FY2015-FY2019 Water Quality Monitoring Report

Upland Stormwater Lakes and Pump Stations

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Acronyms

%Sat	Percent Saturation
Ammonia as N	Ammonia as Nitrogen
°C	Degrees Celsius
CFU/100mL	Colony forming unit per 100 milliliters
DO	Dissolved Oxygen
DO Sat	Dissolved Oxygen Saturation
FDEP	Florida Department of Environmetal Protection
FY	Fiscal Year
GeoMean	Geometric Mean
MDL	Minimum Detection Limit
Mg/L	milligrams per liter
NNC	Numeric Nutrient Criteria
NOAA	National Oceanic and Atmospheric Adminstration
NO_x	Nitrate-Nitrite Nitrogen
NTU	Nephelometric Turbidity Unit
OrthoP	Orthophosphorus
PQL	Practical quantitation limit
QA/QC	Quality Assurance/Quality Control
SC	Specific Conductivity
SU	Standard Units
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
U	Undetected
µg/L	micrograms per liter
µmhos/cm	micro ohms per centimeter

Executive Summary

Summary of Upland Stormwater Lakes from FY 2015 through FY 2019

Monitoring results from data collected at stormwater lakes were reviewed to identify any outliers that exceed Class III Surface Water Quality Standards (Class III Standards are used as a reference for sampling data only) within the data collected over Fiscal Years (FY) 2015 through 2019 amongst all stormwater lakes and pump stations. Nutrient parameters (total nitrogen, total phosphorus, chlorophyll-*a*) were variable by station and drainage basin from FY 2015 through 2019. Total nitrogen (TN) had a five-year mean that was fairly consistent (average between 0.94 and 1.89 mg/L) with the highest five-year average observed in 24B (3.70 mg/L) and 8B (3.04 mg/L). Total Phosphorus (TP) concentrations were consistently below 0.2 mg/L for the duration of the five year sampling period, with the five-year mean below 0.11 mg/L at all stations. One of the stormwater lakes draining to Naples Bay, 24B, had higher overall TP values with a five-year mean of 1.96 mg/L and a maximum concentration of 3.02 mg/L.

Chlorophyll-*a* concentrations at stormwater lakes draining to Moorings Bay (1SE-B, 2B, 3B, and 5B), were the lowest at 1SE-B, while the remaining three lakes had variable spikes in chlorophyll-*a* over the five-year sampling period. Stations that ultimately drain to the Gordon River (6B, 15B, 19B, 20B, 22B, and 26B) were variable with most chlorophyll-*a* concentrations ranging from undetected (0.25 µg/L) to 779 µg/L. Stations that ultimately drain to Naples Bay (11B, 14B, and 24B) and the Gulf of Mexico (8B, 9B, 10B) had more variable chlorophyll-*a* concentrations ranging from around 2.59 to 255 µg/L over the five-year period.

Copper concentrations appeared to be fairly similar over the five year period with averages at 14 of the lakes ranging from 1.58 to 10.54 µg/L; the highest concentrations were found at one lake draining to Moorings Bay (1SE-B) and one draining to the Gordon River (26B), with maximum concentrations of 436 µg/L (26B) and 1160 µg/L (1SE-B). Higher overall copper concentrations indicate potential use of copper sulfate in these lakes.

Fecal coliform and enterococci colony counts were variable throughout the FY 2015 to 2019 sampling period with isolated spikes in colony count appearing to occur after isolated stormwater inflows. Fecal coliform and enterococci values did have a slight upward visual trend for most of the stormwater lakes during the wet season (June to September) which is likely in response to increased rainfall during the rainy season.

Summary of Stormwater Lake Statistical Analysis

As part of the five year reporting update, a series of statistical analysis was used to identify trends within the data and include: creation of box plots to summarize the spread and variability of the data collected, a correlation analysis using the 30-day sum of rainfall data prior to the sampling event and each water quality parameter, a Mann Kendall (annual Kendall) analysis using annual median values for each lake, and a one-way analysis of variance (ANOVA) comparing all lakes within each basin.

Box plots were created to visually compare the median and first and third quartile ranges at the three pump station stations for each parameter for each fiscal year and represent the distribution of the data. Box plots were variable throughout the FY 2015 to 2019 range with data collected after 2017 having a smaller distribution for most parameters. Data for temperature, DO, pH, and specific conductivity (SC) had the largest variability within the data regardless of drainage basin. Concentrations of TN, nitrate-nitrite, and TKN had more consistent results with a narrow range for three of the five years collected (2017-2019) compared to the previously discussed parameters. Chlorophyll-*a*, orthophosphate, TP, and TSS also had fairly consistent ranges with isolated spikes in the 2017 to 2019 data set. The wide range in copper concentrations in lakes 26B and 1SE-B correspond to multiple elevated measurements (most likely caused by repeated treatment with copper sulfate). Finally, bacterial ranges for both fecal coliform and enterococci for lakes draining to Moorings Bay had less variability during 2017-2019, while lakes draining to Naples Bay had the greatest variability and range during 2017-2019.

Spearman's Rank Correlations above 0.50 generally represent a strong relationship between rainfall and the water quality variable, indicating rainfall accounts for at least half of the driving factor in increases or decreases in that parameter. In general, if there was a relationship with a water quality parameter and rainfall, it tended to be the same between lakes, with few exceptions. For lakes draining to Moorings Bay, there was a positive correlation between 30-day NOAA rainfall and temperature, orthophosphate, fecal coliform, and enterococci with at least one lake indicating that higher rainfall totals had parameters with elevated concentrations (Spearman's Rank Correlation, $p < 0.05$). Conversely, there was a negative correlation between 30-day NOAA rainfall and DO, pH, SC, salinity, TN, nitrate-nitrite, TKN, TSS, copper, and hardness indicating that when rainfall was elevated, these concentrations were lower (Spearman's Rank Correlation, $p < 0.05$). Chlorophyll-*a* had a positive correlation with rainfall at 1SE-B, but a negative correlation with rainfall at 5B.

The Kendall Tau analysis (or Mann Kendall) used the fiscal year median for each parameter at each lake, to determine the presence of statistically significant increasing or decreasing trends with a corresponding slope. In general, lakes draining to Moorings Bay had statistically significant decreasing trend over time for chlorophyll-*a*, nitrate-nitrite, orthophosphate, TP, TSS, and copper. A statistically significant increasing trend in water temperature at 5B (slope 1.19 °C/yr) was also noted. For the lakes draining to the Gordon River, there were statistically significant decreasing trends for nutrient parameters and TSS (Mann Kendall, $p < 0.05$). These decreases include decreasing trends for TP, TSS, TN and TKN which all indicate concentrations of nutrients and TSS are gradually decreasing at various lakes draining to the Gordon River over the five-year sampling period. Lake 9B, which drains to the Gulf of Mexico had decreases in SC and salinity. This lake also had a statistically significant decreasing trend in DO. The remaining lakes draining either to the Gulf of Mexico or Naples Bay had statistically significant increasing trends in TN, TKN, ammonia, copper and enterococci.

The ANOVA was used to determine if there were differences in water quality parameters among stations in each of the drainage basins. For lakes draining to Moorings Bay, there were statistically significant differences among stations for half of the parameters (ANOVA, $p < 0.05$). Lakes draining to the Gordon River, also had significant differences among stations for most parameters (ANOVA, $p < 0.05$). For lakes draining to Naples Bay or the Gulf of Mexico, all but two parameters (temperature and copper) had statistical differences among stations (ANOVA, $p < 0.05$).

Quarterly pump station water quality monitoring data was available from FY 2015 to 2019. Field measurements (temperature, dissolved oxygen, pH, SC, salinity, and turbidity) at all stations appeared to be consistent with expected temporal and seasonal variations. Nutrients remained fairly consistent during the sampling period; the exception is the rainfall-induced spikes in copper and mercury during August 2019 at 14-Pump. Fecal coliform measurements at all pump stations exceeded the Florida Class III Surface Water Quality Standards during this 2019 monitoring year, but Class III Standards are used only as a reference for sampling data. The data indicates that rainfall is driving fecal coliform and enterococci spikes at the pump stations.

