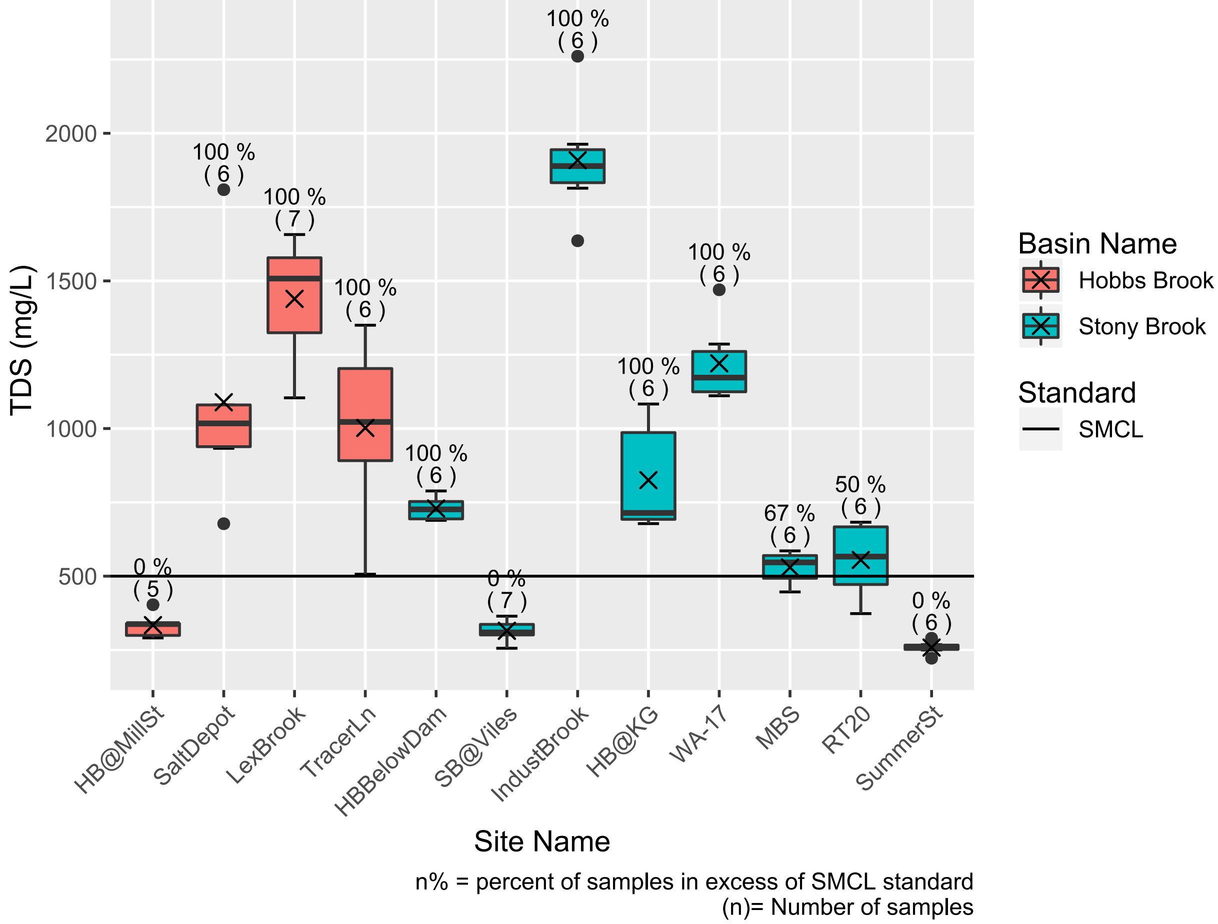

Figure 37: Tributary TDS, 2017

7.3 TRIBUTARY EPA NUTRIENT CRITERIA

7.3.1 Total Phosphorus (TP) and Turbidity

Four sites, HB @ Mill St, Tracer Ln, Indust Brook, and MBS had median TP concentrations greater than the 0.02375 mg/L EPA nutrient criterion. All sites except RT 20 exceeded 0.02375 mg/L at least once in 2017 (Figure 38). The exceedances at HB @ Mill St, Tracer Ln, and MBS occurred primarily during the growing season, from late June through early November (Appendix D). The sites are located downstream of wetland systems which may have been sources of organic phosphorous. The exceedances at Indust Brook, which was also downstream of a wetland system, were more evenly distributed throughout the year (Appendix D). Although samples were collected under base-flow conditions, the even spread of TP exceedances during and outside the growing season could indicate inorganic sources of TP, such as roadway sediments, which settle in the stream. At WA-17, the only sample to exceed the EPA nutrient criterion was on outlier collected on April 11, 2017 (0.09 mg/L) (Appendix D). The water was visibly turbid during the sampling event and was later traced to an illicit discharge from construction work upstream in the catchment.

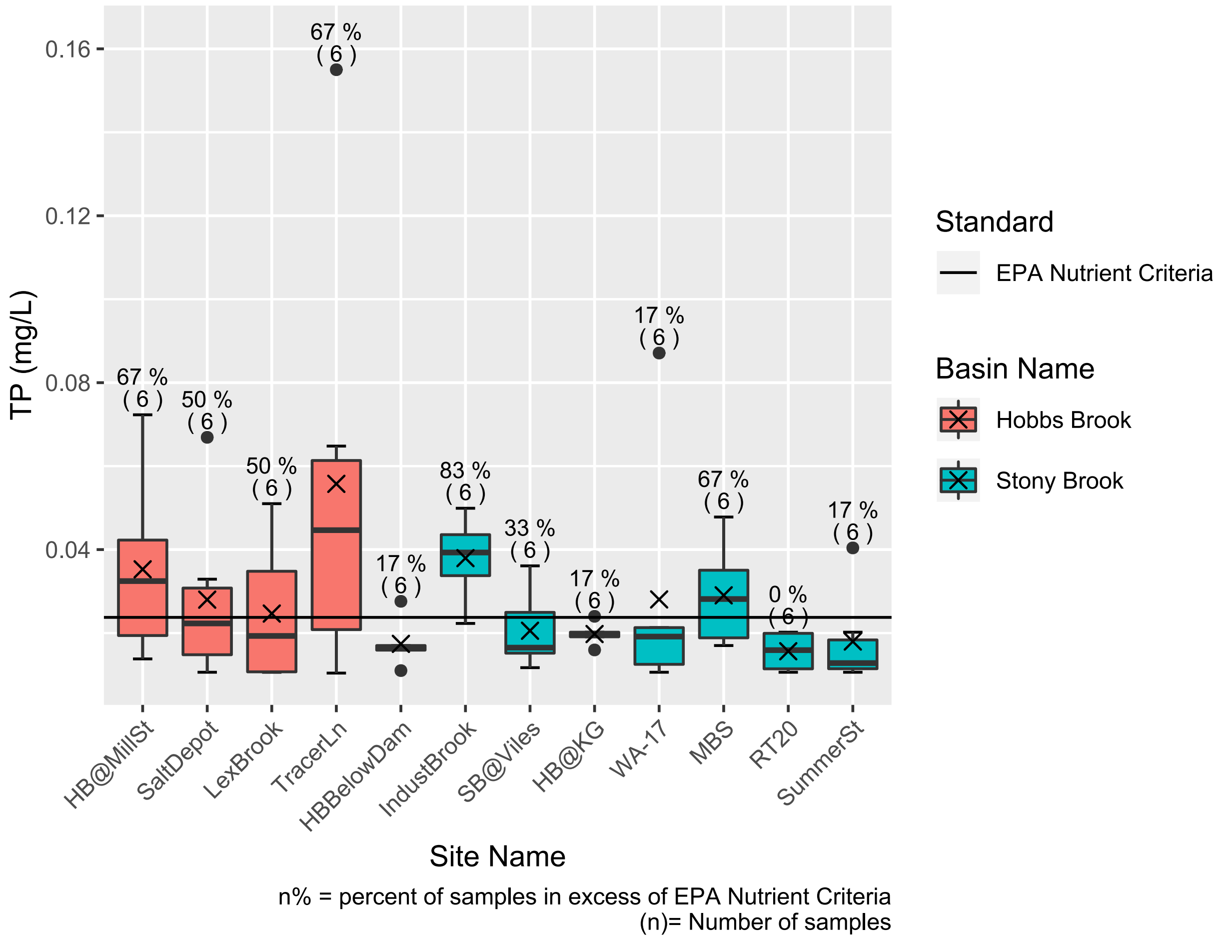

Figure 38: Tributary Base-flow TP, 2017

In addition to exceeding the TP EPA nutrient criterion, median turbidity levels at HB @ Mill St, Tracer Ln, and Indust Brook were above the EPA nutrient criterion of 1.68 NTU (Figure 39). Median turbidity at Salt Depot and WA-17 also exceeded 1.68 NTU. Despite exceeding the TP EPA nutrient criterion, MBS median turbidity was below the 1.68 NTU threshold. All sites with medians exceeding the nutrient criterion were located downstream of wetland systems, which may have exported wetland sediments and organic matter that contributed to turbidity. Iron oxidizing bacteria may also have been a source of turbidity at Salt Depot and Tracer Ln. Sediments from roadways and development activities may have added to turbidity at Tracer Ln and Indust Brook, although these sources would be expected to have a greater influence during stormflow sampling than during base-flow sampling. The 15.2 NTU outlier at WA-17 occurred during the April 11th sampling event and was the result of the illicit construction discharge.

Even though all TP samples collected in 2017 at WA-17 were below the EPA nutrient criterion except for the illicit discharge, both TP and turbidity concentrations have increased since 2012 when a new stormwater wetland system was installed upstream of the sampling station (Figure 40). Prior to

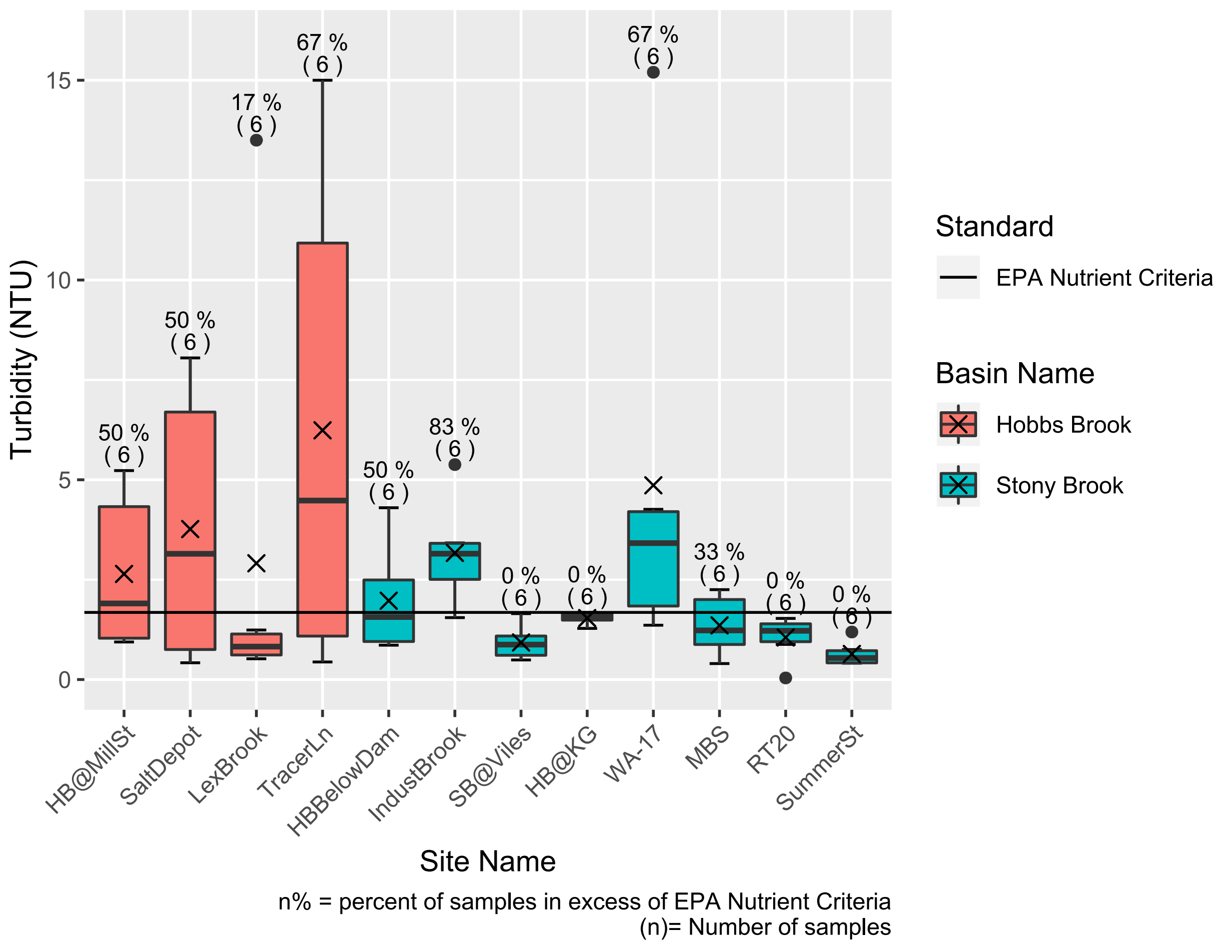

Figure 39: Tributary Base-flow Turbidity, 2017

installation of the stormwater wetland system, TP concentrations were approximately 0.01 mg/L and only one sample between 2000 and 2012 exceeded the EPA nutrient criterion (Figure 40). Similarly, turbidity levels were generally below 1 NTU and only one sample exceeded the 1.68 turbidity EPA nutrient criterion (Figure 40). After 2012, results for both turbidity and TP became more variable with higher median concentrations. Turbidity results were nearly all greater than 1 NTU and TP and turbidity exceeded the nutrient criteria with much greater frequency (Figure 40).

The increase in TP and turbidity concentrations after installation of the stormwater wetland system was greater during the plant growing season than during plant dormancy (Figure 41).[21] Before the installation, median TP concentrations during and after the growing seasons were the same (0.01 mg/L) and were below the EPA nutrient criterion (Figure 41). After the system became operational, median TP increased during both seasons, but was higher during the plant growing season (0.029 mg/L) than during plant dormancy (0.017 mg/L). Likewise, median turbidity before installation of the pond was 0.54 NTU during

[21] The 0.0871 mg/L TP and 15.2 NTU results recorded during an illicit discharge to WA-17 on April 11, 2017 were excluded from analysis comparing base-flow water quality before and after the stormwater wetland system installation.

plant dormancy and 0.30 NTU during the growing season. By contrast, the post-installation median turbidity was 1.6 NTU during plant dormancy, just below the 1.68 EPA nutrient criterion, and 1.9 NTU during the growing season (Figure 41). It is likely that the increase in TP and turbidity during the growing season is from plant and algae growth in the ponds.

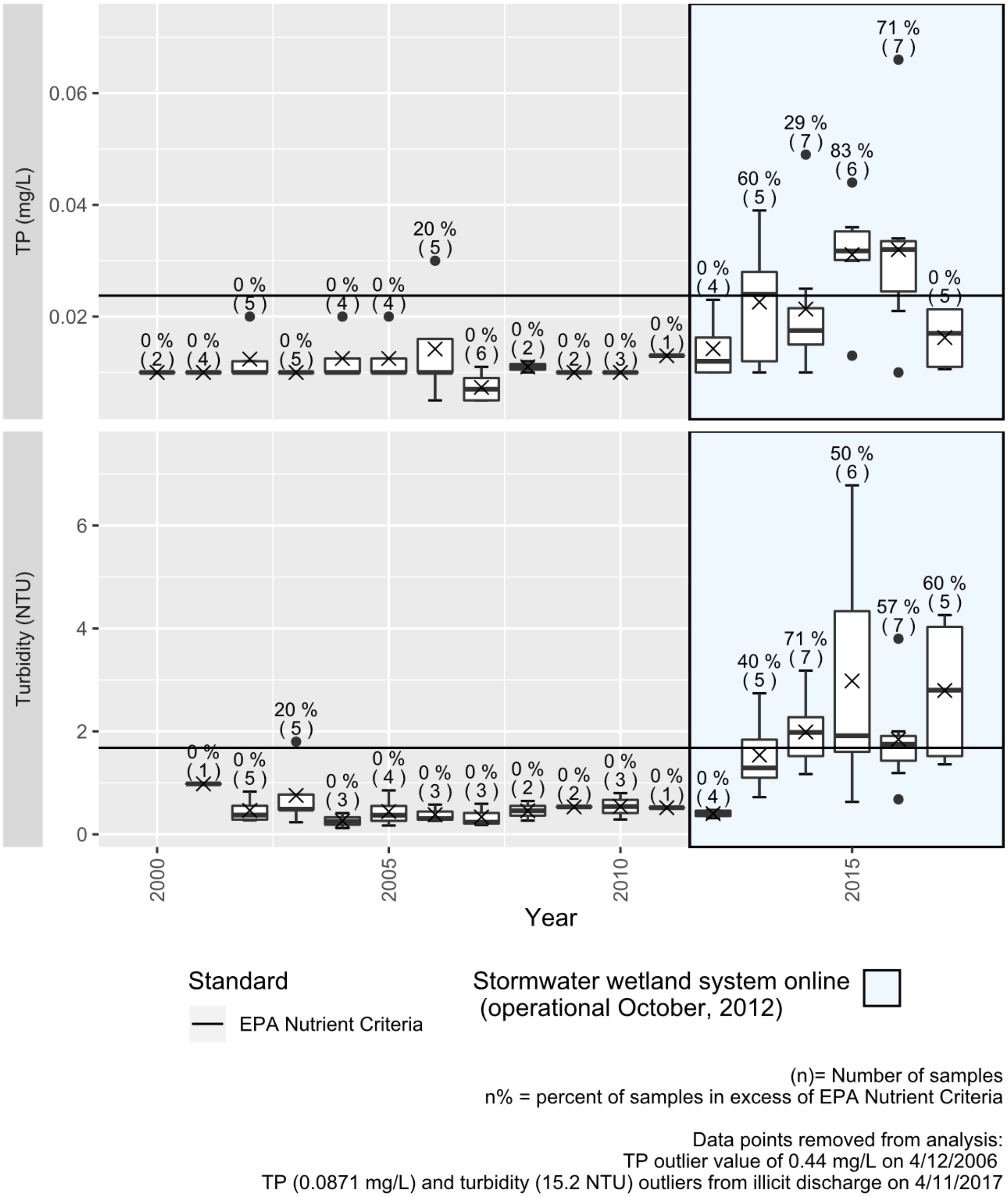

Figure 40: WA-17 Base-flow TP and Turbidity, 2000-2017

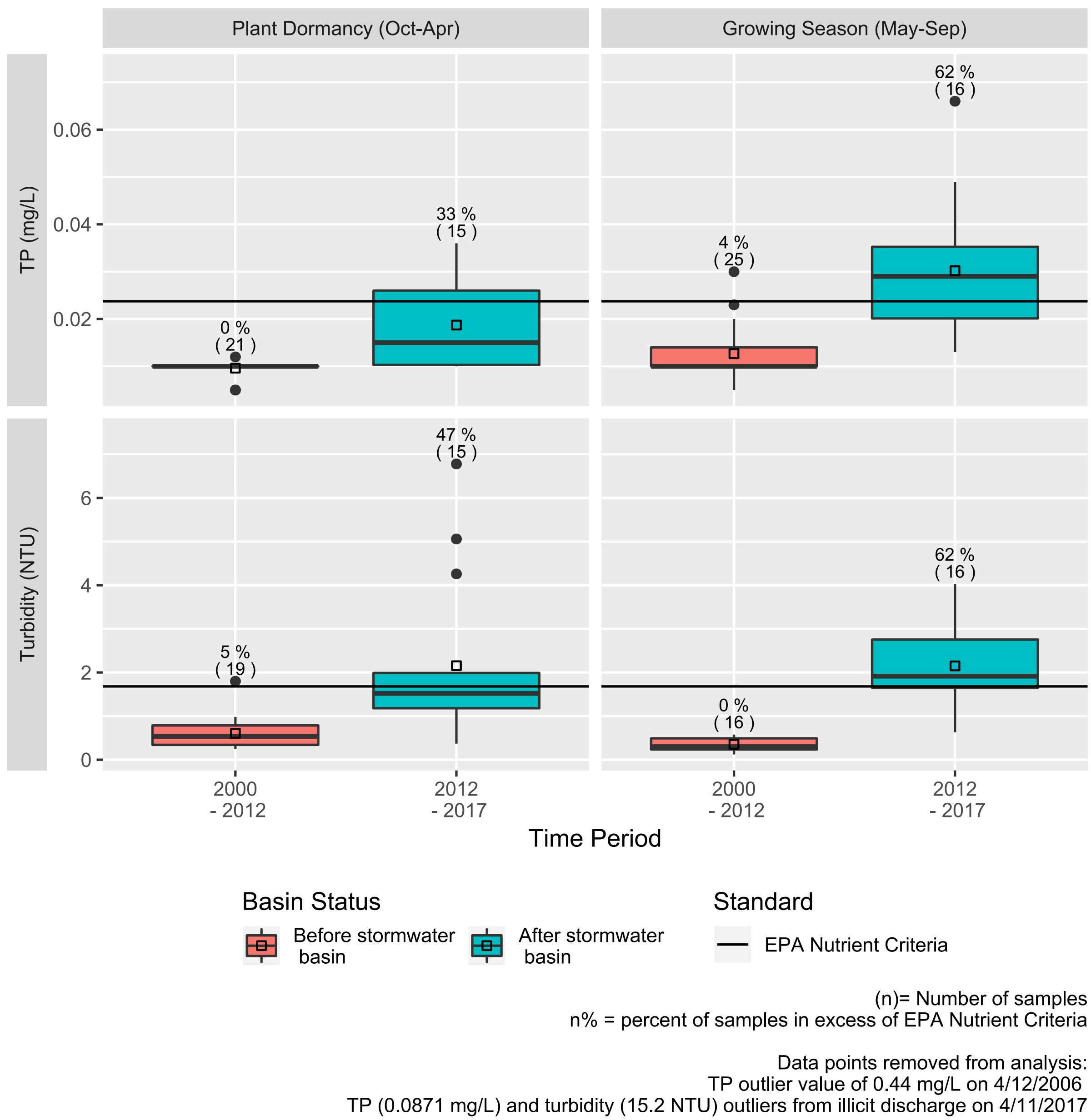

Figure 41: WA-17 Base-flow TP and Turbidity by Growing Season, Before and After Installation of Stormwater Wetland System

The increase in base-flow TP and turbidity, especially during the growing season, indicates that the wetland system is having unintended water quality impacts. The system was designed to redirect piped flows into a sediment forebay, spill into a wet pond before overflowing and seeping through an elevated wetland bench into a second pond, and then discharge to the original flow path through an outlet control structure. The goal was to remove stormwater sediment and pollutants through settling, phytoremediation, and filtration and remove a direct discharge from the water supply for HAZMAT intervention purposes. However, a USGS comparison of stormwater quality before the installation of the ponds (water years 2005-2007) and after (water years 2013-2015) showed no significant difference in stormflow TP concentrations (Smith, 2017). The ponds also appeared to worsen base-flow water quality as measured by TP and turbidity (Figures 40 and 41; Smith, 2017). To remedy the situation, CWD coordinated with MassDOT to install a base-flow bypass weir so that only stormflow will enter the pond. The weir was installed in 2018 and water quality at WA-17 will continue to be monitored to determine if conditions improve.