Management Recommendations

During the FY 2015 to 2019 monitoring period, water quality parameters were variable both spatially and temporally. Challenges managing stormwater and the associated nutrients are complex and often require a multifaceted approach to adequately address the many sources of nutrient loading into lakes, ponds and stormwater systems.

Overall management strategies have had a positive effect on water quality as seen in the decreasing trends in TP, TSS, TN and TKN for lakes draining into Gordon River and Moorings Bay, which all indicate concentrations of nutrients and TSS have been decreasing over the last five years. Additional management strategies for TN, TKN, ammonia, copper, and DO concentrations may be necessary for lakes draining into Naples Bay or the Gulf of Mexico and may include: additional littoral plantings, mechanical removal of organic muck, retrofitting stormwater conveyance systems with additional filter treatment systems, changes in the duration and timing of street sweeping program, routine maintenance of catchment basins, the use of binding agents, and additional aeration. Management of fecal coliform and enterococci levels within stormwater ponds may benefit from changes to the frequency and timing of street sweeper programs within these basins. Installing and maintaining pet waste stations coupled with targeted stormwater education/outreach may provide an effective management strategy for reducing bacterial loading from stormwater

Trends from the last five years indicate that additional data is needed to further identify trends in the data versus potential seasonal outliers caused by natural variability (rainfall, temperature, hurricanes, etc.), which will aid in future management decisions. Data from the upcoming FY 2020 sampling will help to identify potential trends that can be addressed with management decisions.

1 Introduction

This summary report provides the results from Fiscal Year (FY) 2015 through 2019 water quality monitoring of the City of Naples Streets and Stormwater Department (City) stormwater lakes and pump stations (Table 1 and Figure 1). All lakes listed below were originally sampled three times in FY 2015 (December 2014, February 2015, and July 2015), quarterly in FY 2016, and then monthly or quarterly as described. Monthly sampling was completed at the following ten lakes: Devils Lake (1SE-B), Swan Lake (2B), Colonnade Lake (3B), Lake Suzanne (5B), South Lake (9B), 15th Avenue North Lake-WTP Lake (19B), Forest Lake (20B), Lake Manor (22B), and NCH Lake (26B); the remaining six stormwater lakes Mandarin Lake (6B), Sun Lake Terrace (15B), Alligator Lake (10B), East Lake (11B), Lantern Lake (14B), and Half Moon Lake (24B) were sampled quarterly. The stations sampled and frequency of sampling during FY 2018 and 2019 (October 2017 to September 2019) was based on the updated survey design that began in October 2016 and also included one additional lake, North Lake (8B). Pump station monitoring was also conducted on a quarterly basis from FY 2016 to 2019. None of the lakes or pump stations sampled for this report qualify as Class III waterbodies at this time, and the Class III Surface Water Quality Standards are used as a reference value only throughout this report. This summary report provides water quality results collected by Cardno staff from December 2014 to September 2019.

Table 1. City of Naples stormwater lakes and pump station names, station coordinates, drainage basin, and sampling frequency.

Monitoring Station	Lake Name	Drainage Basin	Latitude	Longitude	Sampling Frequency
1SE-B	Devils Lake	Moorings Bay	26.2054	-81.8081	Monthly
2B	Swan Lake		26.1980	-81.8067	
3B	Colonnade Lake		26.1935	-81.8067	
5B	Lake Suzanne		26.1831	-81.8018	
6B	Mandarin Lake	Gordon River	26.1646	-81.7989	Quarterly
15B	Sun Lake Terrace		26.1811	-81.7924	
19B	15th Ave N Lake (WTP Lake)		26.1660	-81.7950	Monthly
20B	Forest Lake		26.1621	-81.7944	
22B	Lake Manor		26.1565	-81.7921	
26B	NCH Lake		26.1495	-81.7975	
8B	North Lake	Gulf of Mexico	26.1549	-81.8027	
9B	South Lake		26.1534	-81.8034	
10B	Alligator Lake		26.1520	-81.8072	Quarterly
11B	East Lake	Naples Bay	26.1385	-81.7990	
14B	Lantern Lake		26.1163	-81.7998	
24B	Half Moon Lake		26.1151	-81.7995	
PW-Pump	Public Works Pump	Pump Stations	26.1509	-81.7902	Quarterly
11-Pump	Cove Pump		26.1341	-81.7939	
14-Pump	Port Royal Pump		26.1155	-81.7987	

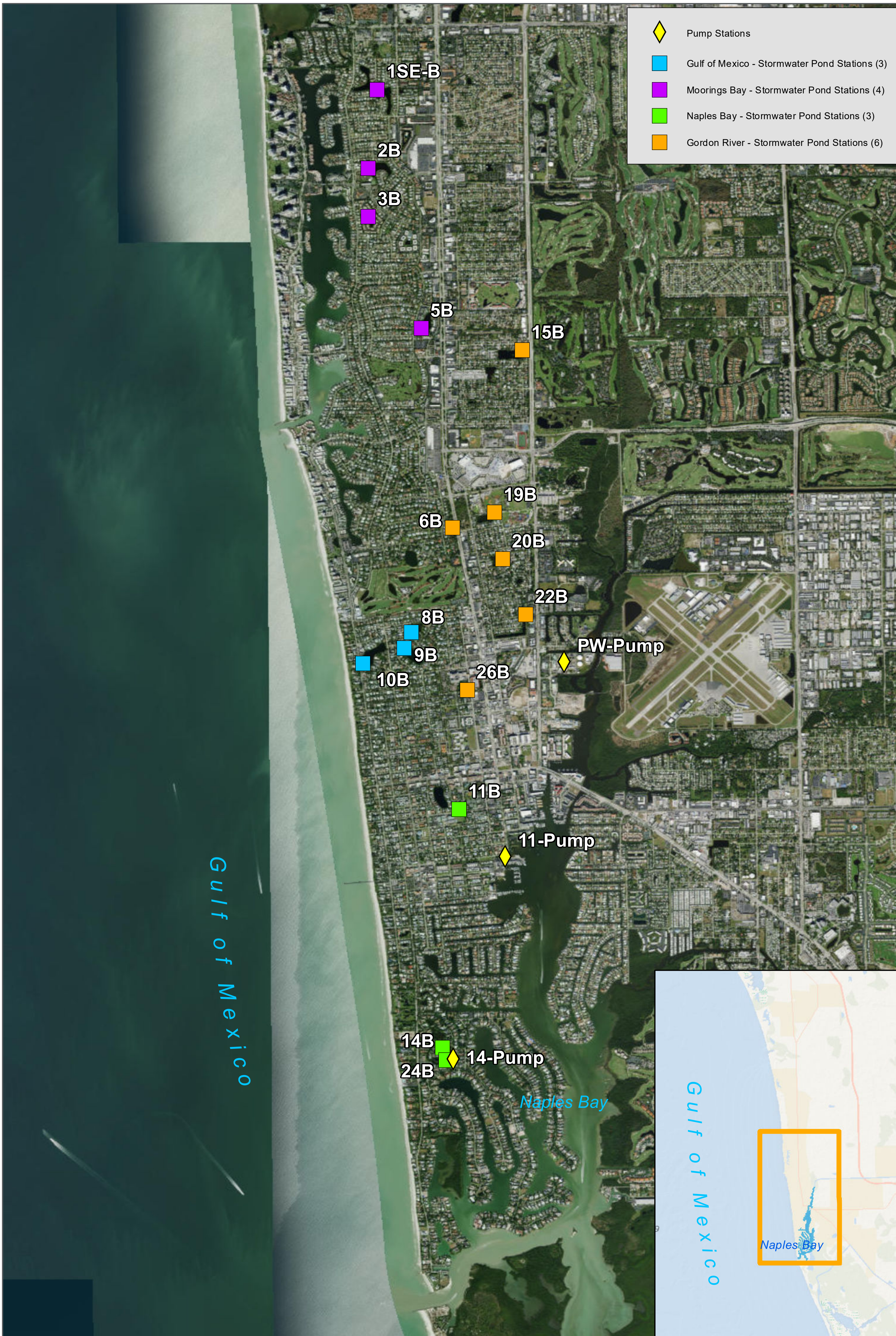

Image:2018

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Figure 1. Stormwater Lakes and Pump Stations