7.3.2 Nitrogen

TN is the sum of TKN (ammonia nitrogen and organic nitrogen) and nitrate/nitrite nitrogen. Median TN concentrations at all sites except Salt Depot exceeded the EPA nutrient criterion of 0.61 mg/L, while median concentrations at seven sites exceeded the 0.31 mg/L nitrate and nitrite nitrogen criterion (Figure 42). Summer St had the highest TN concentration of any tributary in the watershed (median = 2.57 mg/L), followed by WA-17 (median = 2.10 mg/L) and Lex Brook (1.73 mg/L) (Figure 42). The TN concentrations at these sites were primarily driven by nitrate/nitrite concentrations. In fact, Summer St, WA-17, and Lex Brook had the three lowest median TKN concentrations of all 12 tributaries in 2017. Summer St was also the only tributary site with a median TKN concentration (0.25 mg/L) below the EPA nutrient criterion of 0.3 mg/L. Sources of nitrate and nitrite include fertilizers and solid sanitary waste effluent. Over 16 percent of the Summer St catchment was comprised of a golf course, and more than 20 percent of the land was low density residential (Appendix A). Fertilizer used on lawns and the golf course may have been sources of the elevated nitrogen. The catchment is also served by septic systems, another potential source of nitrate/nitrite nitrogen.

The nitrate and nitrite nitrogen sources at WA-17 and Lex Brook were less easily to identify. Both sites are located adjacent to highways and WA-17 is downstream of the previously discussed constructed stormwater wetland (Figure 3). The majority of both catchments are also served by sewer systems. Sewer lines are one potential source of the nitrate, whereby leaking pipes could leach nitrogen-rich effluent into the groundwater.

A spike in nitrate/nitrite nitrogen levels occurred after in 2013 and 2014 after the October 2012 installation of the stormwater pond and wetland system (Figure 43). The spike in nitrate and nitrite was presumably due to the erosion of construction soils and fertilizers added to help establish new vegetation. Median nitrate and nitrite nitrogen concentrations in 2015 through 2017 were similar to pre-construction levels and may even represent a slight decreasing trend (Figure 43). The post-installation median nitrate and nitrite nitrogen concentration during the growing season was less than during plant dormancy (1.16 mg/L compared to 2.04 mg/L) whereas the difference in medians between the seasons prior to the installation of the stormwater treatment system was less extreme (2.24 mg/L during the growing season and 1.83 mg/L during plant dormancy) (Figure 44). This suggests that the wetland system may now act as a nitrate sink during the growing season due to plant uptake.

TKN concentrations remained consistent between the plant growth and dormancy seasons, both before and after installation of the pond and wetland system (Figure 44). However, TKN concentrations did become overall more variable after installation of the treatment system. The median TKN concentration was also slightly higher after installation of the wetland/pond system, potentially due to increased algal and plant growth. TN was largely governed by nitrate/nitrate nitrogen concentrations, exhibiting the same patterns as nitrate and nitrite nitrogen with regard to seasonality.

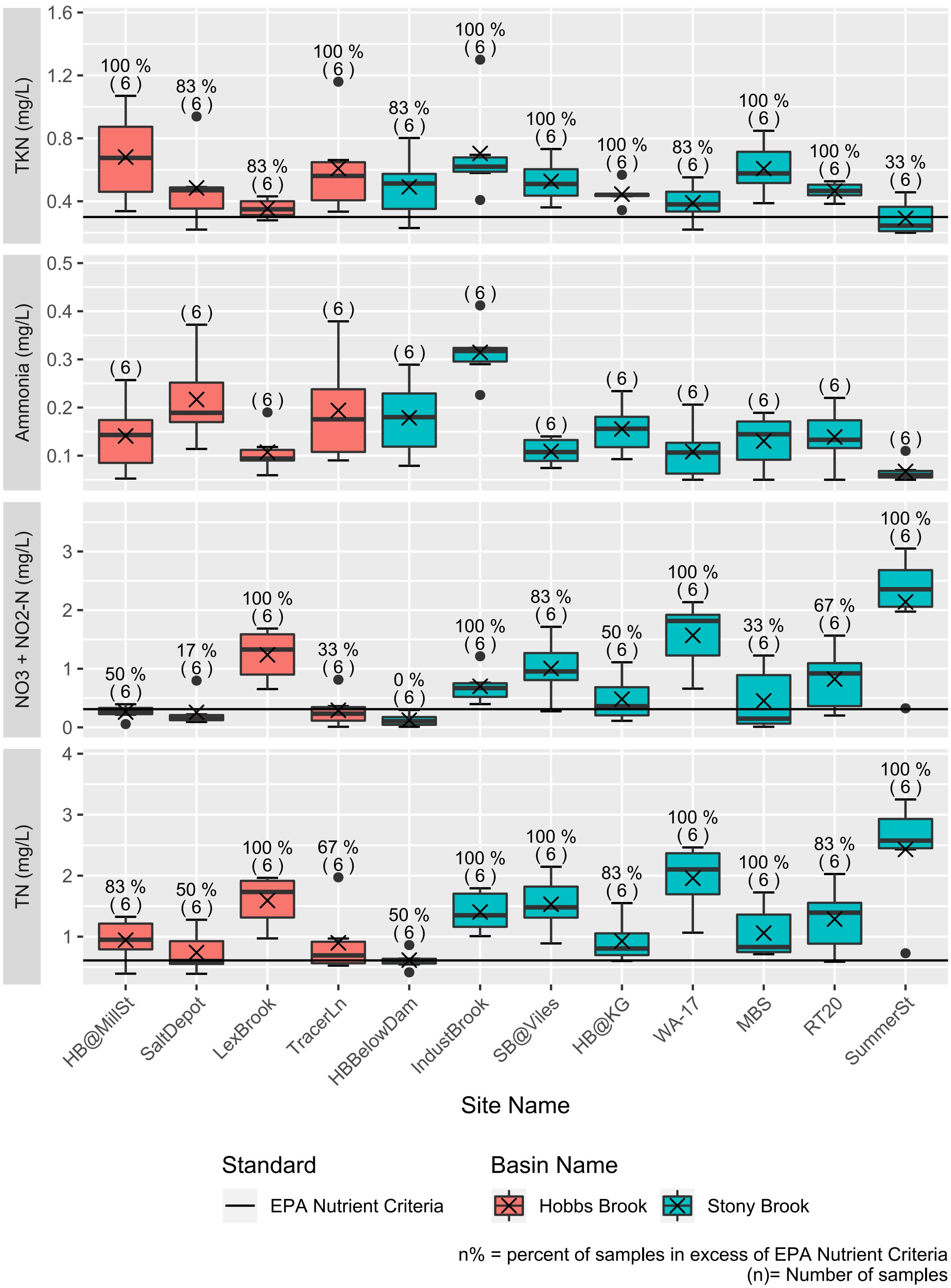

Figure 42: Tributary Base-flow Nitrogen, 2017

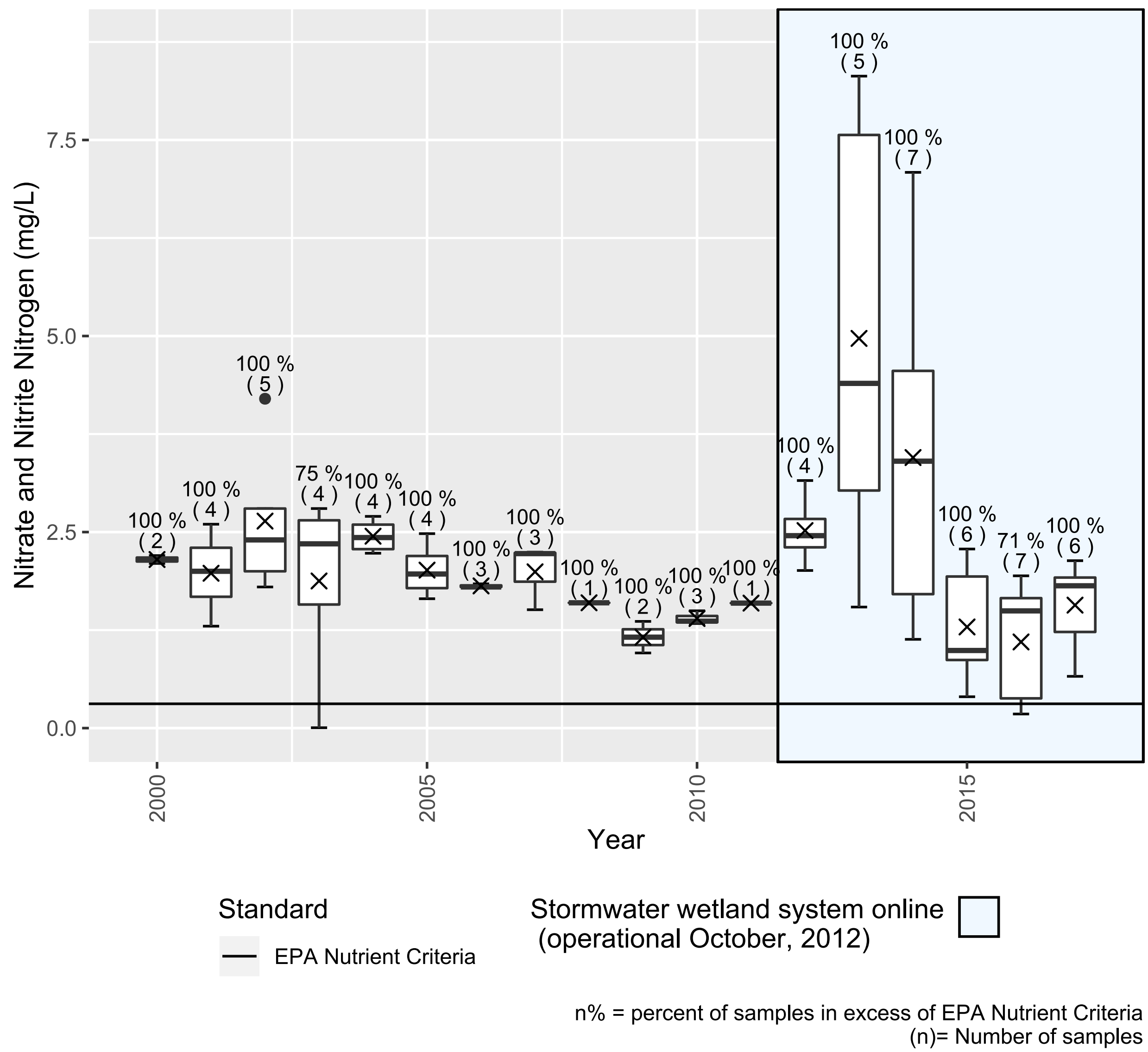

Figure 43: WA-17 Base-flow Nitrate and Nitrite Nitrogen, 2000-2017

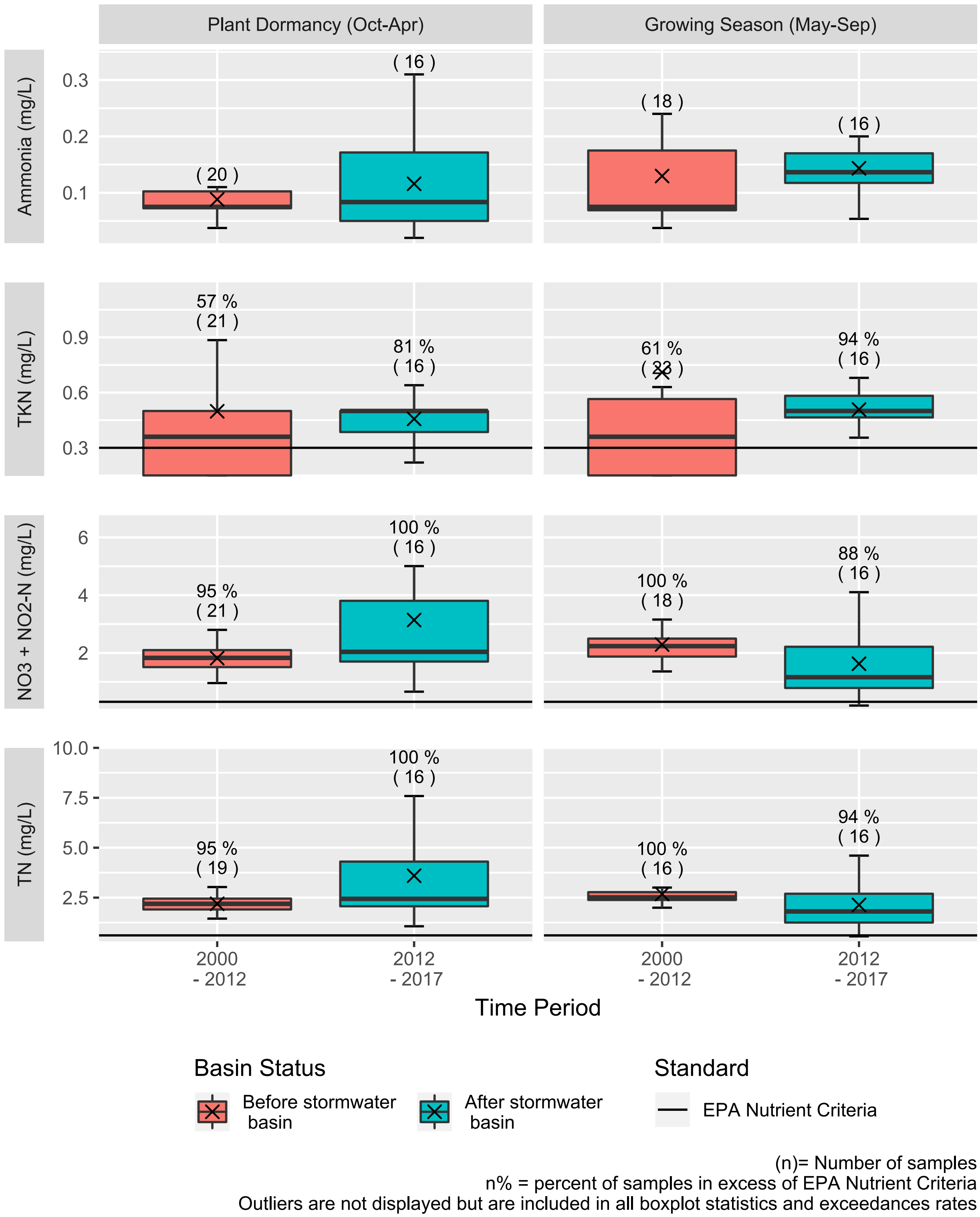

Figure 44: WA-17 Base-flow Nitrogen Before and After Stormwater Wetland System Installation, by Growth Season

8 TRIBUTARY WET WEATHER MONITORING

Stormwater runoff disproportionally impairs water bodies in developed watersheds. Impervious surfaces such as parking lots and roadways store metals, oils, and sediments from cars, aerial deposition, and other sources, which, during storms, are rapidly shunted to streams via piped drainage networks or overland flow. The stormflow generated from these surfaces often occurs at erosive velocities. In undeveloped watersheds, trees, uncompacted soils, and vegetation capture and recharge much of the stormwater runoff. The amount of water that flows to streams as runoff does not exacerbate erosion and is generally of good quality.

Since the Cambridge watershed is relatively developed, pollutants associated with sediment and particulates can be expected to increase during stormflow. On the other hand, pollutants that are present in high levels in groundwater, such as sodium and chloride, can become diluted during heavy rain events. USGS continuous monitoring stations outfitted to automatically sample storm events were located at Lex Brook, Tracer Lane, WA-17, and Summer St in 2017. The USGS stormwater samples were collected throughout the entire storm, mixed together, and then analyzed for a variety of chemical and nutrient parameters. The stormwater sampling data are available online by station ID number. Between January and December 2017, the USGS sampled between four and six storm events at each of the four sites (Table 6). USGS also collected four to five water quality grab samples during base-flow conditions at each site. The USGS stormwater chloride, calcium, sodium, and TP concentrations are compared to USGS and CWD base-flow samples in 2017 (Figures 45 – 48).

Median sodium, calcium, and chloride concentrations in watershed catchments with high percentages of roadway areas (Lexington Brook, Tracer Lane, WA-17) decreased during storm events due to dilution from runoff (Appendix A; Figures 45 - 47). USGS and CWD base-flow samples were generally well aligned, although base-flow chloride results at Tracer Ln were higher in USGS samples than in CWD samples. As in previous years, the variation in sodium, chloride, and calcium concentrations between dry and wet sampling efforts was less pronounced in the Summer St catchment, which does not receive highway runoff.

Phosphorus tends to stay in the particulate phase and is thus introduced to the water supply most commonly in runoff. Sources of TP in the watershed include fertilizers, the natural weathering of rocks and soils, and septic tank leaks and failures (Smith, 2013). Sediment from vehicle tracking and erosion from construction or development activities are also potential sources of phosphorus. As of June 5, 2016, new regulations from the Massachusetts Department of Agricultural Resources prohibit the application of phosphorus containing fertilizers on lawns and turf fields unless soil tests indicate a phosphorus deficiency. More years of data are needed to determine whether the new regulations have had an impact on TP concentrations in the Cambridge watershed.

Total phosphorus concentrations were higher in stormflow samples than in base-flow at all four monitoring locations sampled in 2017 (Figure 48). Tracer Ln, which receives stormwater discharges from the highway, had the largest difference in TP concentration in stormflow compared to base-flow. One particular storm at Tracer Ln, sampled from May 5th to May 7th, 2017 had a TP concentration of 1.62 mg/L, nearly 16 times higher than the maximum level observed during base-flow (Figure 48). This points to a large influx of stormwater. Median and maximum stormflow TP concentrations at WA-17 were lower than both Lex Brook and Tracer Ln, and the maximum stormflow TP was lower than the maximum concentration at Summer St (Figure 48).

During 2016, Lex Brook showed the largest difference in TP concentrations between wet and dry weather when compared to Tracer Ln, WA-17 and Summer St (CWD, 2017). In 2017, the TP concentration at Lex Brook exhibited a more muted response to stormflow, which suggests potential improvement in maintenance of stormwater treatment devices along I-95. However, the increase in TP concentrations during storm events at all sites indicates that water quality could benefit from additional maintenance of existing stormwater treatment devices or the implementation of new stormwater treatment best management practices.