City of Naples, Natural Resources Division
Collier County, Florida

0 3,000 6,000 Feet
0 900 1,800 Meters

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Date Created: 7/7/2020 Date Revised: 7/7/2020 File Path: Q:\UnitedStates\Florida\Tampa\City_Of_Naples\Water Quality Analysis Project\working\arcmap\Fig3_6_CON_Stmwtr_Pond_Locations_20200707.mxd
GIS Analyst: James.Bottiger

2 Upland Stormwater Lakes

2.1 Water Quality Summaries

The following table and time series plots summarize both field and lab water quality measurements collected by Cardno staff at designated stormwater lake monitoring stations (Figure 1) from December 2014 to September 2019.

Stormwater lake samples were collected at the control structures to represent water quality exiting the lake. Table 2 includes a summary of total number of sampling events as well as minimums, maximums, and five-year means for total nitrogen (TN), total phosphorus (TP), chlorophyll-*a*, and copper for each stormwater lake.

Results of all sampled water quality parameters from FY 2015 through FY 2019 are detailed in time series plots (Figures 2-19) in Sections 2.1.1 and 2.1.2. Monitoring stations are grouped on plots by the associated final drainage destinations (water bodies) and are as followed: Monitoring stations 1SE-B, 2B, 3B, and 5B correspond with lakes that discharge into Moorings Bay (represented with ■); 6B, 15B, 19B, 20B, 22B, and 26B correspond with lakes that ultimately discharge into the Gordon River (represented with a ●); and lakes 8B, 9B, 10B, 11B, 14B, and 24B correspond with lakes whose final discharge destination is either Naples Bay or the Gulf of Mexico (represented with a ▲, AMEC 2012).

Table 2. Minimums, maximums, and five-year means of total nitrogen, total phosphorus, chlorophyll-*a*, and copper for stormwater lakes in Naples, Florida from December 2014 to August 2019.

Lake Name	Monitoring Station	Associated Waterbody	Sample Period	Number of Samples	Total Nitrogen (mg/L)			Total Phosphorus (mg/L)			Chlorophyll-*a* (µg/L)			Copper (µg/L)		
					Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Devils Lake	1SE-B	Moorings Bay	Dec 14-Aug 19	42	0.71	1.99	1.09	U (0.008)	0.21	0.05	U (0.25)	15.70	4.68	U (0.346)	1160	60.38
Swan Lake	2B		Dec 14-Aug 19	36	0.61	2.42	1.28	U (0.008)	0.39	0.12	0.86	135	33.87	1.31	59.4	8.42
Colonnade Lake	3B		Dec 14-Aug 19	42	0.72	1.85	1.13	0.013	0.25	0.11	4.65	492.0	36.58	1.00	23.6	4.96
Lake Suzanne	5B		Dec 14-Aug 19	42	0.57	2.50	1.23	0.066	0.45	0.15	0.67	290.0	37.68	U (0.346)	30.10	5.34
Mandarin Lake	6B	Gordon River	Dec 14-Aug 19	27	0.68	1.87	1.15	0.016	0.16	0.09	1.24	73.8	20.54	U (0.346)	9.40	1.58
Sun Lake Terrace	15B		Dec 14-Aug 19	27	0.65	2.03	1.15	0.038	0.36	0.05	U (0.25)	41.0	14.96	1.28	65.70	8.67
15th Ave N Lake (WTP Lake)	19B		Dec 14-Aug 19	42	0.90	4.33	1.45	0.009	0.27	0.09	2.45	252.0	38.90	U (0.346)	7.40	1.29
Forest Lake	20B		Dec 14-Aug 19	42	0.72	6.69	1.89	0.026	0.42	0.10	U (0.25)	511	60.46	U (0.346)	8.00	1.27
Lake Manor	22B		Dec 14-Aug 19	42	0.36	2.84	0.94	U (0.008)	0.27	0.08	3.46	41.6	15.45	U (0.346)	25.60	2.36
NCH Lake	26B		Dec 14-Aug 19	42	0.59	7.75	1.24	U (0.008)	0.19	0.08	11.0	779	51.16	7.24	436	80.08
North Lake	8B	Gulf of Mexico	Oct 17-Aug 19	23	1.13	10.50	3.04	0.014	1.07	0.21	25.9	249	85.14	1.40	41	7.40
South Lake	9B		Dec 14-Aug 19	42	1.20	4.92	1.78	0.053	0.56	0.20	3.88	236	58.28	1.00	47.2	8.95
Alligator Lake	10B		Dec 14-Aug 19	21	0.90	1.98	1.28	0.085	0.20	0.11	5.21	91.5	31.58	U (0.272)	22.30	3.55
East Lake	11B	Naples Bay	Dec 14-Aug 19	21	0.56	1.43	1.05	0.112	0.40	0.13	2.59	56.4	22.26	1.00	13.70	4.69
Lantern Lake	14B		Dec 14-Aug 19	21	1.25	2.75	1.91	0.311	1.04	0.51	10.9	266.0	71.98	U (0.272)	99.3	10.54
Half Moon Lake	24B		Dec 14-Aug 19	21	0.72	5.72	3.70	1.90	3.02	1.96	56	255	133.833	0.83	13.00	3.34

Gray shaded rows indicate monitoring stations that typically have specific conductivities of 4580 µS/cm or higher; Class III Marine Standards are provided as reference only.