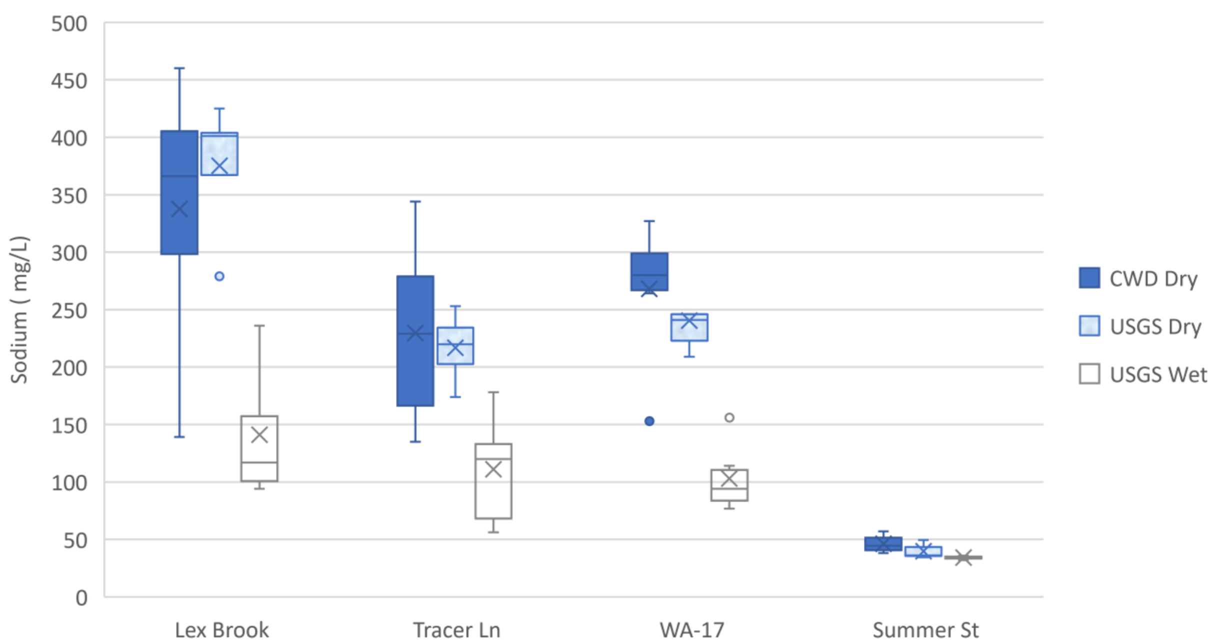

Figure 45: Comparison of CWD Base-flow (CWD Dry), USGS Base-flow (USGS Dry), and USGS Stormflow (USGS Wet) Sodium Concentrations at Lex Brook, Tracer Ln, and WA-17, 2017

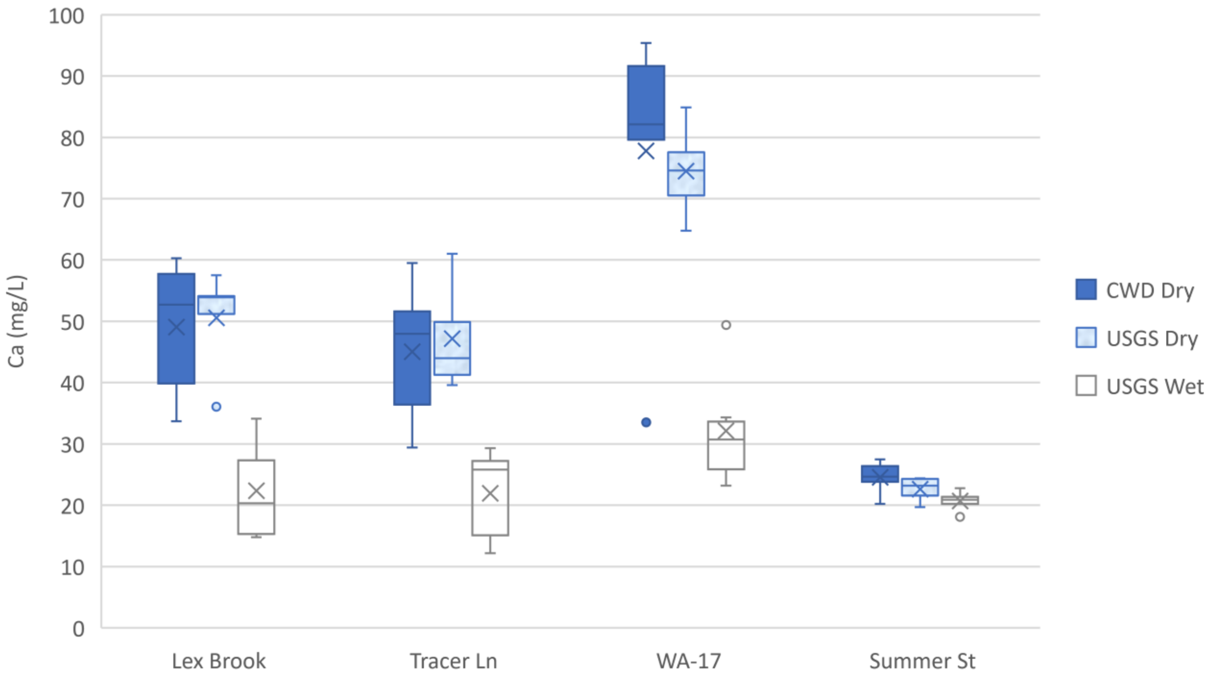

Figure 46: Comparison of CWD Base-flow (CWD Dry), USGS Base-flow (USGS Dry), and USGS Stormflow (USGS Wet) Calcium Concentrations at Lex Brook, Tracer Ln, and WA-17, 2017

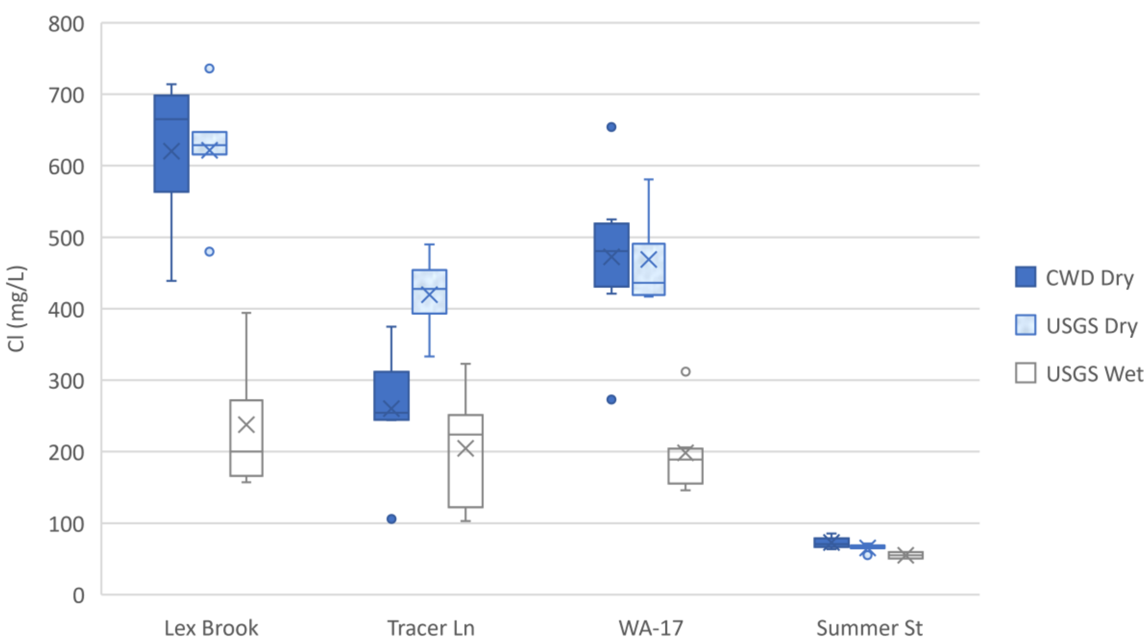

Figure 47: Comparison of CWD Base-flow (CWD Dry), USGS Base-flow (USGS Dry), and USGS Stormflow (USGS Wet) Chloride Concentrations at Lex Brook, Tracer Ln, and WA-17, 2017

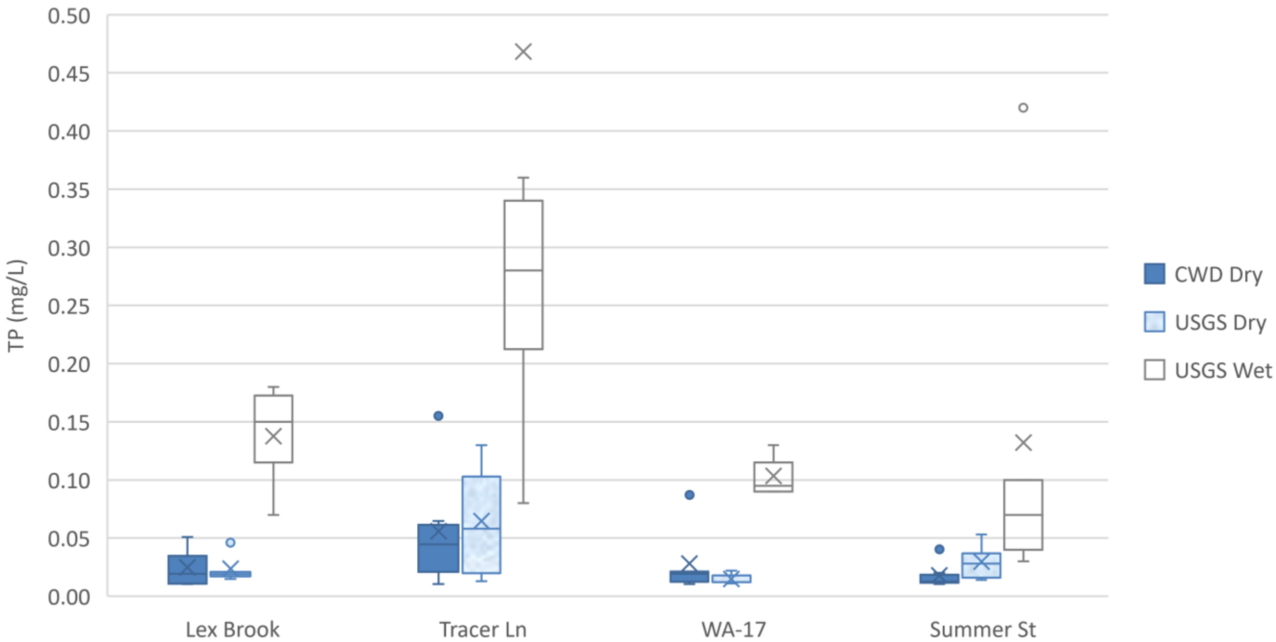

Figure 48: Comparison of CWD Base-flow (CWD Dry), USGS Base-flow (USGS Dry), and USGS Stormflow (USGS Wet) TP Concentrations at Lex Brook, Tracer Ln, and WA-17, 2017

A TP outlier of 1.62 mg/L is included in the "USGS wet" boxplot statistic calculations at Tracer Ln. However, the point is not displayed on the graph.

9 LOAD AND YIELDS

9.1 BASE-FLOW LOADS AND YIELDS

Loads and yields of sodium, chloride, nitrate and nitrite nitrogen, and TP were calculated for base-flow at each tributary monitoring station. Understanding the contribution of each tributary to reservoir pollutant loads can help prioritize and target management activities within the watershed.

9.1.1 Sodium and Chloride Base-flow Loads and Yields

The three sites with the highest sodium and chloride base-flow loads were RT 20 (sodium = 3,909 tons, chloride= 6,898 tons), HB @ KG (sodium = 1,824 tons, chloride = 3,043 tons), and HB Below Dam (sodium = 1,197 tons, chloride = 2,216 tons) (Figures 49 and 50). Although RT 20, HB @ KG, and HB Below Dam were among the largest drainage areas in the watershed (22 mi^2, 8.5 mi^2, and 6.9 mi^2, respectively), the drainage area size alone is insufficient to explain the high loads. SB @ Viles had a 10.2 mi^2 watershed but had sodium and chloride loads less than RT 20, HB @ KG, and HB Below Dam. Unlike RT 20, HB Below Dam, and HB @ KG, SB @ Viles was unimpacted by regulated flows at Hobbs Brook Reservoir and did not receive highway runoff (Figure 3 and Appendix A).

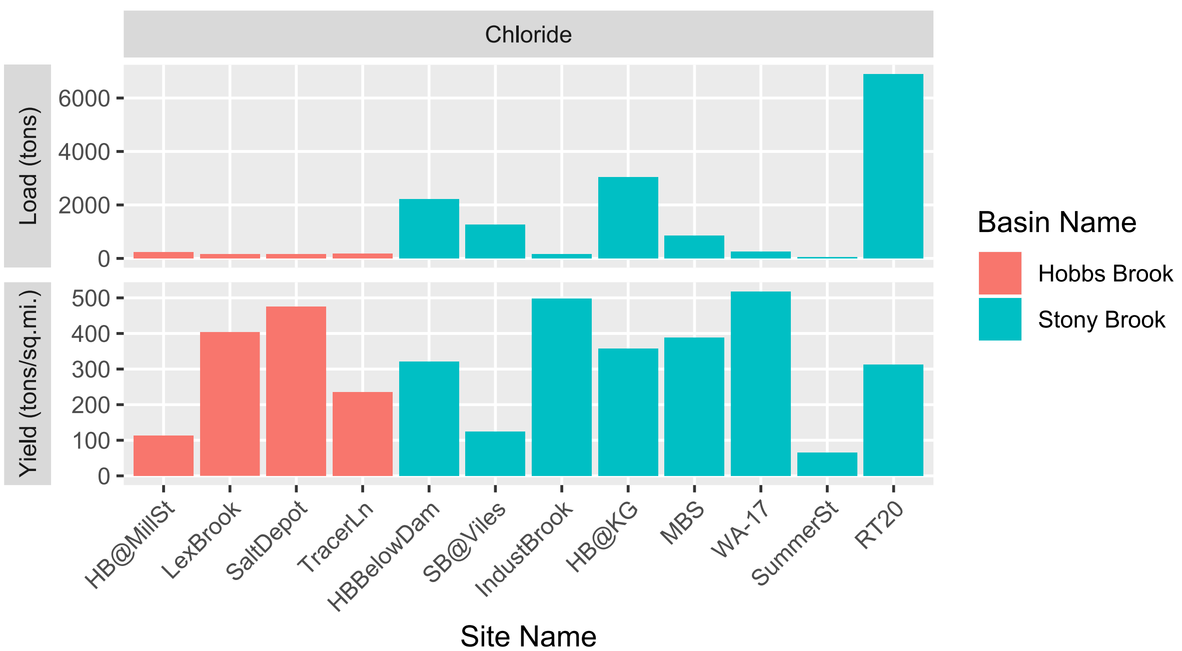

Figure 49: Tributary Base-flow Chloride Loads and Yields, 2017

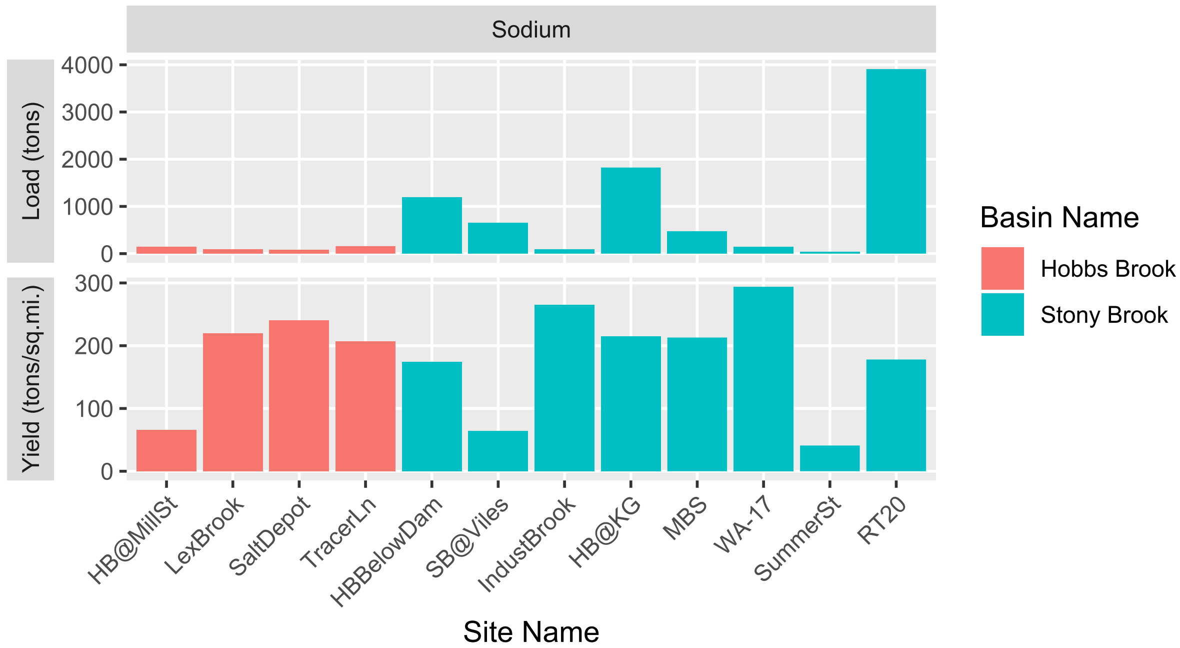

Figure 50: Tributary Base-flow Sodium Loads and Yields, 2017

When accounting for the effect of catchment size, tributaries that received highway runoff were among the most salt impacted and contributed loads disproportionate to their catchment size. For example, the tributaries with the four highest sodium and chloride base-flow yields were all heavily developed catchments or were impacted by highway salt storage: WA-17, Indust Brook, Salt Depot, and Lex Brook (Figures 49 and 50). Tributaries draining to the Hobbs Brook Reservoir produced sodium and chloride loads that were only a fraction of the RT 20 loads; however, the with the exception of the less developed HB @ Mill St catchment and Tracer Ln chloride, sodium and chloride yields from Lex Brook, Salt Depot, and Tracer Ln were greater than RT 20 (Figures 49 and 50).[22] HB @ KG and RT 20 were both downstream of Hobbs Brook Reservoir. As such, the loads of sodium and chloride at these sites were influenced by the salt loads in water released from the reservoir. The sodium and chloride loads at HB Below Dam in 2017 were 1,197 tons and 2,216 tons, respectively. This was equivalent to approximately one third of the sodium and chloride base-flow load at RT 20 and over two thirds of total base-flow sodium and chloride at HB @ KG.

9.1.2 Nutrient Base-flow Loads and Yields

Similar to the sodium and chloride loads, RT 20 had the highest base-flow nitrogen (nitrate and nitrite nitrogen) and TP loads of the 12 tributary sites (nitrogen = 42,465 lbs/mi^2, TP = 807 lbs/mi^2) (Figures 51 and 52). This result was expected due to the large drainage area. Unlike the sodium and chloride loads, the sites with the second and third highest nutrient loads were the two tributaries next largest in

[22] Sodium and chloride concentrations at MBS from the October 3, 2017 sampling event were anomalously high outliers. This drew the mean concentrations used to calculate the loads higher than expected (Figure 36 and Appendix D). Likewise, the chloride load at Tracer Ln may be low due to an outlier concentration of 106 mg/L measured on January 31, 2017 (Figure 36).

catchment size. SB @ Viles (10.2 mi^2) had a nitrogen load of 22,129 lbs/mi^2 and a TP load of 453 lbs/mi^2, followed by HB @ KG (8.5 mi^2) with a nitrogen load of 8,411 lbs/mi^2 and a TP of 345 lbs/mi^2.

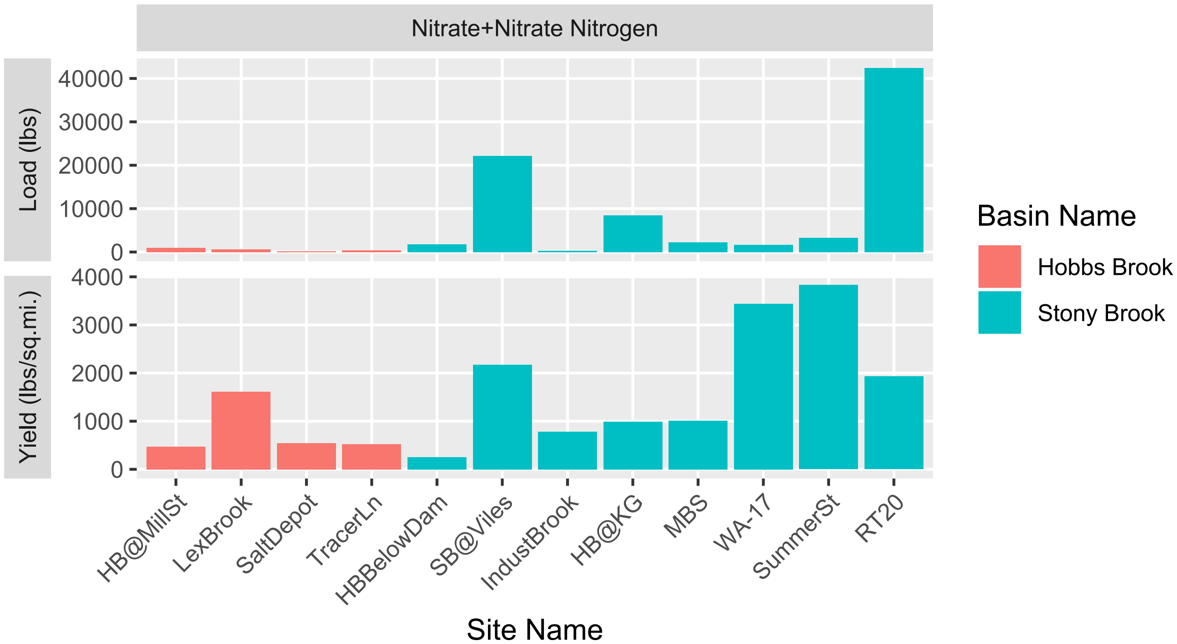

Figure 51: Tributary Base-flow Nitrate and Nitrite Nitrogen Loads and Yields, 2017

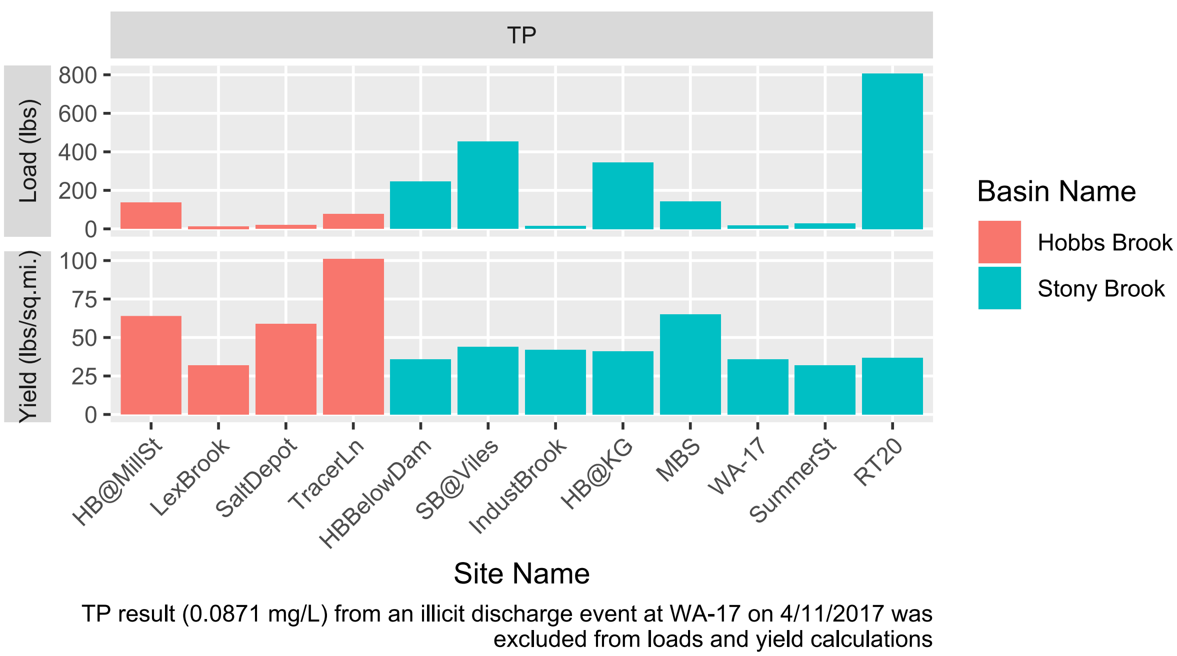

Figure 52: Tributary Base-flow TP Loads and Yields, 2017

From a yield prospective, Summer St was the greatest contributor of nitrogen in the watershed (3,829 lbs/mi^2), followed closely by WA-17 (3,440 lbs/mi^2) (Figure 51). RT 20 and SB @ Viles, which had the highest nitrogen loads of all twelve tributary sites, had the next highest yields at 1,930 lbs/mi^2 and 2,170 lbs/mi^2, respectively. As discussed in section 7.3.2, sources of nitrogen in the less developed Stony Brook Reservoir subbasin, especially Summer St, include fertilizer runoff from lawns and golf courses and septic system leachate. Potential sources of nitrogen from the WA-17 catchment include possible leaking sanitary sewer pipes and fertilizer runoff from land scaping at commercial and industrial facilities.

TP base-flow yields followed a different pattern than nitrogen, with yields highest at tributary sites downstream of wetland systems. Tracer Ln had the highest yield (101 lbs/ mi^2), followed by MBS and HB @ Mill St (65 and 64 lbs/mi^2, respectively), then Salt Depot (59 lbs/mi^2) (Figure 52). The Tracer Ln load and yield were influenced by a high outlier TP concentration of 0.16 mg/L from the June 27, 2017 sampling event (Figure 38 and Appendix D). Tracer Ln, MBS, HB @ Mill St, and Salt Depot are all downstream of wetland systems high in organic matter; silty-mucky sediment from the breakdown of organic matter is commonly observed near the sampling locations at all four sites.

9.2 STORMFLOW LOADS AND YIELDS

Using mean concentrations of sodium, chloride, and TP from stormwater samples collected by the USGS in 2017, comparisons of stormflow and base-flow loads and yields were performed for Lex Brook, Tracer Ln, WA-17, and Summer St. The USGS did not collect stormwater samples for nitrogen compounds in 2017. After adding the stormflow loads to the previously calculated base-flow loads, yields for all three parameters were still higher at Lex Brook, Tracer Ln, and WA-17 than at Summer St (Figure 53). Loads of sodium and chloride were lowest at Summer St. WA-17 had the lowest total TP load in 2017 (88 lbs), followed by Summer St (108 lbs), and Lex Brook (119 lbs). Tracer Ln had by far the highest total TP load (627 lbs). Lex Brook, Tracer Ln, and WA-17 were all adjacent to highways and had more intensely developed watershed catchments than the Summer St catchment (Figure 3 and Appendix A).

Base-flow was predominately responsible for salt loads in the three more developed catchments (Figure 53 and Table 9). At Lex Brook, Tracer Ln, and WA-17, base-flow accounted for 62-80 percent of the total sodium load and 60-79 percent of the total chloride load. By contrast, storm-flow accounted for the majority of the sodium and chloride loads at Summer St (54 percent and 56 percent). The high contributions of salt from base-flow at Lex Brook, Tracer Ln, and WA-17 may indicate salt contamination in the groundwater from prolonged use of sodium chloride as a deicing chemical along the state and interstate highways. This is supported by the fact that Summer St, which does not have a highway in its catchment area, had the lowest proportion of sodium and chloride contributed by base-flow (46 percent and 44 percent).

Stormflow was the greater contributor of TP loads at all four sites, contributing nearly 90 percent of the total TP load at Lex Brook and Tracer Ln (Figure 53 and Table 9). TP is often associated with sediment, which can be more easily transported during stormflow (Smith, 2013). Stormflow contributed 80 percent of the total TP load, less than Lex Brook and Tracer Ln although still more than at Summer St (75 percent). The high contribution of the TP load from stormflow at all sites demonstrates the importance of stormwater best management practices in addressing TP pollution.

Table 9: Percent Contribution of Base-flow and Stormflow to Total Sodium, Chloride, and TP Load at Lex Brook, Tracer Ln, WA-17 and Summer St, 2017

Site Name	Sodium load (%)		Chloride load (%)		TP load (%)	
	Base-flow	Stormflow	Base-flow	Stormflow	Base-flow	Stormflow
Lex Brook	62%	38%	64%	36%	11%	89%
Tracer Ln	71%	29%	60%	40%	12%	88%
WA-17	80%	20%	79%	21%	20%	80%
Summer St	46%	54%	44%	56%	25%	75%

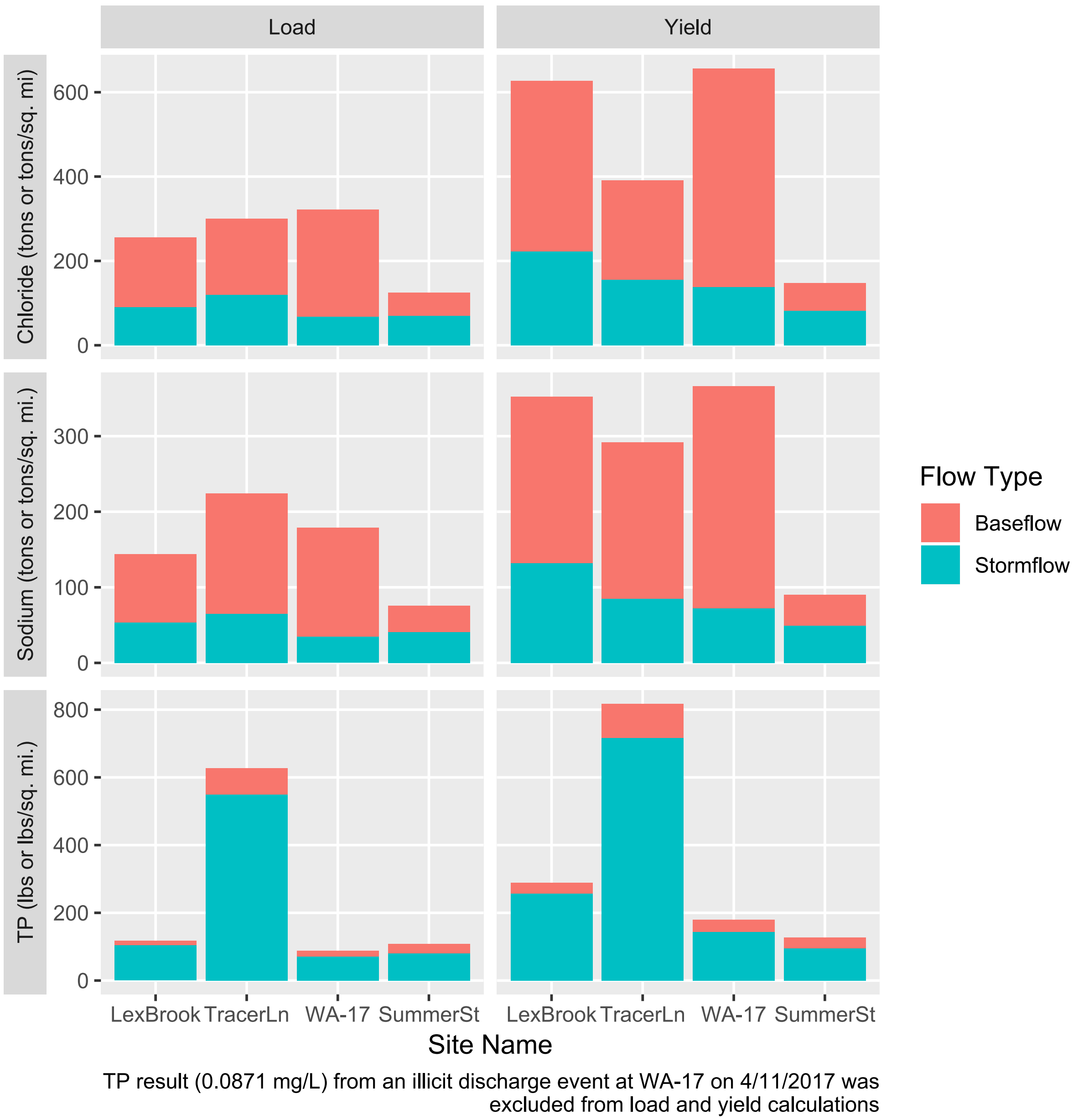

Figure 53: Base-flow and Stormflow Loads and Yields, Lex Brook, Tracer Ln, WA-17, and Summer St, 2017

10 RESERVOIR RETENTION TIME

10.1 RETENTION TIME OVERVIEW

Reservoir retention time is the amount of time necessary for a reservoir to refill if it were completely empty, or the amount of time that it would take to drain if inputs ceased. The retention time is also defined as the average amount of time a water molecule remains in a waterbody, or the flushing rate. Reservoir retention time assumes equal inflows and outflows to the reservoir and is calculated by dividing the total storage capacity by the total inflows to, or outflows from, the waterbody. Reservoirs with longer retention times (low flushing rate) may respond slower to degradation or improvement of inflow water quality; water in a reservoir with a shorter retention time (high flushing rate) will turn over more quickly. Therefore, changes in source water quality are likely to impact reservoir water quality faster when the retention time is shorter.

The retention times of the Hobbs Brook and Stony Brook Reservoirs were calculated using outflow data from USGS monitoring stations. CWD raw water intake data from Fresh Pond to the Walter J. Sullivan Treatment Plant was used to quantify outflows from Fresh Pond. Cambridge reservoirs are managed water bodies, so variations in the timing of water releases can result in an imbalance between reservoir inflows and outflows within a year. Despite annual variation in reservoir storage, the Cambridge reservoirs are in long-term equilibrium.

10.2 RESERVOIR RETENTION TIMES

The Hobbs Brook Reservoir had the longest retention time of the three reservoirs (Tables 10, 11, and 13). The hydraulic retention time in 2017 was 21 months and was 14 months for the ten-year average. The 2017 annual outflow from Hobbs Brook Reservoir, as measured at the HB Below Dam monitoring station (USGS station 01104430), was 1.69 billion gallons (Table 10).

Table 10: Hobbs Brook Reservoir Retention Time 2008-2017

Year	Hobbs Outflow (MG)	Storage Capacity (MG)	Estimated Retention Time (months)
2008	2,464	2,898	14
2009	3,613	2,898	10
2010	4,889	2,518	6
2011	2,653	2,518	11
2012	1,806	2,518	17
2013	1,431	2,518	21
2014	2,565	2,518	12
2015	2,858	2,898	12
2016	1,671	2,898	21
2017	1,685	2,898	21

The retention time at the Hobbs Brook Reservoir was calculated using the total storage capacity of 2.5 billion gallons for 2010-2014 and 2.9 billion gallons for 2008-2009. The difference in storage capacity is due to the removal of spillway flash boards at the Hobbs Brook Dam in 2010. The flash boards were replaced in 2015[23] increasing the storage capacity back to 2.9 billion gallons.

Stony Brook Reservoir retention time was 18 days (about 0.6 months) in 2017, the shortest retention time of all three reservoirs in the Cambridge water supply system (Table 11). Inputs to the Stony Brook Reservoir are contributed primarily by its watershed during winter and spring and from the Hobbs Brook Reservoir during the summer and fall. From the Stony Brook Reservoir, water is diverted to Fresh Pond via an aqueduct, and excess water is released into the Charles River. Outflow to the Charles River was estimated from the USGS gaging station located downstream of the Stony Brook gatehouse.

Table 11: Stony Brook Reservoir Retention Time, 2011-2017

Year	Stony to Charles (MG)	Stony to Fresh Pond (MG)	Total Output from Stony (MG)	Storage Capacity (MG)	Estimated Retention Time (days)
2010	10,514	Data not available	Data not available	418	--
2011	7,663	4,899	12,562	418	11
2012	2,177	5,256	7,433	418	22
2013	4,220	4,098	8,318	418	18
2014	5,473	4,317	9,790	418	15
2015	2,375	5,691	8,066	418	18
2016*	1,863	4,230	6,093	418	26
2017	3111	4976	8087	418	18
*2016 Conduit flow data gaps 8/17, 8/23, 9/20-10/16 were estimated based on average conduit flows during similar time periods.					

Rain totals were higher in 2017 than 2016, resulting in an increase in the amount of flow released to the Charles River (Table 12 and Figure 54). Data from the Hobbs Brook Reservoir (USGS station 01104430) indicate that the Hobbs Brook and Stony Brook watersheds received an estimated 42.87 inches of rain in 2017 (Table 12). While this rain total was 6.2 inches higher than in 2016 and resulted in the end of the drought in April of 2017, it was still 2.84 inches less than the 45.71 inch National Oceanic and Atmospheric Administration (NOAA) 1981-2010 normal recorded at the Bedford Hanscom Field, MA weather station.[24]

[23] The flashboards were replaced between 2014 and 2015, although the exact timing of the replacement is unknown. These calculations assume the replacement did not occur until 2015.

[24] Climate normal data were accessed from the NOAA National Centers for Environmental Information website at https://www.ncdc.noaa.gov/cdo-web/datatools/normals.

Table 12: Hobbs Brook Below Dam Precipitation Gage (01104430) Total Annual Precipitation (Inches)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016*	2017**
Total Precipitation	62.73	47.69	54.67	57.04	43.8	40.17	48.31	33.33	36.67	42.87

*Data were from USGS meteorological station 422518071162501 due to missing precipitation data from USGS station 01104430 from 2/18-3/3 in 2015 and 2/4-2/8, 2/10, 2/14-2/16, and 4/4-4/5. **2017 provisional data subject to revision.

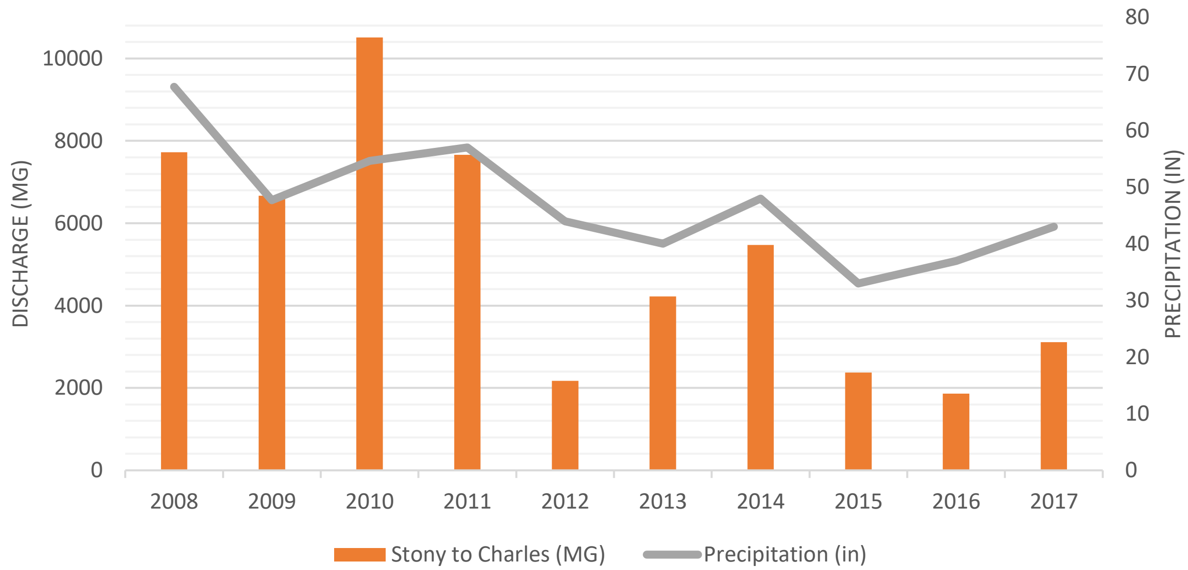

Figure 54: Total Discharge from Stony Brook Reservoir to the Charles River and Total Precipitation, 2008-2017

Total output from Fresh Pond to the treatment plant (estimated from the total water produced by the plant) was 4.7 billion gallons in 2017 and Fresh Pond had a retention time of 3.8 months (Table 13). The ten-year average retention time is approximately four months. Cambridge did not use MWRA water to supplement the water supplied by Fresh Pond in 2017.

Table 13: Fresh Pond Reservoir Retention Time, 2008-2017

Year	Fresh Pond to WTP (MG)	Storage Capacity (MG)	Estimated Retention Time (months)
2008	4,878	1,507	3.7
2009	4,748	1,507	3.8
2010	4,850	1,507	3.7
2011	4,709	1,507	3.8
2012	4,749	1,507	3.8
2013	3,552	1,507	5.0
2014	3,764	1,507	4.8
2015	5,068	1,507	3.6
2016	3,855	1,507	4.7
2017	4,704	1,507	3.8

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12 GLOSSARY

Algal bloom— The rapid proliferation of passively floating, simple plant life in and on a body of water.

Anoxic— The absence of oxygen; anaerobic. DO below 0.5 mg/L.

Benthic sediments— The surface layer and some sub-surface layers of sediment in contact with the bottom zone of a water body, such as a lake or ocean.

Discharge (hydraulics)— Rate of flow, especially fluid flow; a volume of liquid passing a point per unit of time, commonly expressed in cubic feet per second, million gallons per day, or liters per second.

Dissolved oxygen (DO) — Oxygen dissolved in water; one of the most important indicators of the condition of a water body. Dissolved oxygen is necessary for the life of fish and most other aquatic organisms.

Drainage basin— Land area drained by a river or stream; watershed.

Epilimnion— Warm, oxygen-rich, upper layer of water in a lake or other body of water, usually seasonal. *See also* Metalimnion, Hypolimnion

Eutrophic— Term applied to a body of water with a high degree of nutrient enrichment and high productivity.

Eutrophication— Process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

Escherichia coli **(*E. coli*) bacteria**— Type of bacteria that is found in the human gastrointestinal tract. *E. coli* is commonly used as an indicator of fecal contamination in groundwater, as the result of an improper sewage connection or septic system failure.

Groundwater— In the broadest sense, all subsurface water, as distinct from surface water; as more commonly used, that part of the subsurface water in the saturated zone. *See also* Surface water.

Hypolimnion— Cold, oxygen-poor, deep layer of water in a lake or other water body. *See also* Epilimnion, Metalimnion.

Hypoxic — The deprivation of oxygen compared to how much is required by the system. DO below approximately 2 mg/L.

Load— Material that is moved or carried by streams, reported as the weight of the material transported during a specific time period, such as kilograms per day or tons per year.

Maximum contaminant level (MCL)— Maximum permissible level of a contaminant in water that is delivered to any user of a public water system, established by a regulatory agency such as the U.S. Environmental Protection Agency. *See also* Secondary maximum contaminant level.

Mean— The arithmetic average obtained by dividing the sum of a set of quantities by the number of quantities in the set.

Median— The middle or central value in a distribution of data ranked in order of magnitude. The median also is known as the 50th percentile.

Mesotrophic— Term applied to a body of water with intermediate nutrient content and intermediate productivity.

Metalimnion— Transition zone between the warm upper layer and the cold deep layer of a lake or other water body, characterized by rapidly decreasing temperature with increasing depth. *See also* Epilimnion, Hypolimnion.

Minimum reporting limit (MRL) — The lowest measured concentration of a constituent that can be reported reliably using a given analytical method.

Monitoring station— A site on a stream, canal, lake, or reservoir used to observe systematically the chemical quality and discharge or stage of water.

Nutrient— An element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Oligotrophic— Term applied to a body of water low in nutrients and in productivity.

pH— The logarithm of the reciprocal of the hydrogen ion concentration of a solution; a measure of the acidity (pH less than 7) or alkalinity (pH greater than 7) of a solution; a pH of 7 is neutral.

Phytoplankton algae— Free-floating, mostly microscopic aquatic plants.

Chlorophyll-*a* — Primary light-trapping pigment in most phytoplankton algae. Concentration can be used as an indirect indicator of the abundance of phytoplankton algae in a lake or other water body.

Runoff— The part of precipitation that appears in surface streams. It is equivalent to streamflow unaffected by artificial diversions, storage, or other human works in or on the stream channel.

Secondary maximum contaminant level (SMCL) — Maximum recommended level of a contaminant in water that is delivered to any user of a public water system. These contaminants affect the esthetic quality of the water such as odor or appearance; therefore, the levels are intended as guidelines. *See also* Maximum contaminant level.

Specific conductance — A measure of the ability of a sample of water to conduct electricity normalized to 25°C.

Subbasin — Drainage basin or watershed defined by a specific monitoring station and representing the land area that contributes water to that station.

Surface water — An open body of water, such as a stream or lake.

Thermal stratification — Seasonal division of a lake or other water body into a warm upper layer and a cold deep layer that is no longer in contact with the atmosphere. In some lakes, thermal stratification can result in a loss of oxygen in the deep layer and subsequent chemical stratification.

Trihalomethane formation potential (THMFP) — Tendency of naturally occurring organic compounds in a water supply to form toxic trihalomethanes during water treatment.

Trophic state — The extent to which a body of water is enriched with plant nutrients. *See also* Eutrophic, Mesotrophic, Oligotrophic.

Trophic state index (TSI) — A numerical index indicating the degree of nutrient enrichment of a body of water.

Turbidity — The opaqueness or reduced clarity of a fluid due to the presence of suspended matter.

Water year — The continuous 12-month period, October 1 through September 30, in U.S. Geological Survey reports dealing with the surface-water supply. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1998, is referred to as the "1998" water year. This report, however, operates on a calendar year.

Wetlands — Lands that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Yield — The weight of material transported during any given time divided by unit drainage area, such as kilograms per day per square kilometer or tons per year per square mile.