2.1.1 Time Series Plots of Field Parameters

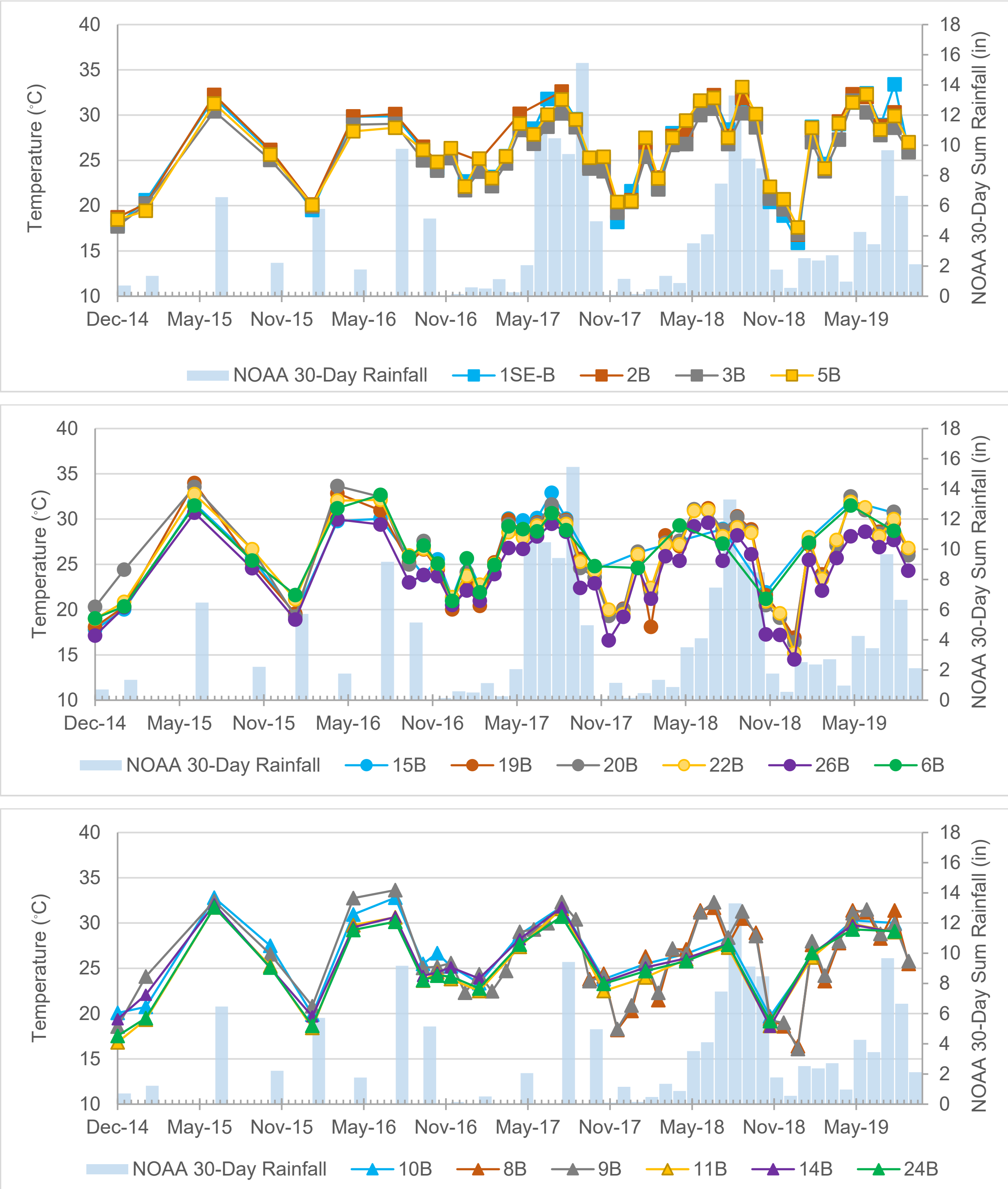


Figure 2. Time series plots of water temperature and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

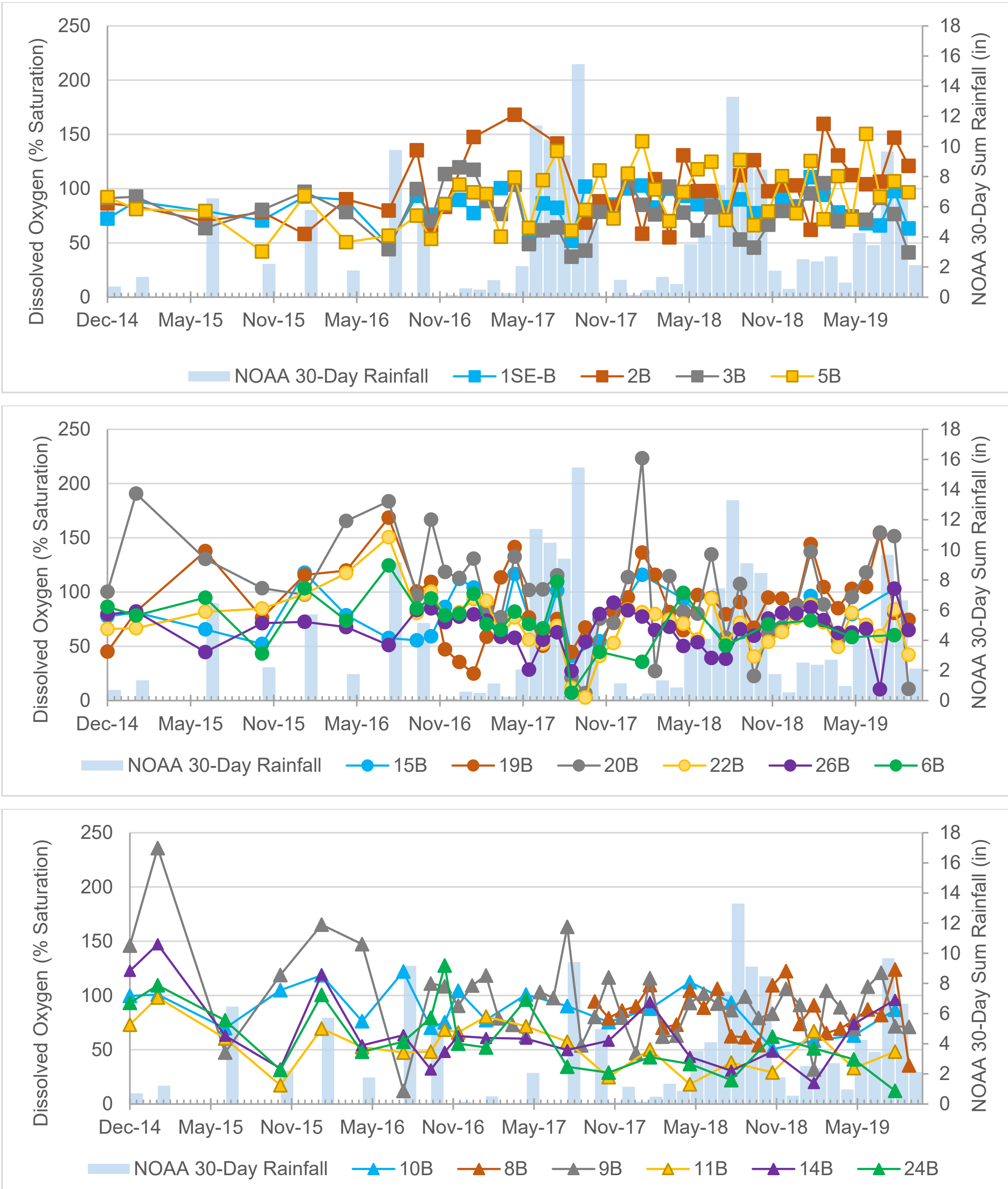


Figure 3. Time series plots of dissolved oxygen saturation and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