13 APPENDIX A: TRIBUTARY CATCHMENT AREA AND LAND COVER

Table 14. USGS Stations and Corresponding CWD Site Names

	HB @ MILL ST	SALT DEPOT	LEX BROOK	TRACER LN	HB BELOW DAM	INDUST BROOK*	SB @ VILES	HB @ KG	MBS	WA-17	RT 20	SUMMER ST	STONY BROOK DAM
USGS Site ID	01104405	01104410	01104415	01104420	01104430	01104433	01104370	01104440	01104453	01104455	01104460	01104475	01104480
Drainage Area (mi²)	2.2	0.34	0.41	0.77	6.9	0.36, (0.33)	10.2	8.5	2.2	0.48	22.0	0.85	23.7

0.33 mi2 is the effective drainage area of the Industrial Brook catchment (Smith, 2013)

Table 15. 2005 MassGIS Land Use Classification, Percent by Area per USGS Subbasin

	Sampling Station ID													
2005 MA Land Use	**01104405**	**01104410**	**01104415**	**01104420**	**01104430**	**01104433**	**01104370**	**01104440**	**01104453**	**01104455**	**01104460**	**01104475**	**01104480**	**Watershed Total**
Forest	56.58	50.35	27.05	27.2	32.68	12.13	47.1	49.2	42.3	39.77	23.17	45.07	38.66	43.26
Low Density Residential	7.23	0.14	6.94	7.33	2.59	0.06	18.08	18.75	21.31	0.04	9.41	20.6	19.21	13.86
Forested Wetland	20.79	10.5	0.28	11.16	2.62	8.09	11.49	5.11	9.42	0.92	2.47	3.01	1.13	9.33
Water	0.29			0.13	29.33	0.26	3.78	1.47	0.43	0.17	8.48	1.27	16.31	6.49
Commercial		8.29	3.4	9.26	8.19	35.77	0.82	5.01	1.21	7.92	15.98		1.58	3.32
Cropland	3.17		0.97	0.27	0.05		4.89	1.25	1.21			1.87		2.74
Non-Forested Wetland	1.95	7.26	1.27	1.71	0.84	0.63	3.71	3.41	3.46		4.61	0.63	0.4	2.73
Medium Density Residential			24.46	10.48	9.52		0.33		2.84	6.62	0.15	0.29	0.32	2.69
Very Low Density Residential	3.13	0.01		0.14	0.73		3.89	1.22	3.69	0.25		3.38	0.45	2.66
Transportation		0.1	16.12	6.61	5.89	10.82	0.54	0.04		10.6	4.12		6.27	2.24
Industrial		5.41		5.98	4.92	32.03	0.11	5.7		17.19	3.17	0.04		2.16
Urban Public/Institutional	1.55	4.56	2.24	1.7	0.67	0.21	1.03	1.73	4.58	0.06	1.54	1.38	7.09	1.69
High Density Residential			15.48	16.27	0.07					6.78			7.26	1.24
Pasture	1.58	1.36			0.17		1.27	1.16	1.64			4.23		1.11
Multi-Family Residential			0.09	0.22	0.02		1.22	3.21	0.45	0.48	7.82			0.88
Open Land	1.09	3.68	0.47	1.55	0.37		0.8	0.92	0.87		4.1	0.37	0.56	0.84
Golf Course									1.16			16.75		0.71
Participation Recreation	1.17	0.82	1.22		0		0.49	1.82	2.25			0.61	0.14	0.69
Powerline/Utility	0.08	7.51			1.34		0.13		0.68	7.45	1.86			0.6
Cemetery	0.72								2.17					0.27
Mining									0.36	0.15	12.33		0.32	0.23
Brushland/Successional	0.3						0.02					0.48		0.06
Orchard	0.15						0.07							0.05
Spectator Recreation	0.05						0.08						0.3	0.05
Junkyard										1.61	0.6			0.04
Waste Disposal	0.18						0.06							0.04
Transitional							0.03		0		0.19			0.02
Water-Based Recreation							0.05							0.02

14 APPENDIX B: BASE-FLOW AND STORMFLOW SEPARATION AND DISCHARGE ESTIMATION METHODS

14.1 Base-flow and Stormflow Separation

Separation of base-flow from total discharge at Lex Brook, Salt Depot, Tracer Lane, HB Below Dam, SB @ Viles, HB @ KG, WA-17, Summer St, and RT 20 was performed according to the Fixed Interval Method. With the Fixed Interval Method, the lowest recorded discharge value over a fixed time interval (3 to 11 days) is used to represent base-flow over the entire interval (Sloto and Crouse, 1996). The fixed time interval (2N*) is a function of the drainage area of a catchment, and is calculated by first estimating the recession period for surface runoff following a storm event:

$N=A^{0.2}$

Where:

N=recession period, A=area of catchment (sq. mi)

2N* = the odd integer between 3 and 11 closest to twice the recession period (N*2)

In this study, all catchments had intervals of 3 days. Therefore, base-flow was calculated as the lowest discharge value in each three-day period of 2017. For example, base-flow for each day between January 1 and January 3 was assigned based on the minimum value recorded during the interval. The same process was repeated for the next three days, January 4 – January 6. Stormflow was calculated as the difference between total discharge and base-flow.[25] A difference of zero between total discharge and base-flow represents dry conditions with no stormflow.

[25] Discharge at RT 20 and HB @ KG is heavily influenced by upstream releases of water from the Hobbs Brook Reservoir. Therefore, increases in discharge can be attributable to both storm events and managed releases of water from the reservoir. To avoid erroneously counting dam releases as stormflow, the daily average discharge measured from the HB Below Dam gage was subtracted from the daily average discharge at RT 20 and HB @ KG. Base-flow was then calculated as the three-day minimum of these differences. For the purposes of calculating loads and yields, water released from Hobbs Brook Reservoir was treated as base-flow. Therefore, after calculating daily base-flow, daily mean discharge from the HB Below Dam was added to the daily base-flow total for each site. Daily stormflow at each site was calculated by subtracting the sum of daily base-flow and daily HB Below Dam flow from total mean daily flow.

During the summer and early fall in 2017, mean daily flow from HB Below Dam was sometimes greater than recorded flow downstream at HB @ KG, resulting in “negative” base-flow during certain three-day intervals. In most situations, adding the HB Below dam flow to the “negative” base-flow was sufficient to create positive base-flow. Where this was not the case, it was assumed that total daily flow recorded at HB @ KG was attributable to natural base-flow plus water released from HB Below Dam and was used as a proxy for calculated base-flow. Potential reasons why discharge from HB Below Dam was greater than HB @ KG included: water released from Hobbs Brook Reservoir that had not yet reached the monitoring station at HB @ KG, measurement error between USGS and CWD discharge calculations at HB Below Dam and HB @ KG, and the possibility that the stretch of Hobbs Brook between HB Below Dam and HB @ KG acted as a “losing” stream, whereby water infiltrated out of the stream channel into the groundwater of the surrounding watershed during summer flow conditions.

Annual total discharge, base-flow, and stormflow were calculated by integrating the discharge data for each category[26]:

$$Q_{annual} = ((Q_2+Q_1)/2)*(t_2-t_1) + ((Q_3+Q_2)/2)*(t_3-t_2)...+ ((Q_n+Q_{n-1})/2)*(t_n-t_{n-1})$$

Where:

Q_{annual} = annual total discharge, base-flow, or stormflow in cubic feet per year

Q_n = instantaneous total discharge, base-flow, or stormflow in cubic feet per second

t_n = time and date of discharge measurement, in seconds elapsed since 1/1/1900 or 1/1/1970[27]

Base-flow separation was performed for all sites where USGS or CWD instantaneous discharge data were available: Lex Brook, Salt Depot, Tracer Ln, SB @ Viles, HB @ KG, WA-17, RT 20, and Summer St. [28]

14.2 Estimation of Missing Discharge Data at HB @ KG

Continuous stage data at HB @ KG was missing from August 31, 2017 at 12:00 PM through October 20, 2017 at 11:30 AM due to site vandalism. Daily average discharge from September 1, 2017 through October 19, 2017 was estimated using drainage area weighting method with SB @ Viles St as a reference site. The drainage area weighting method uses discharge from a reference site to estimate discharge at a site with missing data as follows (Ohio Environmental Protection Agency, 2009):

$$Q_{missing} = (A_{reference} / A_{missing}) * Q_{reference}$$

Where:

$Q_{missing}$ = average daily discharge estimated for the site will missing data (in this case, HB @ KG) in cfs

$A_{missing}$= area of watershed for the site with missing data (in this case, HB @ KG)

$A_{reference}$= area of the watershed for the reference site (in this case, SB @ Viles)

The drainage area weighting method is ideal for sites with similar drainage area of size, land use, and soil type (Ohio Environmental Protection Agency, 2009). SB @ Viles had a similar size watershed as HB @ KG

[26] Daily mean discharge data in cfs were used to calculate stormflow and base-flow at RT 20 and HB @ KG as described in the previous footnote. Rather than integrate the daily data, mean daily discharge in cfs was converted into cubic feet per day by multiplying by 86,400 (the number of seconds in a day) and summed to calculate the total cubic feet of water per year.

[27] Dates stored in Excel, when converted to numeric format, represent the number of days that have elapsed since January 1, 1900. For example, 1/1/1900 at 00:00 = 0 days, 1/1/2014 at 12:00 = 41,640.5 days. This number can be converted into the number of seconds elapsed since 1/1/1900 by multiplying by 86,400, the number of seconds in a day. In R, dates and times in POSIXct format record the data as the number of seconds elapsed since January 1, 1970. Both R and Excel were used to perform load and yield calculations. Having time/date data in numeric format allowed for the calculation of the number of seconds elapsed between each discharge measurement (t_n-t_{n-1}).

[28] See sections 5.5.2 and 5.8 for more information on USGS and CWD discharge monitoring.

(10.2 mi^2 versus 8.5 mi^2) and similar land use characteristics (Appendix A). However, because HB @ KG is downstream of the Hobbs Brook Reservoir outlet (HB Below Dam), the drainage area of the Hobbs Brook Reservoir (6.9 mi^2) was subtracted from the drainage area of HB @ KG to derive only the portion of the watershed downstream of the Hobbs Brook dam (1.6 mi^2). The drainage area weighting method was used to estimate average daily flow from this 1.6 mi^2 portion of the HB @ KG watershed. The average daily flow from HB Below Dam was then added to the daily flows estimated for the 1.6 mi^2 to derive the total estimated daily flow for HB @ KG during the period of missing data. These estimated daily discharge values were used to calculate total flow, base-flow, and stormflow as described in section 14.1 during the September 1st through October 19th timeframe.

To ensure the accuracy of the estimated data, the drainage area weighting method with added HB Below Dam flow was also used to estimate the total cubic feet of flow at HB @ KG from January 1, 2017 through August 31, 2017 and November 20, 2017 through December 31st. The total cubic feet of flow calculated using the estimated data differed by less than 2 percent compared to the total cubic feet of flow calculated using observed data. This indicates that the estimated data can reliably be used to approximate flow during periods of missing data at HB @ KG.

16 Appendix C: Quality Control Measures – Field Duplicate and Field Blank Results

Field Duplicate (FDUP) Relative Percent Difference (RPD) Result

Site Name	Date	Sample Result	FDUP Result	RPD (%)		Sample Result	FDUP Result	RPD (%)
BlacksNook								
	5/31/2017							
NH3 (mg/L)		0.115	0.126	9%	E. coli (MPN/100 ml)	7	15	73%
TKN (mg/L)		0.718	0.683	5%	Fe (mg/L)	0.770	0.840	9%
TP (mg/L)		0.043	0.041	3%	Mn (mg/L)	0.056	0.060	7%
NO3 (mg/L)		0.015	0.020	29%	Lab pH	7.36	7.38	0%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	12	11	9%
Chl-a (mg/m3)		3.4	3.8	13%	SO4 (mg/L)	0.9	0.9	0%
Al (mg/L)		0.002	0.010	140%	Total Alkalinity (mg CaCO3/L)	57	49	15%
Ca (mg/L)		20	19	7%	Total Coliform (MPN/100ml)	326	276	17%
Cl (mg/L)		25	25	0%	TOC (mg/L)	5.9	6.1	3%
Color (CU)		26	28	7%	Turbidity (NTU)	2.2	2.1	2%
Conductivity (uS/cm)		166	172	4%	UV254 (abs)	0.146	0.180	21%
FP@DH								
	9/19/2017							
NH3 (mg/L)		0.132	0.090	37%	E. coli (MPN/100 ml)			
TKN (mg/L)		0.424	0.403	5%	Fe (mg/L)	0.150	0.120	22%
TP (mg/L)		0.011	0.011	0%	Mn (mg/L)	0.054	0.048	12%
NO3 (mg/L)		0.359	0.343	5%	Lab pH	7.43	7.47	1%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	121	122	1%
Chl-a (mg/m3)		2.0	2.0	0%	SO4 (mg/L)	14.9	14.7	1%
Al (mg/L)		0.008	0.007	17%	Total Alkalinity (mg CaCO3/L)	33	34	5%
Ca (mg/L)		30	30	0%	Total Coliform (MPN/100ml)			
Cl (mg/L)		222	221	0%	TOC (mg/L)	3.4	3.4	0%
Color (CU)		11	11	0%	Turbidity (NTU)	0.4	0.4	0%
Conductivity (uS/cm)		781	783	0%	UV254 (abs)	0.117	0.117	0%

Field Duplicate (FDUP) Relative Percent Difference (RPD) Result

Site Name	Date	Sample Result	FDUP Result	RPD (%)		Sample Result	FDUP Result	RPD (%)
FP@Intake								
	9/19/2017							
NH3 (mg/L)					E. coli (MPN/100 ml)	2	3	40%
TKN (mg/L)					Fe (mg/L)			
TP (mg/L)					Mn (mg/L)			
NO3 (mg/L)					Lab pH			
NO2 (mg/L)					Na (mg/L)			
Chl-a (mg/m3)					SO4 (mg/L)			
Al (mg/L)					Total Alkalinity (mg CaCO3/L)			
Ca (mg/L)					Total Coliform (MPN/100ml)	10	124	170%
Cl (mg/L)					TOC (mg/L)			
Color (CU)					Turbidity (NTU)			
Conductivity (uS/cm)					UV254 (abs)			
HB@KG								
	3/21/2017							
NH3 (mg/L)		0.075	0.111	39%	E. coli (MPN/100 ml)	225	201	11%
TKN (mg/L)		0.321	0.366	13%	Fe (mg/L)	0.630	0.860	31%
TP (mg/L)		0.012	0.020	53%	Mn (mg/L)	0.371	0.456	21%
NO3 (mg/L)		0.780	0.760	3%	Lab pH	7.14	7.18	1%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	281	258	8%
Chl-a (mg/m3)					SO4 (mg/L)	20.0		
Al (mg/L)		0.018	0.077	123%	Total Alkalinity (mg CaCO3/L)	14	35.5	87%
Ca (mg/L)		56	50	10%	Total Coliform (MPN/100ml)	488	410.6	17%
Cl (mg/L)		495	482	3%	TOC (mg/L)	1.3	1.4	7%
Color (CU)		15	15	0%	Turbidity (NTU)	1.5	1.6	3%
Conductivity (uS/cm)		1610	1630	1%	UV254 (abs)	0.101	0.086	16%

Field Duplicate (FDUP) Relative Percent Difference (RPD) Result

Site Name	Date	Sample Result	FDUP Result	RPD (%)		Sample Result	FDUP Result	RPD (%)
MBS								
	8/15/2017							
NH3 (mg/L)		0.153			E. coli (MPN/100 ml)	579	461	23%
TKN (mg/L)		0.756			Fe (mg/L)	0.820		
TP (mg/L)		0.036			Mn (mg/L)	0.087		
NO3 (mg/L)		0.005			Lab pH	6.35		
NO2 (mg/L)		0.005			Na (mg/L)	140		
Chl-a (mg/m3)					SO4 (mg/L)	8.0		
Al (mg/L)		0.154			Total Alkalinity (mg CaCO3/L)	41		
Ca (mg/L)		31			Total Coliform (MPN/100ml)	2420	2419.6	0%
Cl (mg/L)		222			TOC (mg/L)	7.8		
Color (CU)		74			Turbidity (NTU)	2.3		
Conductivity (uS/cm)		777			UV254 (abs)	0.417		
NorthPond								
	8/2/2017							
NH3 (mg/L)		0.173	0.195	12%	E. coli (MPN/100 ml)	10		
TKN (mg/L)		0.999	1.090	9%	Fe (mg/L)	1.270	0.861	38%
TP (mg/L)		0.048	0.045	7%	Mn (mg/L)	0.139	0.062	77%
NO3 (mg/L)		0.005	0.005	0%	Lab pH	7.73	7.66	1%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	15	14	4%
Chl-a (mg/m3)		9.9			SO4 (mg/L)	0.5	0.405	21%
Al (mg/L)		0.000	0.000	0%	Total Alkalinity (mg CaCO3/L)	29	105	115%
Ca (mg/L)		40	37	7%	Total Coliform (MPN/100ml)	2420		
Cl (mg/L)		28	27	3%	TOC (mg/L)	13.8	13.9	1%
Color (CU)		56	54	4%	Turbidity (NTU)	4.3	4.2	2%
Conductivity (uS/cm)		287	288	0%	UV254 (abs)	0.439	0.433	1%

Field Duplicate (FDUP) Relative Percent Difference (RPD) Result

Site Name	Date	Sample Result	FDUP Result	RPD (%)		Sample Result	FDUP Result	RPD (%)
NorthPond								
	11/29/2017							
NH3 (mg/L)		0.201	0.172	16%	E. coli (MPN/100 ml)	10	10	0%
TKN (mg/L)		1.100	1.070	3%	Fe (mg/L)	2.180	2.390	9%
TP (mg/L)		0.067	0.073	9%	Mn (mg/L)	0.314	0.348	10%
NO3 (mg/L)		0.005	0.005	0%	Lab pH	7.26	7.2	1%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	15	15	0%
Chl-a (mg/m3)		36.7	35.9	2%	SO4 (mg/L)	3.2	3.3	3%
Al (mg/L)		0.105	0.164	44%	Total Alkalinity (mg CaCO3/L)	94	98	4%
Ca (mg/L)		37	36	2%	Total Coliform (MPN/100ml)	1410	980	36%
Cl (mg/L)		29	29	1%	TOC (mg/L)	14.7	14.9	1%
Color (CU)		72	76	5%	Turbidity (NTU)	4.0	4.5	10%
Conductivity (uS/cm)		267	274	3%	UV254 (abs)	0.491	0.495	1%
SaltDepot								
	11/2/2017							
NH3 (mg/L)		0.170	0.186	9%	E. coli (MPN/100 ml)	613	488	23%
TKN (mg/L)		0.443	0.538	19%	Fe (mg/L)	0.960	0.970	1%
TP (mg/L)		0.024	0.024	0%	Mn (mg/L)	0.580	0.598	3%
NO3 (mg/L)		0.136	0.094	37%	Lab pH	6.82	6.79	0%
NO2 (mg/L)		0.005	0.005	0%	Na (mg/L)	241	249	3%
Chl-a (mg/m3)					SO4 (mg/L)	15.3	14.8	3%
Al (mg/L)		0.027	0.027	1%	Total Alkalinity (mg CaCO3/L)	35	37	6%
Ca (mg/L)		48	50	4%	Total Coliform (MPN/100ml)	2420	2419.6	0%
Cl (mg/L)		505	495	2%	TOC (mg/L)	5.4	7.7	35%
Color (CU)		52	51	2%	Turbidity (NTU)	1.6	1.6	2%
Conductivity (uS/cm)		1590	1600	1%	UV254 (abs)	0.337	0.333	1%

Field Blank Results

Site Name | Date | Field Blank Result | Field Blank Result

FP@Intake

11/28/2017

NH3 (mg/L)		0.057	E. coli (MPN/100 ml)	<	1
TKN (mg/L)	<	0.100	Fe (mg/L)		0.010
TP (mg/L)	<	0.011	Mn (mg/L)		0.000
NO3 (mg/L)		0.005	Lab pH		6.34
NO2 (mg/L)	<	0.005	Na (mg/L)		0
Chl-a (mg/m3)	<	2.0	SO4 (mg/L)		3
Al (mg/L)	<	0.000	Total Alkalinity (mg CaCO3/L)		1.5
Ca (mg/L)		0	Total Coliform (MPN/100ml)	<	1
Cl (mg/L)		0	TOC (mg/L)		0.3
Color (CU)		1	Turbidity (NTU)		0.1
Conductivity (uS/cm)		1	UV254 (abs)		0.102

HB@DH

7/20/2017

NH3 (mg/L)	<	0.050	E. coli (MPN/100 ml)	<	1
TKN (mg/L)	<	0.010	Fe (mg/L)		0.010
TP (mg/L)	<	0.011	Mn (mg/L)		0.000
NO3 (mg/L)		0.005	Lab pH		6.28
NO2 (mg/L)	<	0.005	Na (mg/L)		0
Chl-a (mg/m3)	<	2.0	SO4 (mg/L)		1.3
Al (mg/L)	<	0.000	Total Alkalinity (mg CaCO3/L)		1
Ca (mg/L)		0	Total Coliform (MPN/100ml)	<	1
Cl (mg/L)		0	TOC (mg/L)		0.2
Color (CU)		4	Turbidity (NTU)		0.1
Conductivity (uS/cm)		9	UV254 (abs)		0.006

Field Blank Results

Site Name | Date | Field Blank Result | | Field Blank Result

HB@KG

3/21/2017

Parameter	Qualifier	Field Blank Result	Parameter	Qualifier	Field Blank Result
NH3 (mg/L)			E. coli (MPN/100 ml)		
TKN (mg/L)			Fe (mg/L)		0.004
TP (mg/L)			Mn (mg/L)		0.000
NO3 (mg/L)		0.020	Lab pH		6.3
NO2 (mg/L)	<	0.005	Na (mg/L)		0
Chl-a (mg/m3)			SO4 (mg/L)		1.6
Al (mg/L)		0.000	Total Alkalinity (mg CaCO3/L)		1
Ca (mg/L)		0	Total Coliform (MPN/100ml)		
Cl (mg/L)		0	TOC (mg/L)		0.2
Color (CU)		0	Turbidity (NTU)		0.1
Conductivity (uS/cm)		13	UV254 (abs)		0.001

MBS

3/23/2017

Parameter	Qualifier	Field Blank Result	Parameter	Qualifier	Field Blank Result
NH3 (mg/L)	<	0.050	E. coli (MPN/100 ml)	<	1
TKN (mg/L)	<	0.100	Fe (mg/L)		
TP (mg/L)	<	0.011	Mn (mg/L)		
NO3 (mg/L)			Lab pH		
NO2 (mg/L)			Na (mg/L)		
Chl-a (mg/m3)			SO4 (mg/L)		
Al (mg/L)			Total Alkalinity (mg CaCO3/L)		
Ca (mg/L)			Total Coliform (MPN/100ml)	<	1
Cl (mg/L)			TOC (mg/L)		
Color (CU)			Turbidity (NTU)		
Conductivity (uS/cm)			UV254 (abs)		

Field Blank Results

Site Name	Date	Parameter		Field Blank Result	Parameter		Field Blank Result
SB@DH							
	11/30/2017						
		NH3 (mg/L)	<	0.050	E. coli (MPN/100 ml)	<	1
		TKN (mg/L)	<	0.100	Fe (mg/L)		0.010
		TP (mg/L)	<	0.011	Mn (mg/L)		0.000
		NO3 (mg/L)		0.005	Lab pH		6.38
		NO2 (mg/L)	<	0.005	Na (mg/L)		0
		Chl-a (mg/m3)	<	2.0	SO4 (mg/L)		13.8
		Al (mg/L)	<	0.000	Total Alkalinity (mg CaCO3/L)		1.5
		Ca (mg/L)		0	Total Coliform (MPN/100ml)	<	1
		Cl (mg/L)		0	TOC (mg/L)		0.3
		Color (CU)		2	Turbidity (NTU)		0.1
		Conductivity (uS/cm)		1	UV254 (abs)		0.001
SB@Intake							
	8/30/2017						
		NH3 (mg/L)	<	0.050	E. coli (MPN/100 ml)	<	1
		TKN (mg/L)		0.141	Fe (mg/L)		0.010
		TP (mg/L)	<	0.011	Mn (mg/L)		0.000
		NO3 (mg/L)		0.050	Lab pH		5.98
		NO2 (mg/L)	<	0.010	Na (mg/L)		0
		Chl-a (mg/m3)	<	2.0	SO4 (mg/L)		1.6
		Al (mg/L)	<	0.000	Total Alkalinity (mg CaCO3/L)		1.5
		Ca (mg/L)		0	Total Coliform (MPN/100ml)	<	1
		Cl (mg/L)		0	TOC (mg/L)		0.3
		Color (CU)		1	Turbidity (NTU)		0.2
		Conductivity (uS/cm)		6	UV254 (abs)		0.006

Field Blank Results

Site Name	Date	Field Blank Result				Field Blank Result	
SummerSt							
	10/19/2017						
NH3 (mg/L)		<	0.050	E. coli (MPN/100 ml)		<	1
TKN (mg/L)		<	0.100	Fe (mg/L)			0.010
TP (mg/L)		<	0.011	Mn (mg/L)			0.000
NO3 (mg/L)			0.010	Lab pH			5.79
NO2 (mg/L)		<	0.005	Na (mg/L)			0
Chl-a (mg/m3)				SO4 (mg/L)			8.6
Al (mg/L)		<	0.000	Total Alkalinity (mg CaCO3/L)			15
Ca (mg/L)			0	Total Coliform (MPN/100ml)		<	1
Cl (mg/L)			0	TOC (mg/L)			0.3
Color (CU)			1	Turbidity (NTU)			0.0
Conductivity (uS/cm)			13	UV254 (abs)			0.087

17 Appendix D: Water Quality Result Comparisons to Standards, Guidelines, and Criteria

Reservoir Class A Exceedances

Start Date 1/1/2017 End Date 12/31/2017

DO

Basin	Site Name	Date	DO (mg/L)	DO Standard (mg/L)
Fresh Pond				
Bottom Samples				
	FP@DH			
		6/13/2017	4.37	5
		7/19/2017	1.71	5
		8/22/2017	0.71	5
Number of Exceedances			3	
Number of Samples			9	
% Exceedance			33%	
Hobbs Brook				
Bottom Samples				
	HB@DH			
		6/22/2017	0	5
		7/20/2017	0	5
		8/30/2017	0.01	5
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
	HB@Intake			
		6/22/2017	1.73	5
		7/20/2017	0.45	5
Number of Exceedances			2	
Number of Samples			6	
% Exceedance			33%	
Stony Brook				
Bottom Samples				
	SB@DH			
		6/22/2017	0.42	5
		7/20/2017	0.25	5

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	DO (mg/L)	DO Standard (mg/L)
Stony Brook				
Bottom Samples				
	SB@DH			
		8/30/2017	0.36	5
		10/4/2017	1.93	5
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	SB@Intake			
		7/20/2017	4.06	5
Number of Exceedances			1	
Number of Samples			4	
% Exceedance			25%	

Temperature

No Class A warm water fishery exceedances. Cold water fishery exceedances were not evaluated.

pH

Basin	Site Name	Date	pH	pH Test	Min. Standard	Max. standard
Hobbs Brook						
Surface Samples						
	HB@Upper					
		12/14/2017	8.32	probe	6.5	8.3
			Probe	Lab		
Out of Bounds			1	0		
Number of Samples			6	6		
% Out of Bounds			17%	0%		

E.coli

Basin	Site Name	Date	E. coli (MPN/100 ml)	E. coli Standard (MPN/100ml)
Hobbs Brook				
Surface Samples				
	HB@Intake			
		4/6/2017	579	235

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	E. coli (MPN/100 ml)	E. coli Standard (MPN/100ml)
Hobbs Brook				
Surface Samples				
	HB@Intake			
		9/7/2017	276	235
		9/21/2017	2419.6	235
Number of Exceedances			3	
Number of Samples			52	
% Exceedances			6%	
Stony Brook				
Surface Samples				
	SB@Intake			
		4/6/2017	1200	235
		9/21/2017	365	235
Number of Exceedances			2	
Number of Samples			52	
% Exceedances			4%	

Tributary Class A Exceedances

Start Date 1/1/2017 End Date 12/31/2017

DO

Site Name	Date	DO (mg/L)	DO Standard (mg/L)	Site Type
HB@MillSt				
	9/27/2017	4.02	5	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		
MBS				
	6/27/2017	3.19	5	Tributary
	8/15/2017	0.18	5	Tributary
	9/27/2017	0.58	5	Tributary
	11/2/2017	2.79	5	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
TracerLn				
	6/27/2017	1.8	5	Tributary
	8/15/2017	4.57	5	Tributary
	9/27/2017	2.75	5	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		

Temp

Site Name	Date	Temperature (C)	Temperature Standard (C)	Site Type
RT20				
	8/1/2017	21.08	20	Tributary_ColdWater

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	Temperature (C)	Temperature Standard (C)	Site Type
RT20				
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

pH

Site Name	Date	pH	pH Test	Min. Standard	Max. Standard	Site Type
HB@MillSt						
	1/31/2017	6.42	lab	6.5	8.3	Tributary
	11/2/2017	6.26	lab	6.5	8.3	Tributary
	11/2/2017	6.39	probe	6.5	8.3	Tributary

	Probe	Lab
Out of Bounds	1	2
Number of Samples	6	6
% Out of Bounds	17%	33%

Site Name	Date	pH	pH Test	Min. Standard	Max. Standard	Site Type
MBS						
	6/27/2017	6.4	probe	6.5	8.3	Tributary
	8/15/2017	6.35	lab	6.5	8.3	Tributary
	8/15/2017	6.4	probe	6.5	8.3	Tributary

	Probe	Lab
Out of Bounds	2	1
Number of Samples	6	6
% Out of Bounds	33%	17%

Site Name	Date	pH	pH Test	Min. Standard	Max. Standard	Site Type
TracerLn						
	9/27/2017	6.48	probe	6.5	8.3	Tributary

	Probe	Lab
Out of Bounds	1	0
Number of Samples	6	6
% Out of Bounds	17%	0%

E.coli

Site Name	Date Of Visit	E. coli	E. coli Standard (MPN/100 ml)	Site Type
HB@MillSt				

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date Of Visit	E. coli	E. coli Standard (MPN/100 ml)	Site Type
HB@MillSt				
	6/27/2017	291	235	Tributary
	8/15/2017	488	235	Tributary
	9/27/2017	921	235	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
IndustBrook				
	8/31/2017	365	235	Tributary
	10/3/2017	517	235	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		
LexBrook				
	1/17/2017	276	235	Tributary
	8/1/2017	387	235	Tributary
	8/29/2017	548	235	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
MBS				
	8/15/2017	520	235	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date Of Visit	E. coli	E. coli Standard (MPN/100 ml)	Site Type
SaltDepot				
	8/15/2017	816	235	Tributary
	9/27/2017	291	235	Tributary
	11/2/2017	550.5	235	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
TracerLn				
	6/27/2017	276	235	Tributary
	11/2/2017	261	235	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		

Reservoir SMCL Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Cl-

Basin	Site Name	Date	Chloride (mg/L)	Cl Standard (mg/L)
Fresh Pond				
Surface Samples				
	FP@DH			
		10/18/2017	300	250
Number of Exceedances			1	
Number of Samples			7	
% Exceedance			14%	
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	321	250
		6/22/2017	302	250
		7/20/2017	310	250
		8/30/2017	261	250
		10/4/2017	256	250
		11/30/2017	282	250
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Intake			
		1/12/2017	251.1	250
		1/19/2017	270.9	250
		1/26/2017	278.7	250
		2/2/2017	299.2	250
		2/9/2017	318.8	250
		2/16/2017	315.7	250
		3/16/2017	330	250
		3/23/2017	331	250
		3/30/2017	315	250

HB @ Intake chloride values excluded from 2017 analysis:

8/24/2017: 241 mg/L, value was lower than expected compared to the specific conductance and other chloride values from the same time period.

10/17/2017: 629 mg/L, value was high relative to the corresponding sodium and other and other chloride values from the same time period.

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Chloride (mg/L)	Cl Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Intake			
		4/6/2017	330	250
		4/13/2017	290	250
		4/20/2017	323	250
		4/27/2017	281	250
		5/4/2017	324	250
		5/11/2017	321	250
		5/18/2017	277	250
		5/25/2017	300	250
		6/1/2017	319	250
		6/8/2017	293	250
		6/15/2017	304	250
		6/22/2017	270	250
		6/29/2017	335	250
		7/6/2017	314	250
		7/13/2017	304	250
		7/20/2017	309	250
		7/27/2017	312	250
		8/3/2017	302	250
		8/31/2017	299	250
		9/7/2017	302	250
		9/14/2017	301	250
		9/21/2017	298	250
		9/28/2017	280.2	250
		10/12/2017	266	250
		10/19/2017	309	250
		10/26/2017	305	250
		11/2/2017	291	250
		11/9/2017	293.5	250
		11/16/2017	290.9	250

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Chloride (mg/L)	Cl Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Intake			
		11/22/2017	284.1	250
		11/30/2017	282	250
		12/7/2017	288	250
		12/14/2017	278	250
		12/21/2017	282	250
		12/28/2017	286	250
Number of Exceedances			44	
Number of Samples			46	
% Exceedance			96%	
	HB@Middle			
		2/23/2017	299	250
		3/21/2017	355	250
		12/14/2017	279	250
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
	HB@Upper			
		8/31/2017	318	250
		10/3/2017	283	250
		12/14/2017	274	250
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
Bottom Samples				
	HB@DH			
		4/20/2017	319	250
		6/22/2017	314	250

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Chloride (mg/L)	Cl Standard (mg/L)
Hobbs Brook				
Bottom Samples				
	HB@DH			
Number of Exceedances			2	
Number of Samples			3	
% Exceedance			67%	
Stony Brook				
Surface Samples				
	SB@DH			
		8/30/2017	316	250
		10/4/2017	288	250
Number of Exceedances			2	
Number of Samples			6	
% Exceedance			33%	
	SB@Intake			
		1/5/2017	288	250
		8/31/2017	274	250
		9/7/2017	274	250
		9/21/2017	282	250
		9/28/2017	301.2	250
		10/5/2017	303	250
		10/12/2017	292	250
		10/19/2017	296	250
		10/26/2017	286	250
		11/2/2017	264	250
Number of Exceedances			10	
Number of Samples			46	
% Exceedance			22%	
Bottom Samples				
	SB@DH			
		8/30/2017	323	250

SB @ Intake chloride values excluded from 2017 analysis:

8/24/2017: 309 mg/L, value was higher than expected compared to the specific conductance and other chloride values from the same time period.

10/17/2017: 112 mg/L, value was low relative to the corresponding sodium result and chloride values from the same time period.

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Chloride (mg/L)	Cl Standard (mg/L)
Stony Brook				
Bottom Samples				
	SB@DH			
		10/4/2017	287	250
Number of Exceedances			2	
Number of Samples			4	
% Exceedance			50%	

Mn

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Fresh Pond				
Surface Samples				
	FP@DH			
		6/13/2017	0.059	0.05
		8/22/2017	0.063	0.05
		9/19/2017	0.051	0.05
Number of Exceedances			3	
Number of Samples			7	
% Exceedance			43%	
Bottom Samples				
	FP@DH			
		6/13/2017	0.195	0.05
		8/22/2017	2.68	0.05
		9/19/2017	0.341	0.05
Number of Exceedances			3	
Number of Samples			5	
% Exceedance			60%	
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	0.163286	0.05
		6/22/2017	0.05	0.05

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		8/30/2017	0.101	0.05
		10/4/2017	0.236	0.05
		11/30/2017	0.06	0.05
Number of Exceedances			5	
Number of Samples			6	
% Exceedance			83%	
	HB@Intake			
		1/12/2017	0.222	0.05
		2/2/2017	0.05385	0.05
		2/9/2017	0.21671	0.05
		2/16/2017	0.885912	0.05
		2/23/2017	0.133698	0.05
		4/20/2017	0.072	0.05
		4/27/2017	0.129	0.05
		5/4/2017	0.15	0.05
		5/11/2017	0.218	0.05
		5/18/2017	0.237	0.05
		5/25/2017	0.225	0.05
		6/1/2017	0.118	0.05
		6/8/2017	0.107	0.05
		6/15/2017	0.083	0.05
		6/22/2017	0.051	0.05
		8/31/2017	0.133	0.05
		9/7/2017	0.15	0.05
		9/14/2017	0.095	0.05
		9/21/2017	0.145293	0.05
		9/28/2017	0.066033	0.05
		10/5/2017	0.17	0.05
		10/12/2017	0.081	0.05

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Intake			
		10/19/2017	0.158	0.05
		10/26/2017	0.066	0.05
		11/2/2017	0.114	0.05
		11/9/2017	0.097	0.05
		11/16/2017	0.081397	0.05
		11/22/2017	0.073308	0.05
		11/30/2017	0.061	0.05
		12/7/2017	0.054	0.05
		12/14/2017	0.054	0.05
		12/28/2017	0.056	0.05
Number of Exceedances			32	
Number of Samples			51	
% Exceedance			63%	
	HB@Middle			
		2/23/2017	0.134	0.05
		3/21/2017	0.157	0.05
		7/6/2017	0.079	0.05
		8/31/2017	0.093	0.05
		10/3/2017	0.242508	0.05
		12/14/2017	0.131494	0.05
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Upper			
		2/23/2017	0.107	0.05
		3/21/2017	0.077	0.05
		7/6/2017	0.071	0.05
		8/31/2017	0.077	0.05
		10/3/2017	0.097775	0.05

Start Date	1/1/2017	End Date	12/31/2017	

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Upper			
		12/14/2017	0.211615	0.05
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
Bottom Samples				
	HB@DH			
		4/20/2017	0.055	0.05
		6/22/2017	3.89	0.05
		8/30/2017	7.72	0.05
Number of Exceedances			3	
Number of Samples			3	
% Exceedance			100%	
Stony Brook				
Surface Samples				
	SB@DH			
		4/20/2017	0.064	0.05
		6/22/2017	0.111	0.05
		8/30/2017	0.209	0.05
		10/4/2017	0.219	0.05
		11/30/2017	0.153	0.05
Number of Exceedances			5	
Number of Samples			6	
% Exceedance			83%	
	SB@Intake			
		1/5/2017	0.159	0.05
		1/12/2017	1.05	0.05
		1/19/2017	0.13925	0.05
		1/26/2017	0.15005	0.05

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Stony Brook				
Surface Samples				
	SB@Intake			
		2/2/2017	0.1282	0.05
		2/9/2017	0.128527	0.05
		2/16/2017	0.177324	0.05
		2/23/2017	0.109967	0.05
		3/9/2017	0.095	0.05
		3/16/2017	0.121	0.05
		3/23/2017	0.113	0.05
		3/30/2017	0.095	0.05
		4/6/2017	0.093	0.05
		4/13/2017	0.054	0.05
		4/20/2017	0.054	0.05
		4/27/2017	0.063	0.05
		5/4/2017	0.074	0.05
		5/11/2017	0.101	0.05
		5/18/2017	0.112	0.05
		5/25/2017	0.106	0.05
		6/1/2017	0.144	0.05
		6/8/2017	0.147	0.05
		6/15/2017	0.127	0.05
		6/22/2017	0.151	0.05
		6/29/2017	0.114	0.05
		7/6/2017	0.093	0.05
		7/13/2017	0.264	0.05
		7/27/2017	0.051	0.05
		8/31/2017	0.08	0.05
		9/7/2017	0.072	0.05
		10/5/2017	0.206	0.05
		10/12/2017	0.124	0.05
		10/19/2017	0.365	0.05

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Manganese	Mn Standard (mg/L)
Stony Brook				
Surface Samples				
	SB@Intake			
		10/26/2017	0.261	0.05
		11/2/2017	0.156	0.05
		11/9/2017	0.128	0.05
		11/16/2017	0.139392	0.05
		11/22/2017	0.14835	0.05
		11/30/2017	0.152	0.05
		12/7/2017	0.165	0.05
		12/14/2017	0.174	0.05
		12/21/2017	0.233	0.05
		12/28/2017	0.285	0.05
Number of Exceedances			43	
Number of Samples			51	
% Exceedance			84%	
Bottom Samples				
	SB@DH			
		4/20/2017	0.146	0.05
		6/22/2017	2.46	0.05
		8/30/2017	5.97	0.05
		10/4/2017	3.21	0.05
Number of Exceedances			4	
Number of Samples			4	
% Exceedance			100%	

Fe

Basin	Site Name	Date	Iron (mg/L)	Iron Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	0.36	0.3

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Iron (mg/L)	Iron Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		10/4/2017	0.51	0.3
Number of Exceedances			2	
Number of Samples			6	
% Exceedance			33%	
	HB@Intake			
		2/9/2017	11.40	0.3
		2/16/2017	0.59	0.3
		2/23/2017	0.33	0.3
		4/13/2017	0.35	0.3
		4/20/2017	0.35	0.3
		5/4/2017	0.33	0.3
		5/11/2017	0.32	0.3
		5/18/2017	0.32	0.3
		5/25/2017	0.34	0.3
		6/8/2017	0.36	0.3
		9/7/2017	0.47	0.3
		9/21/2017	0.35	0.3
		9/28/2017	0.30	0.3
		10/5/2017	0.49	0.3
		10/12/2017	0.30	0.3
		10/19/2017	0.45	0.3
		11/2/2017	0.42	0.3
		11/9/2017	0.30	0.3
		11/16/2017	0.34	0.3
		11/22/2017	0.31	0.3
		11/30/2017	0.43	0.3
Number of Exceedances			21	
Number of Samples			51	
% Exceedance			41%	

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Iron (mg/L)	Iron Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Middle			
		2/23/2017	0.33	0.3
		3/21/2017	0.84	0.3
		7/6/2017	0.87	0.3
		8/31/2017	1.55	0.3
		10/3/2017	13.32	0.3
		12/14/2017	0.54	0.3
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Upper			
		2/23/2017	0.35	0.3
		7/6/2017	1.42	0.3
		8/31/2017	1.87	0.3
		10/3/2017	1.20	0.3
		12/14/2017	10.33	0.3
Number of Exceedances			5	
Number of Samples			6	
% Exceedance			83%	
Bottom Samples				
	HB@DH			
		4/20/2017	0.34	0.3
		6/22/2017	1.49	0.3
		8/30/2017	3.67	0.3
Number of Exceedances			3	
Number of Samples			3	
% Exceedance			100%	
Stony Brook				
Surface Samples				
	SB@DH			

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Iron (mg/L)	Iron Standard (mg/L)
Stony Brook				
Surface Samples				
	SB@DH			
		4/20/2017	0.32	0.3
		6/22/2017	0.35	0.3
		8/30/2017	0.33	0.3
		11/30/2017	0.35	0.3
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	SB@Intake			
		1/12/2017	0.31	0.3
		1/19/2017	0.36	0.3
		2/9/2017	1.75	0.3
		2/16/2017	0.41	0.3
		3/16/2017	0.41	0.3
		3/23/2017	0.38	0.3
		3/30/2017	0.30	0.3
		4/6/2017	0.33	0.3
		5/4/2017	0.31	0.3
		5/11/2017	0.38	0.3
		5/18/2017	0.37	0.3
		5/25/2017	0.35	0.3
		6/1/2017	0.43	0.3
		6/8/2017	0.46	0.3
		6/15/2017	0.32	0.3
		6/22/2017	0.37	0.3
		6/29/2017	0.40	0.3
		7/6/2017	0.34	0.3
		7/13/2017	0.42	0.3
		10/19/2017	0.30	0.3
		11/22/2017	0.30	0.3

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Iron (mg/L)	Iron Standard (mg/L)
Stony Brook				
Surface Samples				
	SB@Intake			
		12/21/2017	0.33	0.3
		12/28/2017	0.42	0.3
Number of Exceedances			23	
Number of Samples			51	
% Exceedance			45%	
Bottom Samples				
	SB@DH			
		4/20/2017	0.45	0.3
		6/22/2017	1.25	0.3
		8/30/2017	27.10	0.3
		10/4/2017	0.75	0.3
Number of Exceedances			4	
Number of Samples			4	
% Exceedance			100%	

TDS

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Fresh Pond				
Surface Samples				
	FP@Cove			
		1/4/2017	577	500
		4/13/2017	508	500
		8/22/2017	507	500
		9/19/2017	530	500
		10/18/2017	562	500
		11/28/2017	566	500
Number of Exceedances			6	
Number of Samples			9	
% Exceedance			67%	
	FP@DH			

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Fresh Pond				
Surface Samples				
	FP@DH			
		1/4/2017	589	500
		4/13/2017	530	500
		5/10/2017	504	500
		7/19/2017	514	500
		9/19/2017	533	500
		10/18/2017	563	500
		11/28/2017	577	500
Number of Exceedances			7	
Number of Samples			9	
% Exceedance			78%	
	FP@Intake			
		1/4/2017	585	500
		4/13/2017	526	500
		5/10/2017	502	500
		9/19/2017	533	500
		10/18/2017	560	500
		11/28/2017	567	500
Number of Exceedances			6	
Number of Samples			9	
% Exceedance			67%	
Bottom Samples				
	FP@Cove			
		1/4/2017	582	500
		4/13/2017	520	500
		8/22/2017	531	500
		9/19/2017	537	500
		10/18/2017	584	500
		11/28/2017	565	500

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Fresh Pond				
Bottom Samples				
	FP@Cove			
Number of Exceedances			6	
Number of Samples			9	
% Exceedance			67%	
	FP@DH			
		1/4/2017	586	500
		4/13/2017	533	500
		5/10/2017	521	500
		9/19/2017	540	500
		10/18/2017	562	500
		11/28/2017	569	500
Number of Exceedances			6	
Number of Samples			9	
% Exceedance			67%	
	FP@Intake			
		1/4/2017	585	500
		4/13/2017	526	500
		5/10/2017	502	500
		9/19/2017	534	500
		10/18/2017	560	500
		11/28/2017	567	500
Number of Exceedances			6	
Number of Samples			9	
% Exceedance			67%	
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	736	500
		6/22/2017	706	500
		7/20/2017	693	500

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		8/30/2017	693	500
		10/4/2017	689	500
		11/30/2017	661	500
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Intake			
		4/20/2017	736	500
		6/22/2017	707	500
		7/20/2017	693	500
		8/30/2017	694	500
		10/4/2017	688	500
		11/30/2017	661	500
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Middle			
		2/23/2017	760	500
		3/21/2017	800	500
		7/6/2017	646	500
		8/31/2017	526	500
		10/3/2017	569	500
		12/14/2017	658	500
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Upper			
		8/31/2017	503	500
		10/3/2017	640	500