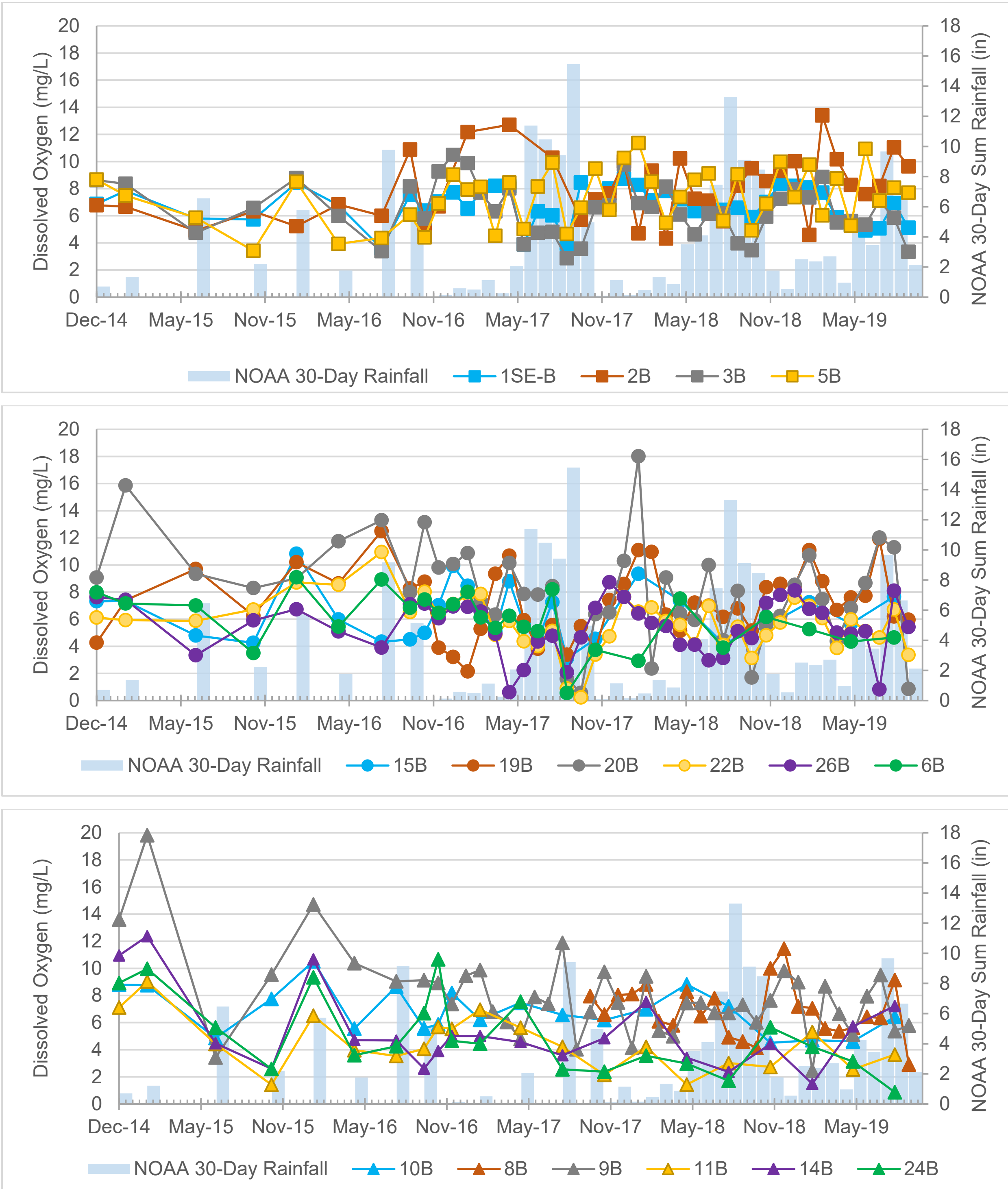


Figure 4. Time series plots of dissolved oxygen concentration (mg/L) and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

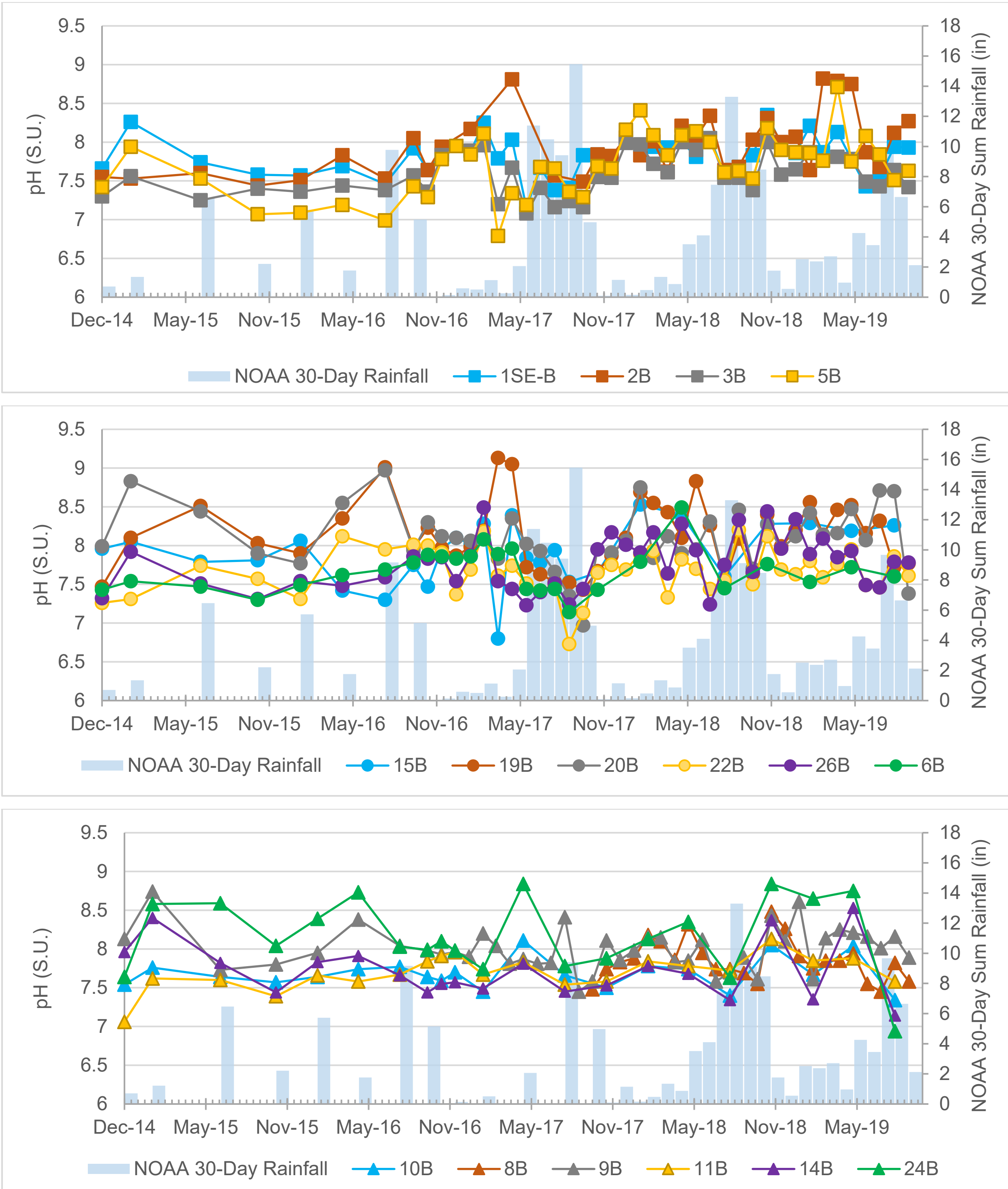


Figure 5. **Time series plots of pH and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).**