Start Date	1/1/2017	End Date	12/31/2017	

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@Upper			
		12/14/2017	655	500
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
Bottom Samples				
	HB@DH			
		4/20/2017	738	500
		6/22/2017	733	500
		7/20/2017	733	500
		8/30/2017	792	500
		10/4/2017	688	500
		11/30/2017	662	500
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
	HB@Intake			
		4/20/2017	736	500
		6/22/2017	716	500
		7/20/2017	707	500
		8/30/2017	694	500
		10/4/2017	688	500
		11/30/2017	662	500
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
Stony Brook				
Surface Samples				
	SB@DH			
		8/30/2017	629	500

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)
Stony Brook				
Surface Samples				
	SB@DH			
		10/4/2017	658	500
		11/30/2017	554	500
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
	SB@Intake			
		8/30/2017	612	500
		10/4/2017	654	500
		11/30/2017	523	500
Number of Exceedances			3	
Number of Samples			4	
% Exceedance			75%	
Bottom Samples				
	SB@DH			
		4/20/2017	509	500
		8/30/2017	656	500
		10/4/2017	664	500
		11/30/2017	529	500
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	SB@Intake			
		8/30/2017	613	500
		10/4/2017	653	500
		11/30/2017	522	500
Number of Exceedances			3	
Number of Samples			4	
% Exceedance			75%	

Tributary SMCL Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Cl-

Site Name	Date	Chloride (mg/L)	Chloride Standard (mg/L)	SiteType
HB@KG				
	2/23/2017	487	250	Tributary
	3/21/2017	488.5	250	Tributary
	7/6/2017	352	250	Tributary
	10/3/2017	307	250	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
HBBelowDam				
	1/17/2017	293	250	Tributary
	3/6/2017	345	250	Tributary
	4/11/2017	331	250	Tributary
	8/1/2017	312	250	Tributary
	8/29/2017	298	250	Tributary
	10/19/2017	304	250	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
IndustBrook				
	2/23/2017	1060	250	Tributary
	3/21/2017	923	250	Tributary
	7/6/2017	822	250	Tributary
	8/31/2017	839	250	Tributary
	10/3/2017	856	250	Tributary
	12/14/2017	867	250	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Chloride (mg/L)	Chloride Standard (mg/L)	SiteType
LexBrook				
	1/17/2017	537	250	Tributary
	3/6/2017	643	250	Tributary
	4/11/2017	439	250	Tributary
	8/1/2017	687	250	Tributary
	8/29/2017	714	250	Tributary
	10/19/2017	702	250	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
MBS				
	3/23/2017	421	250	Tributary
	9/27/2017	853	250	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		
RT20				
	8/1/2017	498	250	Tributary_ColdWater
	8/29/2017	294	250	Tributary_ColdWater
	10/19/2017	298	250	Tributary_ColdWater
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
SaltDepot				
	1/31/2017	413	250	Tributary
	3/23/2017	636	250	Tributary
	6/27/2017	285	250	Tributary
	8/15/2017	494	250	Tributary
	9/27/2017	372	250	Tributary
	11/2/2017	500	250	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	Chloride (mg/L)	Chloride Standard (mg/L)	SiteType
TracerLn				
	6/27/2017	328	250	Tributary
	8/15/2017	375	250	Tributary
	11/2/2017	263	250	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
WA-17				
	1/17/2017	421	250	Tributary
	3/6/2017	654	250	Tributary
	4/11/2017	525	250	Tributary
	8/1/2017	273	250	Tributary
	8/29/2017	501	250	Tributary
	10/19/2017	460	250	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Mn

Site Name	Date	Mn (mg/L)	Mn Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	0.57	0.05	Tributary
	3/21/2017	0.41	0.05	Tributary
	7/6/2017	0.45	0.05	Tributary
	8/31/2017	0.64	0.05	Tributary
	10/3/2017	0.15	0.05	Tributary
	12/14/2017	0.73	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017	

Site Name	Date	Mn (mg/L)	Mn Standard (mg/L)	Site Type
HB@MillSt				
	1/31/2017	0.06	0.05	Tributary
	3/23/2017	0.06	0.05	Tributary
	6/27/2017	0.09	0.05	Tributary
	8/15/2017	0.25	0.05	Tributary
	9/27/2017	0.22	0.05	Tributary
	11/2/2017	0.12	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HBBelowDam				
	1/17/2017	0.13	0.05	Tributary
	3/6/2017	0.53	0.05	Tributary
	4/11/2017	0.11	0.05	Tributary
	8/1/2017	0.89	0.05	Tributary
	8/29/2017	1.56	0.05	Tributary
	10/19/2017	0.10	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
IndustBrook				
	2/23/2017	0.44	0.05	Tributary
	3/21/2017	0.32	0.05	Tributary
	7/6/2017	0.54	0.05	Tributary
	8/31/2017	1.04	0.05	Tributary
	10/3/2017	0.34	0.05	Tributary
	12/14/2017	0.38	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	Mn (mg/L)	Mn Standard (mg/L)	Site Type
LexBrook				
	1/17/2017	0.07	0.05	Tributary
	3/6/2017	0.24	0.05	Tributary
	4/11/2017	0.15	0.05	Tributary
	8/1/2017	0.41	0.05	Tributary
	8/29/2017	0.08	0.05	Tributary
	10/19/2017	7.77	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
MBS				
	6/27/2017	0.08	0.05	Tributary
	8/15/2017	0.09	0.05	Tributary
	9/27/2017	2.49	0.05	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
RT20				
	3/6/2017	0.13	0.05	Tributary_ColdWater
	4/11/2017	0.07	0.05	Tributary_ColdWater
	8/1/2017	0.20	0.05	Tributary_ColdWater
	8/29/2017	0.53	0.05	Tributary_ColdWater
	10/19/2017	0.38	0.05	Tributary_ColdWater
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Mn (mg/L)	Mn Standard (mg/L)	Site Type
SaltDepot				
	1/31/2017	0.26	0.05	Tributary
	3/23/2017	0.23	0.05	Tributary
	6/27/2017	1.27	0.05	Tributary
	8/15/2017	0.38	0.05	Tributary
	9/27/2017	0.76	0.05	Tributary
	11/2/2017	0.59	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
SB@Viles				
	6/27/2017	0.09	0.05	Tributary_ColdWater
	8/15/2017	0.24	0.05	Tributary_ColdWater
	9/27/2017	0.07	0.05	Tributary_ColdWater
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
SummerSt				
	10/19/2017	0.11	0.05	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		
TracerLn				
	1/31/2017	0.12	0.05	Tributary
	3/23/2017	0.05	0.05	Tributary
	6/27/2017	2.33	0.05	Tributary
	8/15/2017	0.76	0.05	Tributary
	9/27/2017	0.19	0.05	Tributary
	11/2/2017	0.18	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	Mn (mg/L)	Mn Standard (mg/L)	Site Type
WA-17				
	1/17/2017	0.17	0.05	Tributary
	3/6/2017	0.22	0.05	Tributary
	4/11/2017	0.30	0.05	Tributary
	8/1/2017	0.30	0.05	Tributary
	8/29/2017	0.28	0.05	Tributary
	10/19/2017	0.82	0.05	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Fe

Site Name	Date	Fe (mg/L)	Iron Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	1.11	0.3	Tributary
	3/21/2017	0.75	0.3	Tributary
	7/6/2017	0.85	0.3	Tributary
	8/31/2017	0.95	0.3	Tributary
	10/3/2017	0.40	0.3	Tributary
	12/14/2017	0.51	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HB@MillSt				
	1/31/2017	0.40	0.3	Tributary
	3/23/2017	0.31	0.3	Tributary
	6/27/2017	1.36	0.3	Tributary
	8/15/2017	11.80	0.3	Tributary
	9/27/2017	1.16	0.3	Tributary
	11/2/2017	0.95	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Fe (mg/L)	Iron Standard (mg/L)	Site Type
HBBelowDam				
	3/6/2017	0.44	0.3	Tributary
	4/11/2017	0.30	0.3	Tributary
	8/1/2017	0.50	0.3	Tributary
	8/29/2017	14.10	0.3	Tributary
	10/19/2017	0.36	0.3	Tributary
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		
IndustBrook				
	2/23/2017	1.78	0.3	Tributary
	3/21/2017	1.41	0.3	Tributary
	7/6/2017	1.31	0.3	Tributary
	8/31/2017	1.14	0.3	Tributary
	10/3/2017	0.85	0.3	Tributary
	12/14/2017	1.46	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
LexBrook				
	1/17/2017	0.36	0.3	Tributary
	3/6/2017	0.38	0.3	Tributary
	4/11/2017	0.34	0.3	Tributary
	8/1/2017	0.45	0.3	Tributary
	8/29/2017	0.35	0.3	Tributary
	10/19/2017	5.06	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017	

Site Name	Date	Fe (mg/L)	Iron Standard (mg/L)	Site Type
MBS				
	1/31/2017	0.30	0.3	Tributary
	3/23/2017	0.33	0.3	Tributary
	6/27/2017	1.10	0.3	Tributary
	8/15/2017	0.82	0.3	Tributary
	9/27/2017	7.27	0.3	Tributary
	11/2/2017	0.40	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
RT20				
	3/6/2017	0.45	0.3	Tributary_ColdWater
	4/11/2017	0.43	0.3	Tributary_ColdWater
	8/1/2017	0.47	0.3	Tributary_ColdWater
	8/29/2017	1.01	0.3	Tributary_ColdWater
	10/19/2017	0.38	0.3	Tributary_ColdWater
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		
SaltDepot				
	1/31/2017	0.31	0.3	Tributary
	3/23/2017	0.40	0.3	Tributary
	6/27/2017	16.00	0.3	Tributary
	8/15/2017	3.42	0.3	Tributary
	9/27/2017	3.09	0.3	Tributary
	11/2/2017	0.97	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Fe (mg/L)	Iron Standard (mg/L)	Site Type
SB@Viles				
	6/27/2017	1.14	0.3	Tributary_ColdWater
	9/27/2017	0.33	0.3	Tributary_ColdWater
	11/2/2017	0.51	0.3	Tributary_ColdWater
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
SummerSt				
	3/6/2017	0.31	0.3	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		
TracerLn				
	1/31/2017	0.43	0.3	Tributary
	3/23/2017	0.44	0.3	Tributary
	6/27/2017	15.30	0.3	Tributary
	8/15/2017	5.85	0.3	Tributary
	9/27/2017	0.68	0.3	Tributary
	11/2/2017	1.35	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
WA-17				
	1/17/2017	1.22	0.3	Tributary
	3/6/2017	0.62	0.3	Tributary
	4/11/2017	2.51	0.3	Tributary
	8/1/2017	0.37	0.3	Tributary
	8/29/2017	0.87	0.3	Tributary
	10/19/2017	0.82	0.3	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

TDS

Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	1072	500	Tributary
	3/21/2017	1083	500	Tributary
	7/6/2017	729.1	500	Tributary
	8/31/2017	699.3	500	Tributary
	10/3/2017	690.2	500	Tributary
	12/14/2017	678	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HBBelowDam				
	1/17/2017	752	500	Tributary
	3/6/2017	788.5	500	Tributary
	4/11/2017	753.1	500	Tributary
	8/1/2017	691.8	500	Tributary
	8/29/2017	700.3	500	Tributary
	10/19/2017	689	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)	Site Type
IndustBrook				
	2/23/2017	2261	500	Tributary
	3/21/2017	1963	500	Tributary
	7/6/2017	1636	500	Tributary
	8/31/2017	1814	500	Tributary
	10/3/2017	1889	500	Tributary
	12/14/2017	1889	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
LexBrook				
	1/17/2017	1223	500	Tributary
	3/6/2017	1426	500	Tributary
	4/11/2017	1104	500	Tributary
	8/1/2017	1591	500	Tributary
	8/9/2017	1657	500	Tributary
	8/29/2017	1566	500	Tributary
	10/19/2017	1508	500	Tributary
Number of Exceedances		*7*		
Number of Samples		*7*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)	Site Type
MBS				
	1/31/2017	566.5	500	Tributary
	3/23/2017	585.6	500	Tributary
	8/15/2017	526.6	500	Tributary
	9/27/2017	570.9	500	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
RT20				
	8/1/2017	635.1	500	ributary_ColdWat
	8/29/2017	682.7	500	ributary_ColdWat
	10/19/2017	677.6	500	ributary_ColdWat
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
SaltDepot				
	1/31/2017	933.1	500	Tributary
	3/23/2017	954.8	500	Tributary
	6/27/2017	677.6	500	Tributary
	8/15/2017	1080	500	Tributary
	9/27/2017	1809	500	Tributary
	11/2/2017	1080	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	TDS (mg/L)	TDS Standard (mg/L)	Site Type
TracerLn				
	1/31/2017	1229	500	Tributary
	3/23/2017	1350	500	Tributary
	6/27/2017	882	500	Tributary
	8/15/2017	918.7	500	Tributary
	9/27/2017	1126	500	Tributary
	11/2/2017	506.6	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
WA-17				
	1/17/2017	1111	500	Tributary
	3/6/2017	1470	500	Tributary
	4/11/2017	1286	500	Tributary
	8/1/2017	1159	500	Tributary
	8/29/2017	1186	500	Tributary
	10/19/2017	1113	500	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Reservoir MA Drinking Water Guideline Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Na

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Fresh Pond				
Surface Samples				
	FP@DH			
		4/13/2017	114	20
		5/10/2017	121	20
		6/13/2017	108	20
		8/22/2017	110	20
		9/19/2017	122	20
		10/18/2017	139	20
		11/28/2017	132	20
Number of Exceedances			7	
Number of Samples			7	
% Exceedances			100%	
Bottom Samples				
	FP@DH			
		4/13/2017	117	20
		5/10/2017	123	20
		6/13/2017	115	20
		8/22/2017	97	20
		9/19/2017	119	20
Number of Exceedances			5	
Number of Samples			5	
% Exceedances			100%	
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	208	20
		6/22/2017	174	20

Start Date	1/1/2017	End Date	12/31/2017	

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Hobbs Brook				
	HB@DH			
		7/20/2017	170	20
		8/30/2017	134	20
		10/4/2017	174	20
		11/30/2017	147	20
Number of Exceedances			6	
Number of Samples			6	
% Exceedances			100%	
	HB@Intake			
		1/5/2017	124	20
		1/12/2017	139	20
		1/19/2017	140	20
		1/26/2017	156	20
		2/2/2017	156	20
		2/9/2017	178	20
		2/16/2017	175	20
		2/23/2017	166	20
		3/9/2017	166	20
		3/16/2017	178	20
		3/23/2017	174	20
		3/30/2017	172	20
		4/6/2017	170	20
		4/13/2017	172	20
		4/20/2017	181	20
		4/27/2017	172	20
		5/4/2017	161	20
		5/11/2017	185	20
		5/18/2017	183	20

HB @ Intake sodium values excluded from 2017 analysis:

8/10/2017: 116 mg/L, result lower than expected compared to the corresponding specific conductance and other sodium values from the same time period.

8/24/2017: 116 mg/L, result lower than expected compared to the corresponding specific conductance and other sodium values from the same time period.

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Hobbs Brook				
	HB@Intake			
		5/25/2017	187	20
		6/1/2017	174	20
		6/8/2017	187	20
		6/15/2017	182	20
		6/22/2017	180	20
		6/29/2017	178	20
		7/6/2017	177	20
		7/13/2017	182	20
		7/20/2017	172	20
		7/27/2017	180	20
		8/3/2017	168	20
		8/17/2017	160	20
		8/31/2017	155	20
		9/7/2017	186	20
		9/14/2017	164	20
		9/21/2017	170	20
		9/28/2017	173	20
		10/5/2017	170	20
		10/12/2017	179	20
		10/19/2017	171	20
		10/26/2017	151	20
		11/2/2017	155	20
		11/9/2017	148	20
		11/16/2017	150	20
		11/22/2017	155	20
		11/30/2017	154	20

Start Date	1/1/2017	End Date	12/31/2017	

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Hobbs Brook				
	HB@Intake			
		12/7/2017	158	20
		12/14/2017	164	20
		12/21/2017	162	20
		12/28/2017	160	20
Number of Exceedances			49	
Number of Samples			49	
% Exceedances			100%	
	HB@Middle			
		2/23/2017	166	20
		3/21/2017	206	20
		7/6/2017	161	20
		8/31/2017	127	20
		10/3/2017	165	20
		12/14/2017	153	20
Number of Exceedances			6	
Number of Samples			6	
% Exceedances			100%	
	HB@Upper			
		2/23/2017	171	20
		3/21/2017	108	20
		7/6/2017	114	20
		8/31/2017	136	20
		10/3/2017	168	20
		12/14/2017	175	20
Number of Exceedances			6	
Number of Samples			6	
% Exceedances			100%	
Bottom Samples				

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Hobbs Brook				
	HB@DH			
		4/20/2017	178	20
		6/22/2017	183	20
		8/30/2017	110	20
Number of Exceedances			3	
Number of Samples			3	
% Exceedances			100%	
Stony Brook				
Surface Samples				
	SB@DH			
		4/20/2017	84	20
		6/22/2017	94	20
		7/20/2017	94	20
		8/30/2017	185	20
		10/4/2017	167	20
		11/30/2017	114	20
Number of Exceedances			6	
Number of Samples			6	
% Exceedances			100%	
	SB@Intake			
		1/5/2017	85	20
		1/12/2017	88	20
		1/19/2017	92	20
		1/26/2017	108	20
		2/2/2017	100	20
		2/9/2017	94	20
		2/16/2017	105	20
		2/23/2017	94	20
		3/9/2017	98	20

SB @ Intake sodium values excluded from 2017 analysis:

8/10/2017: 179 mg/L, result higher than expected compared to the corresponding specific conductance and other sodium values from the same time period.

8/24/2017: 149 mg/L, result higher than expected compared to the corresponding specific conductance and other sodium values from the same time period.

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Sodium (mg/L)	Sodium Standard (mg/L)
Stony Brook				
	SB@Intake			
		3/16/2017	116	20
		3/23/2017	114	20
		3/30/2017	101	20
		4/6/2017	107	20
		4/13/2017	79	20
		4/20/2017	79	20
		4/27/2017	83	20
		5/4/2017	73	20
		5/11/2017	92	20
		5/18/2017	91	20
		5/25/2017	83	20
		6/1/2017	85	20
		6/8/2017	88	20
		6/15/2017	93	20
		6/22/2017	97	20
		6/29/2017	92	20
		7/6/2017	92	20
		7/13/2017	93	20
		7/20/2017	110	20
		7/27/2017	108	20
		8/3/2017	104	20
		8/17/2017	114	20
		8/31/2017	136	20
		9/7/2017	167	20
		9/14/2017	157	20
		9/21/2017	156	20

Start Date	1/1/2017	End Date	12/31/2017	
Basin	**Site Name**	**Date**	**Sodium (mg/L)**	**Sodium Standard (mg/L)**
Stony Brook				
	SB@Intake			
		9/28/2017	157	20
		10/5/2017	161	20
		10/12/2017	170	20
		10/19/2017	167	20
		10/26/2017	151	20
		11/2/2017	135	20
		11/9/2017	130	20
		11/16/2017	116	20
		11/22/2017	110	20
		11/30/2017	114	20
		12/7/2017	117	20
		12/14/2017	113	20
		12/21/2017	108	20
		12/28/2017	121	20
Number of Exceedances			49	
Number of Samples			49	
% Exceedances			100%	
Bottom Samples				
	SB@DH			
		4/20/2017	122	20
		6/22/2017	116	20
		8/30/2017	189	20
		10/4/2017	164	20
Number of Exceedances			4	
Number of Samples			4	
% Exceedances			100%	

Tributary MA Drinking Water Guideline Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Na

Site Name	Date	Na (mg/L)	Na Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	294	20	Tributary
	3/21/2017	270	20	Tributary
	7/6/2017	184	20	Tributary
	8/31/2017	185	20	Tributary
	10/3/2017	167	20	Tributary
	12/14/2017	153	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HB@MillSt				
	1/31/2017	69	20	Tributary
	3/23/2017	79	20	Tributary
	6/27/2017	66	20	Tributary
	8/15/2017	80	20	Tributary
	9/27/2017	74	20	Tributary
	11/2/2017	66	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HBBelowDam				
	1/17/2017	160	20	Tributary
	3/6/2017	163	20	Tributary
	4/11/2017	172	20	Tributary
	8/1/2017	171	20	Tributary
	8/29/2017	199	20	Tributary
	10/19/2017	152	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017	

Site Name	Date	Na (mg/L)	Na Standard (mg/L)	Site Type
IndustBrook				
	2/23/2017	655	20	Tributary
	3/21/2017	532	20	Tributary
	7/6/2017	397	20	Tributary
	8/31/2017	526	20	Tributary
	10/3/2017	244	20	Tributary
	12/14/2017	500	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
LexBrook				
	1/17/2017	139	20	Tributary
	3/6/2017	351	20	Tributary
	4/11/2017	281	20	Tributary
	8/1/2017	460	20	Tributary
	8/29/2017	381	20	Tributary
	10/19/2017	413	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
MBS				
	1/31/2017	145	20	Tributary
	3/23/2017	143	20	Tributary
	6/27/2017	109	20	Tributary
	8/15/2017	140	20	Tributary
	9/27/2017	477	20	Tributary
	11/2/2017	126	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017	
Site Name	**Date**	**Na (mg/L)**	**Na Standard (mg/L)**	**Site Type**
RT20				
	1/17/2017	98	20	Tributary_ColdWater
	3/6/2017	101	20	Tributary_ColdWater
	4/11/2017	81	20	Tributary_ColdWater
	8/1/2017	267	20	Tributary_ColdWater
	8/29/2017	183	20	Tributary_ColdWater
	10/19/2017	179	20	Tributary_ColdWater
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
SaltDepot				
	1/31/2017	224	20	Tributary
	3/23/2017	228	20	Tributary
	6/27/2017	168	20	Tributary
	8/15/2017	300	20	Tributary
	9/27/2017	199	20	Tributary
	11/2/2017	245	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
SB@Viles				
	1/31/2017	55	20	Tributary_ColdWater
	3/23/2017	57	20	Tributary_ColdWater
	6/27/2017	61	20	Tributary_ColdWater
	8/15/2017	61	20	Tributary_ColdWater
	9/27/2017	77	20	Tributary_ColdWater
	11/2/2017	43	20	Tributary_ColdWater
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Na (mg/L)	Na Standard (mg/L)	Site Type
SummerSt				
	1/17/2017	40	20	Tributary
	3/6/2017	42	20	Tributary
	4/11/2017	38	20	Tributary
	8/1/2017	47	20	Tributary
	8/29/2017	53	20	Tributary
	10/19/2017	57	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
TracerLn				
	1/31/2017	294	20	Tributary
	3/23/2017	344	20	Tributary
	6/27/2017	225	20	Tributary
	8/15/2017	233	20	Tributary
	9/27/2017	147	20	Tributary
	11/2/2017	135	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
WA-17				
	1/17/2017	264	20	Tributary
	3/6/2017	304	20	Tributary
	4/11/2017	327	20	Tributary
	8/1/2017	153	20	Tributary
	8/29/2017	284	20	Tributary
	10/19/2017	276	20	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Reservoir EPA Nutrient Criteria Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Nitrate and Nitrite

Basin	Site Name	Date	Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)
Fresh Pond				
Surface Samples				
	FP@DH			
		4/13/2017	0.732	0.05
		5/10/2017	0.685	0.05
		6/13/2017	0.575	0.05
		8/22/2017	0.382	0.05
		9/19/2017	0.356	0.05
		11/28/2017	0.324	0.05
Number of Exceedances			6	
Number of Samples			7	
% Exceedance			86%	
Bottom Samples				
	FP@DH			
		4/13/2017	0.705	0.05
		5/10/2017	0.645	0.05
		6/13/2017	0.465	0.05
		8/22/2017	0.238	0.05
		9/19/2017	0.286	0.05
Number of Exceedances			5	
Number of Samples			5	
% Exceedance			100%	
Hobbs Brook				

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	0.116	0.05
		6/22/2017	0.0807	0.05
		11/30/2017	0.168	0.05
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
	HB@Middle			
		2/23/2017	0.77	0.05
		3/21/2017	0.465	0.05
		12/14/2017	0.171	0.05
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
	HB@Upper			
		2/23/2017	0.38	0.05
		3/21/2017	0.275	0.05
		12/14/2017	0.301	0.05
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
Bottom Samples				
	HB@DH			
		4/20/2017	0.121	0.05
		8/30/2017	0.0718	0.05
Number of Exceedances			2	
Number of Samples			3	
% Exceedance			67%	
Stony Brook				

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)
Stony Brook				
Surface Samples				
	SB@DH			
		4/20/2017	0.977	0.05
		6/22/2017	0.548	0.05
		7/20/2017	0.405	0.05
		8/30/2017	0.24	0.05
		10/4/2017	0.2622	0.05
		11/30/2017	0.393	0.05
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	
Bottom Samples				
	SB@DH			
		4/20/2017	0.821	0.05
		6/22/2017	0.1917	0.05
		10/4/2017	0.1764	0.05
Number of Exceedances			3	
Number of Samples			4	
% Exceedance			75%	

TKN

Basin	Site Name	Date	TKN (mg/L)	TKN Standard (mg/L)
Fresh Pond				
Bottom Samples				
	FP@DH			
		8/22/2017	0.434	0.43
Number of Exceedances			1	
Number of Samples			5	
% Exceedance			20%	

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	TKN (mg/L)	TKN Standard (mg/L)
Hobbs Brook				
Surface Samples				
	HB@DH			
		4/20/2017	0.465	0.43
		8/30/2017	0.464	0.43
		10/4/2017	0.595	0.43
		11/30/2017	0.463	0.43
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	HB@Middle			
		3/21/2017	0.642	0.43
		7/6/2017	0.592	0.43
		8/31/2017	0.833	0.43
		12/14/2017	0.554	0.43
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	HB@Upper			
		2/23/2017	0.5	0.43
		7/6/2017	0.75	0.43
		8/31/2017	0.807	0.43
		10/3/2017	0.845	0.43
		12/14/2017	0.493	0.43
Number of Exceedances			5	
Number of Samples			6	
% Exceedance			83%	

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	TKN (mg/L)	TKN Standard (mg/L)
Hobbs Brook				
Bottom Samples				
	HB@DH			
		6/22/2017	1.04	0.43
		8/30/2017	3.3	0.43
Number of Exceedances			2	
Number of Samples			3	
% Exceedance			67%	
Stony Brook				
Surface Samples				
	SB@DH			
		6/22/2017	0.493	0.43
		8/30/2017	0.463	0.43
		10/4/2017	0.601	0.43
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	
Bottom Samples				
	SB@DH			
		4/20/2017	0.433	0.43
		6/22/2017	0.704	0.43
		8/30/2017	1.29	0.43
		10/4/2017	0.716	0.43
Number of Exceedances			4	
Number of Samples			4	
% Exceedance			100%	

TP

Basin	Site Name	Date	Total Phosphorus (mg/L)	TP Standard (mg/L)
Fresh Pond				

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Total Phosphorus (mg/L)	TP Standard (mg/L)
Fresh Pond				
Bottom Samples				
	FP@DH			
		4/13/2017	0.017	0.008
		5/10/2017	0.0106	0.008
Number of Exceedances			2	
Number of Samples			5	
% Exceedance			40%	
Hobbs Brook				
Surface Samples				
	HB@DH			
		6/22/2017	0.0117	0.008
		8/30/2017	0.0266	0.008
		10/4/2017	0.017	0.008
		11/30/2017	0.0106	0.008
Number of Exceedances			4	
Number of Samples			6	
% Exceedance			67%	
	HB@Middle			
		2/23/2017	0.012	0.008
		3/21/2017	0.0266	0.008
		7/6/2017	0.0223	0.008
		8/31/2017	0.0659	0.008
		10/3/2017	0.0521	0.008
		12/14/2017	0.0266	0.008
Number of Exceedances			6	
Number of Samples			6	
% Exceedance			100%	

Start Date	1/1/2017	End Date	12/31/2017	
Basin	**Site Name**	**Date**	**Total Phosphorus (mg/L)**	**TP Standard (mg/L)**
Hobbs Brook				
Surface Samples				
	HB@Upper			
		2/23/2017	0.011	0.008
		7/6/2017	0.0404	0.008
		8/31/2017	0.0531	0.008
		10/3/2017	0.051	0.008
		12/14/2017	0.0351	0.008
Number of Exceedances			5	
Number of Samples			6	
% Exceedance			83%	
Bottom Samples				
	HB@DH			
		6/22/2017	0.0234	0.008
		8/30/2017	0.051	0.008
Number of Exceedances			2	
Number of Samples			3	
% Exceedance			67%	
Stony Brook				
Surface Samples				
	SB@DH			
		6/22/2017	0.0159	0.008
		8/30/2017	0.0128	0.008
		11/30/2017	0.0106	0.008
Number of Exceedances			3	
Number of Samples			6	
% Exceedance			50%	

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Total Phosphorus (mg/L)	TP Standard (mg/L)
Stony Brook				
Bottom Samples				
	SB@DH			
		4/20/2017	0.0213	0.008
		6/22/2017	0.0276	0.008
		8/30/2017	0.0202	0.008
		10/4/2017	0.0128	0.008
Number of Exceedances			4	
Number of Samples			4	
% Exceedance			100%	

Secchi Depth

Basin	Site Name	Date	Secchi Depth (m) - w/ Aquascope	Secchi Depth (m) - w/o Aquascope	Criteria (m)
Fresh Pond					
	FP@Cove				
		1/4/2017		4.50	4.9
		4/13/2017	4.50	3.50	4.9
		6/13/2017	4.00	3.50	4.9
		7/19/2017		4.00	4.9
		8/22/2017		4.00	4.9
Number of Below Criteria			2	5	
Number of Samples			8	9	
% Below Criteria			25%	56%	
	FP@DH				
		4/13/2017	4.50	4.00	4.9
		6/13/2017	4.50	4.00	4.9
		7/19/2017	4.00	3.50	4.9
		8/22/2017		4.00	4.9
		9/19/2017	4.50		4.9

Start Date	1/1/2017	End Date	12/31/2017

Basin	Site Name	Date	Secchi Depth (m) - w/ Aquascope	Secchi Depth (m) - w/o Aquascope	Criteria (m)
Fresh Pond					
	FP@DH				
Number of Below Criteria			4	4	
Number of Samples			8	9	
% Below Criteria			50%	44%	
	FP@Intake				
		4/13/2017		4.50	4.9
		6/13/2017	4.00	3.50	4.9
		7/19/2017		4.00	4.9
		8/22/2017		4.00	4.9
Number of Below Criteria			1	4	
Number of Samples			8	9	
% Below Criteria			13%	44%	
Hobbs Brook					
	HB@DH				
		4/20/2017	2.00	1.50	4.9
		7/20/2017		4.00	4.9
		8/30/2017	2.00	2.00	4.9
		10/4/2017		2.00	4.9
		11/30/2017	4.50	4.00	4.9
Number of Below Criteria			3	5	
Number of Samples			5	6	
% Below Criteria			60%	83%	
	HB@Intake				
		4/20/2017	2.50	2.00	4.9
		7/20/2017	4.50	3.50	4.9
		8/30/2017	2.25	2.00	4.9
		10/4/2017		1.50	4.9
		11/30/2017	4.50	4.25	4.9

Start Date 1/1/2017 End Date 12/31/2017

Basin	Site Name	Date	Secchi Depth (m) - w/ Aquascope	Secchi Depth (m) - w/o Aquascope	Criteria (m)
Hobbs Brook					
	HB@Intake				
Number of Below Criteria			4	5	
Number of Samples			5	6	
% Below Criteria			80%	83%	
Stony Brook					
	SB@DH				
		4/20/2017	3.00	2.50	4.9
		6/22/2017	4.50	3.50	4.9
		7/20/2017	4.50	3.50	4.9
		8/30/2017	3.00	2.50	4.9
		10/4/2017		3.50	4.9
		11/30/2017	4.50	4.00	4.9
Number of Below Criteria			5	6	
Number of Samples			5	6	
% Below Criteria			100%	100%	
	SB@Intake				
		6/22/2017		4.00	4.9
		7/20/2017		4.00	4.9
		10/4/2017		3.50	4.9
		11/30/2017	4.50	4.00	4.9
Number of Below Criteria			1	4	
Number of Samples			3	4	
% Below Criteria			33%	100%	

Tributary EPA Nutrient Criteria Exceedances

Start Date 1/1/2017 End Date 12/31/2017

Nitrate and Nitrite

Site Name	Date		Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)	Site Type
HB@KG					
	2/23/2017		1.110	0.31	Tributary
	3/21/2017		0.775	0.31	Tributary
	12/14/2017		0.414	0.31	Tributary
Number of Exceedances			*3*		
Number of Samples			*6*		
% Exceedance			*50%*		
HB@MillSt					
	1/31/2017		0.337	0.31	Tributary
	3/23/2017	<	0.313	0.31	Tributary
	8/15/2017		0.394	0.31	Tributary
Number of Exceedances			*3*		
Number of Samples			*6*		
% Exceedance			*50%*		
IndustBrook					
	2/23/2017		1.213	0.31	Tributary
	3/21/2017		0.725	0.31	Tributary
	7/6/2017		0.761	0.31	Tributary
	8/31/2017		0.397	0.31	Tributary
	10/3/2017		0.488	0.31	Tributary
	12/14/2017		0.615	0.31	Tributary
Number of Exceedances			*6*		
Number of Samples			*6*		
% Exceedance			*100%*		

Start Date	1/1/2017	End Date	12/31/2017	
Site Name	**Date**	**Nitrite+Nitrite as Nitrogen (mg/L)**	**Nitrite+Nitrite as Nitrogen (mg/L)**	**Site Type**
LexBrook				
	1/17/2017	1.535	0.31	Tributary
	3/6/2017	1.685	0.31	Tributary
	4/11/2017	1.605	0.31	Tributary
	8/1/2017	0.827	0.31	Tributary
	8/29/2017	1.120	0.31	Tributary
	10/19/2017	0.653	0.31	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
MBS				
	1/31/2017	1.225	0.31	Tributary
	3/23/2017	1.130	0.31	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		
RT20				
	1/17/2017	1.005	0.31	Tributary_ColdWater
	3/6/2017	1.125	0.31	Tributary_ColdWater
	4/11/2017	0.835	0.31	Tributary_ColdWater
	8/1/2017	1.565	0.31	Tributary_ColdWater
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
SaltDepot				
	9/27/2017	0.797	0.31	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

Start Date	1/1/2017	End Date	12/31/2017	
Site Name	Date	Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)	Site Type
SB@Viles				
	1/31/2017	1.005	0.31	Tributary_ColdWater
	3/23/2017	0.903	0.31	Tributary_ColdWater
	6/27/2017	0.774	0.31	Tributary_ColdWater
	8/15/2017	1.355	0.31	Tributary_ColdWater
	9/27/2017	1.715	0.31	Tributary_ColdWater
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		
SummerSt				
	1/17/2017	2.405	0.31	Tributary
	3/6/2017	2.305	0.31	Tributary
	4/11/2017	1.975	0.31	Tributary
	8/1/2017	0.325	0.31	Tributary
	8/29/2017	3.050	0.31	Tributary
	10/19/2017	2.775	0.31	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
TracerLn				
	6/27/2017	0.813	0.31	Tributary
	11/2/2017	0.362	0.31	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	Nitrite+Nitrite as Nitrogen (mg/L)	Nitrite+Nitrite as Nitrogen (mg/L)	Site Type
WA-17				
	1/17/2017	1.755	0.31	Tributary
	3/6/2017	2.135	0.31	Tributary
	4/11/2017	1.935	0.31	Tributary
	8/1/2017	1.875	0.31	Tributary
	8/29/2017	1.050	0.31	Tributary
	10/19/2017	0.660	0.31	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

TKN

Site Name	Date	TKN (mg/L)	TKN Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	0.44	0.30	Tributary
	3/21/2017	0.34	0.30	Tributary
	7/6/2017	0.44	0.30	Tributary
	8/31/2017	0.57	0.30	Tributary
	10/3/2017	0.43	0.30	Tributary
	12/14/2017	0.45	0.30	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
HB@MillSt				
	1/31/2017	0.45	0.30	Tributary
	3/23/2017	0.49	0.30	Tributary
	6/27/2017	0.88	0.30	Tributary
	8/15/2017	0.86	0.30	Tributary
	9/27/2017	0.34	0.30	Tributary
	11/2/2017	1.07	0.30	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		

Start Date	1/1/2017	End Date	12/31/2017

HBBelowDam

3/6/2017	0.31	0.30	Tributary
4/11/2017	0.49	0.30	Tributary
8/1/2017	0.54	0.30	Tributary
8/29/2017	0.80	0.30	Tributary
10/19/2017	0.59	0.30	Tributary

Number of Exceedances	*5*
Number of Samples	*6*
% Exceedance	*83%*

IndustBrook

2/23/2017	0.58	0.30	Tributary
3/21/2017	0.41	0.30	Tributary
7/6/2017	0.70	0.30	Tributary
8/31/2017	0.61	0.30	Tributary
10/3/2017	1.30	0.30	Tributary
12/14/2017	0.63	0.30	Tributary

Number of Exceedances	*6*
Number of Samples	*6*
% Exceedance	*100%*

LexBrook

1/17/2017	0.38	0.30	Tributary
4/11/2017	0.31	0.30	Tributary
8/1/2017	0.41	0.30	Tributary
8/29/2017	0.43	0.30	Tributary
10/19/2017	0.32	0.30	Tributary

Number of Exceedances	*5*
Number of Samples	*6*
% Exceedance	*83%*

Start Date	1/1/2017	End Date	12/31/2017

MBS				
	1/31/2017	0.50	0.30	Tributary
	3/23/2017	0.39	0.30	Tributary
	6/27/2017	0.85	0.30	Tributary
	8/15/2017	0.76	0.30	Tributary
	9/27/2017	0.59	0.30	Tributary
	11/2/2017	0.56	0.30	Tributary
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
RT20				
	1/17/2017	0.43	0.30	Tributary_ColdWater
	3/6/2017	0.47	0.30	Tributary_ColdWater
	4/11/2017	0.52	0.30	Tributary_ColdWater
	8/1/2017	0.46	0.30	Tributary_ColdWater
	8/29/2017	0.53	0.30	Tributary_ColdWater
	10/19/2017	0.38	0.30	Tributary_ColdWater
Number of Exceedances		*6*		
Number of Samples		*6*		
% Exceedance		*100%*		
SaltDepot				
	3/23/2017	0.32	0.30	Tributary
	6/27/2017	0.94	0.30	Tributary
	8/15/2017	0.46	0.30	Tributary
	9/27/2017	0.48	0.30	Tributary
	11/2/2017	0.49	0.30	Tributary
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		

Start Date	1/1/2017	End Date	12/31/2017

SB@Viles

1/31/2017	0.45	0.30	Tributary_ColdWater
3/23/2017	0.36	0.30	Tributary_ColdWater
6/27/2017	0.73	0.30	Tributary_ColdWater
8/15/2017	0.57	0.30	Tributary_ColdWater
9/27/2017	0.43	0.30	Tributary_ColdWater
11/2/2017	0.62	0.30	Tributary_ColdWater

Number of Exceedances	*6*
Number of Samples	*6*
% Exceedance	*100%*

SummerSt

4/11/2017	0.46	0.30	Tributary
8/1/2017	0.40	0.30	Tributary

Number of Exceedances	*2*
Number of Samples	*6*
% Exceedance	*33%*

TracerLn

1/31/2017	0.37	0.30	Tributary
3/23/2017	0.33	0.30	Tributary
6/27/2017	1.16	0.30	Tributary
8/15/2017	0.66	0.30	Tributary
9/27/2017	0.52	0.30	Tributary
11/2/2017	0.61	0.30	Tributary

Number of Exceedances	*6*
Number of Samples	*6*
% Exceedance	*100%*

Start Date	1/1/2017	End Date	12/31/2017

WA-17				
	3/6/2017	0.33	0.30	Tributary
	4/11/2017	0.48	0.30	Tributary
	8/1/2017	0.36	0.30	Tributary
	8/29/2017	0.55	0.30	Tributary
	10/19/2017	0.41	0.30	Tributary
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		

TP

Site Name	Date	TP (mg/L)	TP Standard (mg/L)	Site Type
HB@KG				
	2/23/2017	0.02	0.02	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		
HB@MillSt				
	6/27/2017	0.04	0.02	Tributary
	8/15/2017	0.07	0.02	Tributary
	9/27/2017	0.03	0.02	Tributary
	11/2/2017	0.04	0.02	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
HBBelowDam				
	8/29/2017	0.03	0.02	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	TP (mg/L)	TP Standard (mg/L)	Site Type
IndustBrook				
	2/23/2017	0.05	0.02	Tributary
	3/21/2017	0.04	0.02	Tributary
	7/6/2017	0.03	0.02	Tributary
	10/3/2017	0.05	0.02	Tributary
	12/14/2017	0.04	0.02	Tributary
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		
LexBrook				
	8/1/2017	0.05	0.02	Tributary
	8/29/2017	0.04	0.02	Tributary
	10/19/2017	0.03	0.02	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
MBS				
	6/27/2017	0.05	0.02	Tributary
	8/15/2017	0.04	0.02	Tributary
	9/27/2017	0.03	0.02	Tributary
	11/2/2017	0.02	0.02	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
SaltDepot				
	6/27/2017	0.07	0.02	Tributary
	9/27/2017	0.03	0.02	Tributary
	11/2/2017	0.02	0.02	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		

Start Date	1/1/2017	End Date	12/31/2017

Site Name	Date	TP (mg/L)	TP Standard (mg/L)	Site Type
SB@Viles				
	6/27/2017	0.04	0.02	Tributary_ColdWater
	11/2/2017	0.03	0.02	Tributary_ColdWater
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		
SummerSt				
	8/29/2017	0.04	0.02	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		
TracerLn				
	6/27/2017	0.16	0.02	Tributary
	8/15/2017	0.06	0.02	Tributary
	9/27/2017	0.04	0.02	Tributary
	11/2/2017	0.05	0.02	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
WA-17				
	4/11/2017	0.09	0.02	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

Turbidity

Site Name	Date	Turbidity (NTU)	Turbidity Standard (NTU)	Site Type
HB@KG				
	8/31/2017	1.68	1.68	Tributary
	12/14/2017	1.68	1.68	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Turbidity (NTU)	Turbidity Standard (NTU)	Site Type
HB@MillSt				
	6/27/2017	2.61	1.68	Tributary
	8/15/2017	4.90	1.68	Tributary
	9/27/2017	5.23	1.68	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
HBBelowDam				
	8/1/2017	2.65	1.68	Tributary
	8/29/2017	4.30	1.68	Tributary
	10/19/2017	2.02	1.68	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
IndustBrook				
	2/23/2017	5.38	1.68	Tributary
	3/21/2017	3.42	1.68	Tributary
	7/6/2017	2.37	1.68	Tributary
	10/3/2017	3.38	1.68	Tributary
	12/14/2017	2.92	1.68	Tributary
Number of Exceedances		*5*		
Number of Samples		*6*		
% Exceedance		*83%*		
LexBrook				
	10/19/2017	13.50	1.68	Tributary
Number of Exceedances		*1*		
Number of Samples		*6*		
% Exceedance		*17%*		

Start Date 1/1/2017 End Date 12/31/2017

Site Name	Date	Turbidity (NTU)	Turbidity Standard (NTU)	Site Type
MBS				
	8/15/2017	2.25	1.68	Tributary
	9/27/2017	2.15	1.68	Tributary
Number of Exceedances		*2*		
Number of Samples		*6*		
% Exceedance		*33%*		
SaltDepot				
	6/27/2017	8.05	1.68	Tributary
	8/15/2017	4.70	1.68	Tributary
	9/27/2017	7.36	1.68	Tributary
Number of Exceedances		*3*		
Number of Samples		*6*		
% Exceedance		*50%*		
TracerLn				
	6/27/2017	12.20	1.68	Tributary
	8/15/2017	15.00	1.68	Tributary
	9/27/2017	7.10	1.68	Tributary
	11/2/2017	1.86	1.68	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		
WA-17				
	4/11/2017	15.20	1.68	Tributary
	8/1/2017	2.80	1.68	Tributary
	8/29/2017	4.03	1.68	Tributary
	10/19/2017	4.26	1.68	Tributary
Number of Exceedances		*4*		
Number of Samples		*6*		
% Exceedance		*67%*		