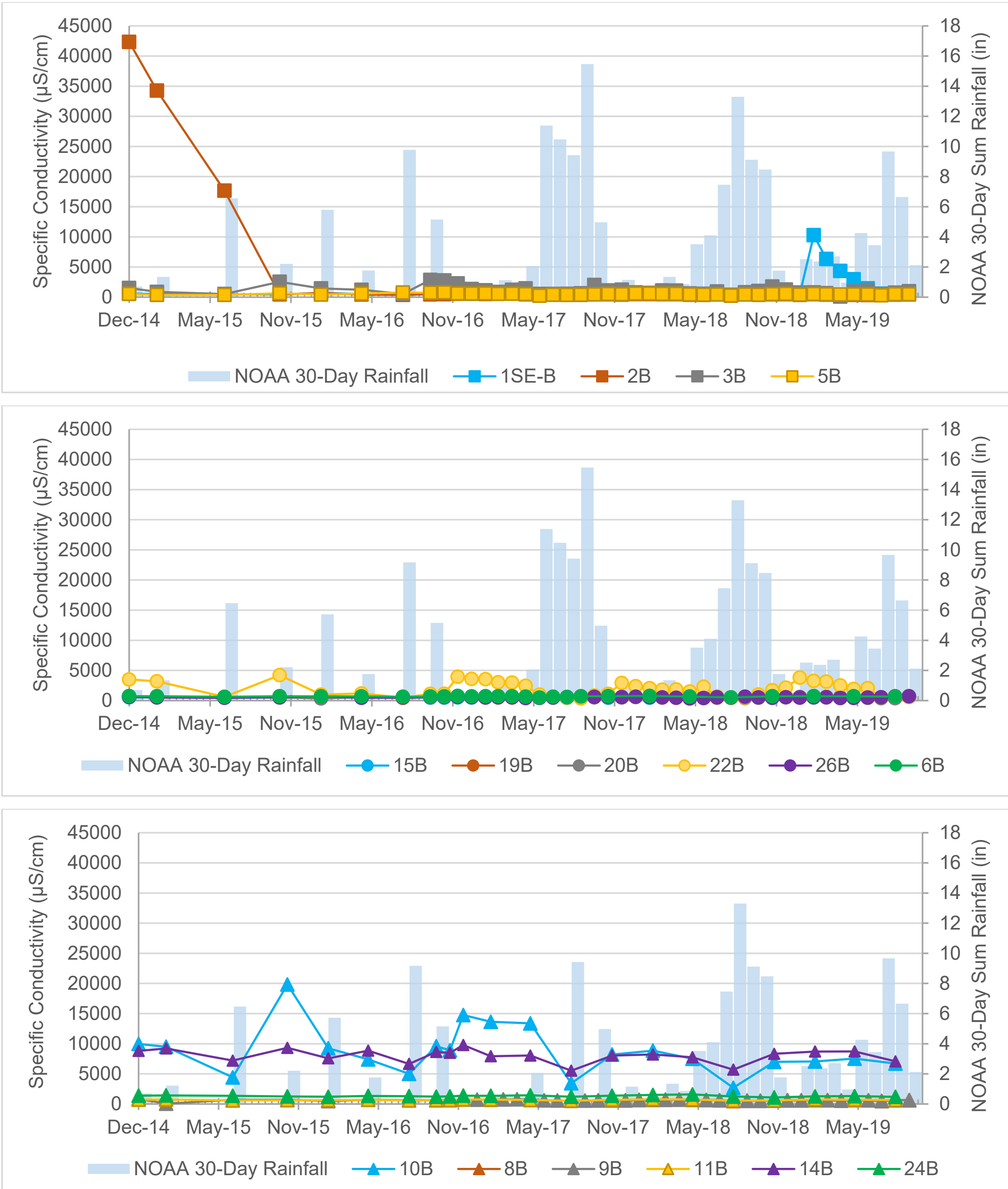


Figure 6. **Time series plots of specific conductivity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).**

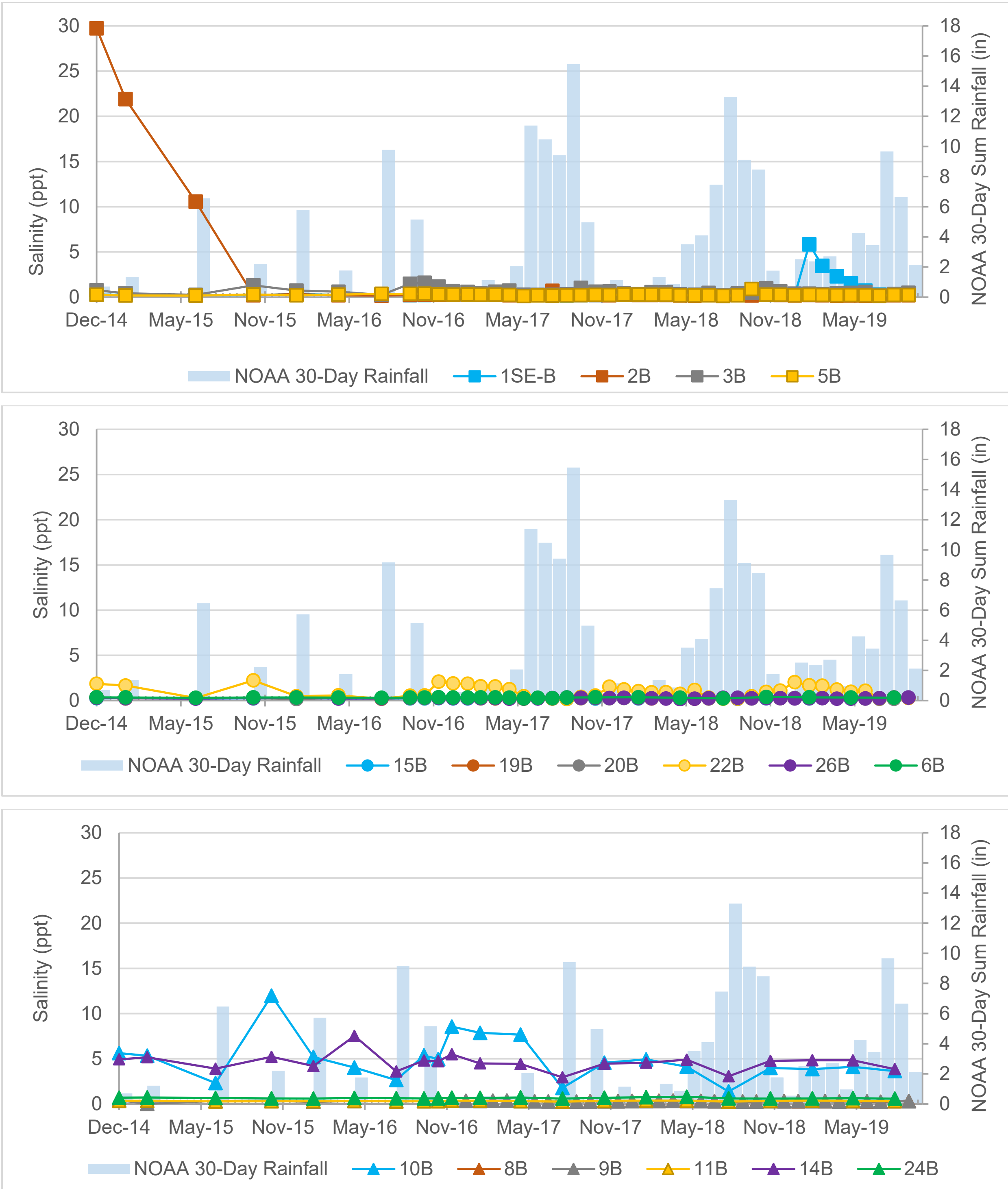
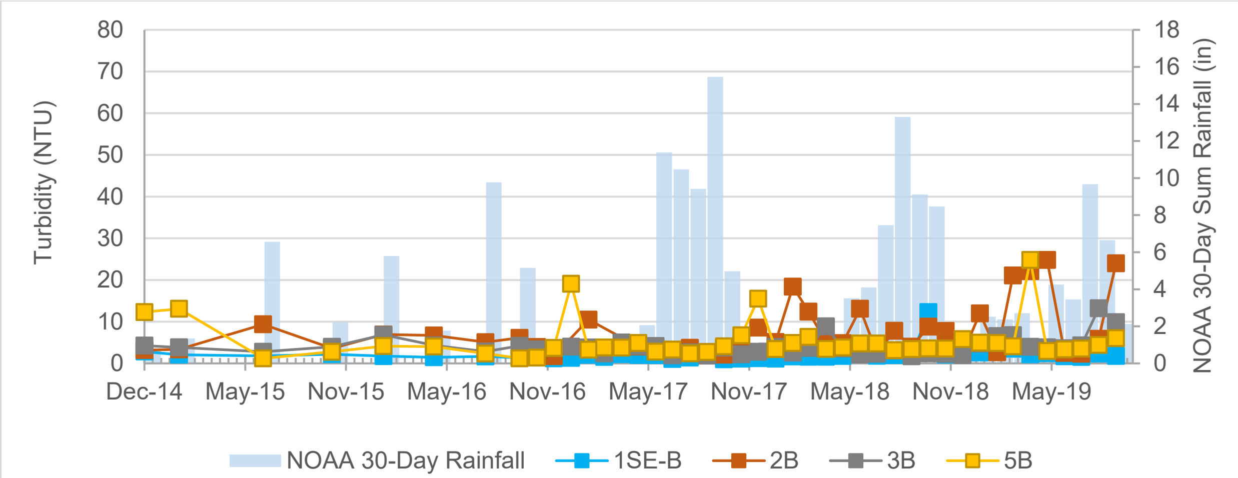
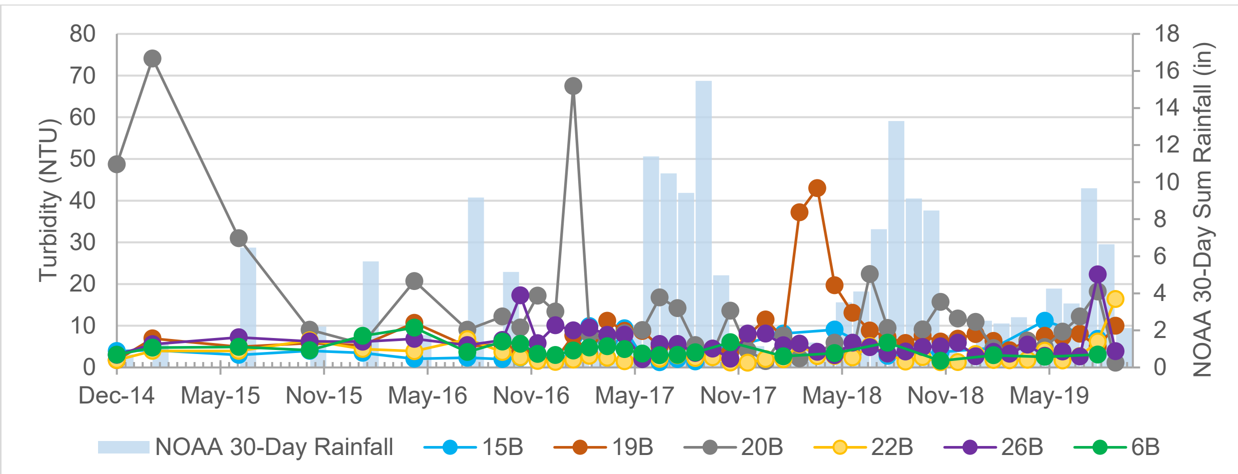


Figure 7. Time series plots of salinity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).





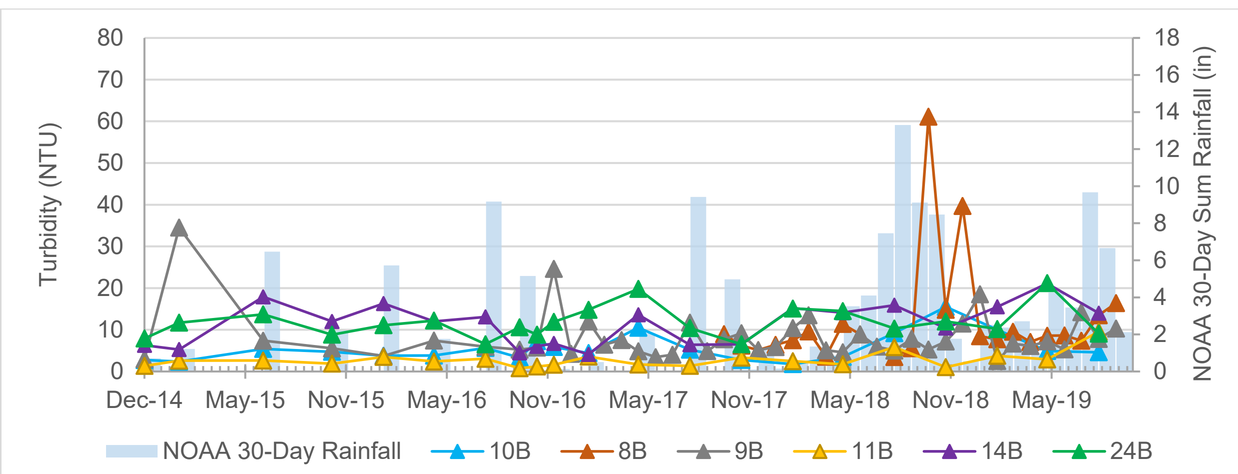


Figure 8. Time series plots of turbidity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

2.1.2 Time Series Plots of Lab Parameters

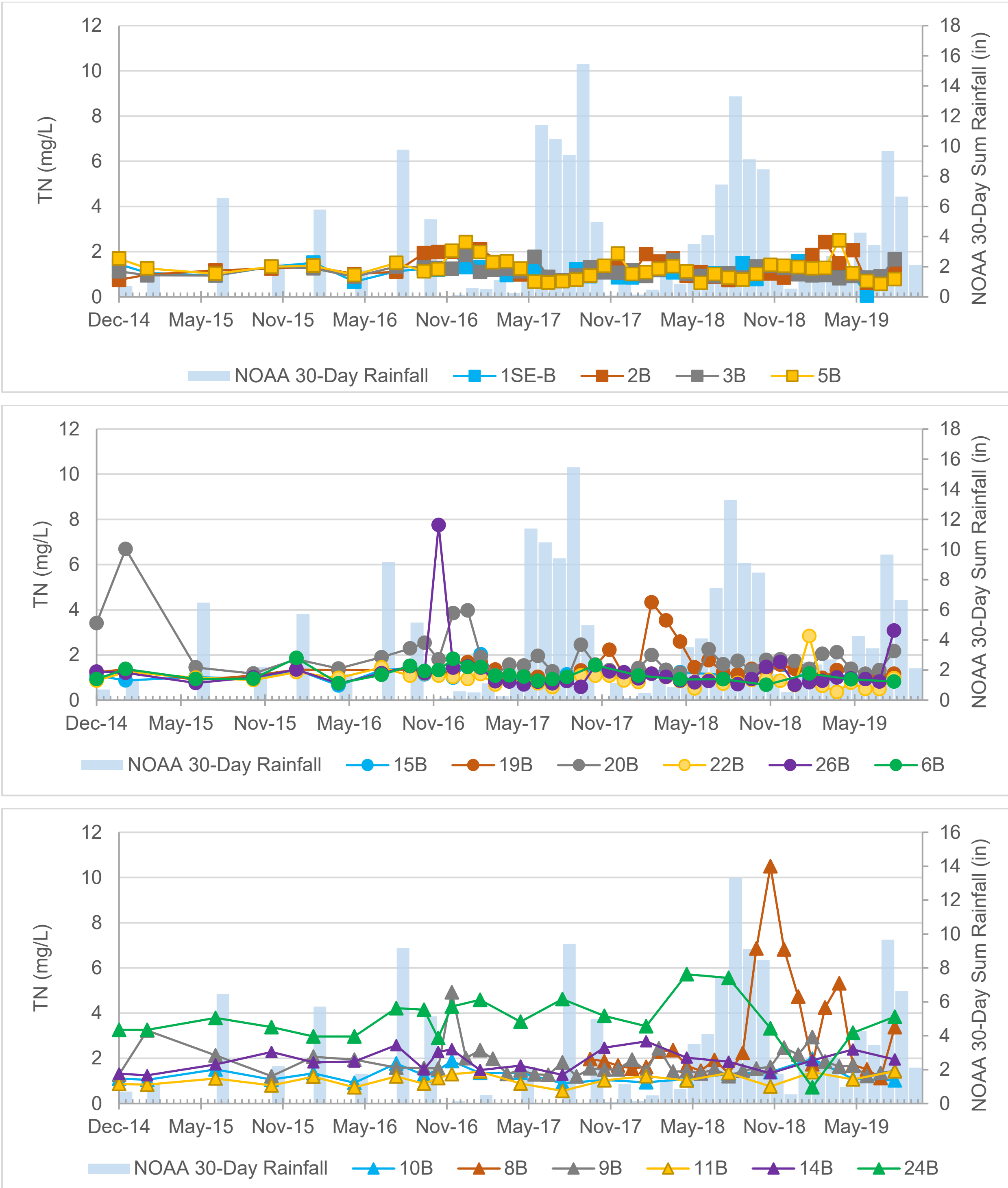


Figure 9. Time series plots of total nitrogen and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

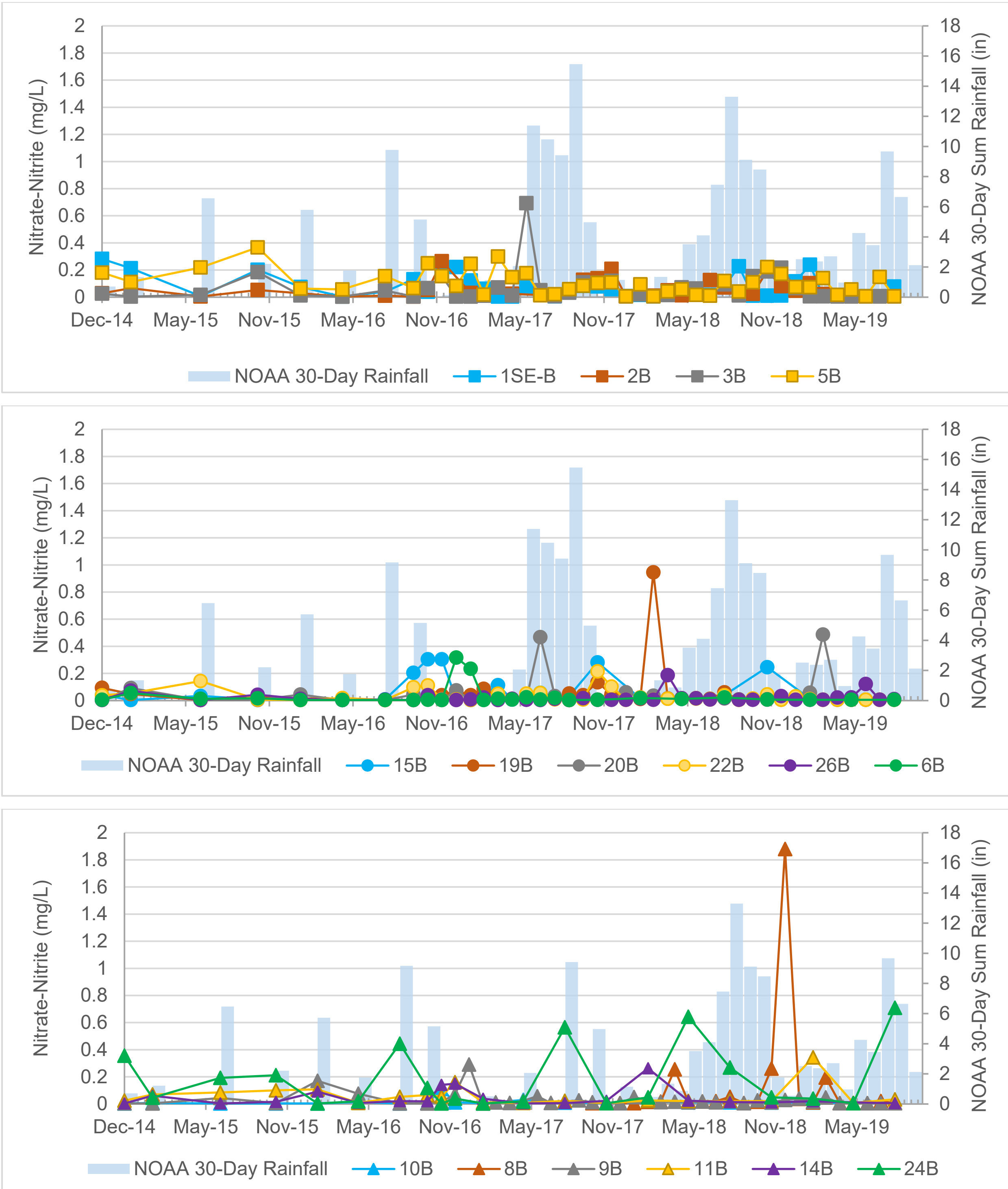


Figure 10. Time series plots of nitrate-nitrite and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

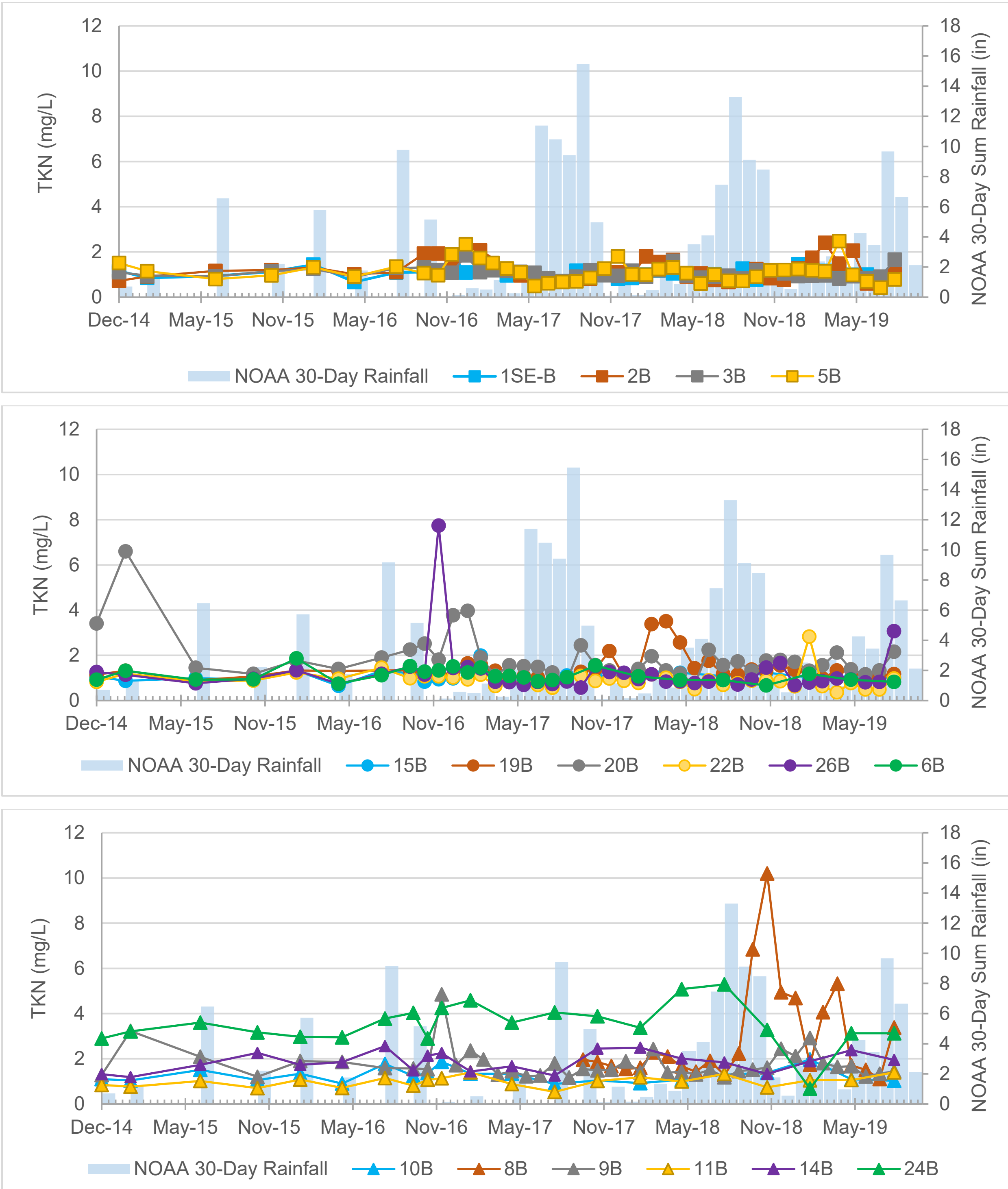


Figure 11. Time series plots of Total Kjeldahl Nitrogen and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

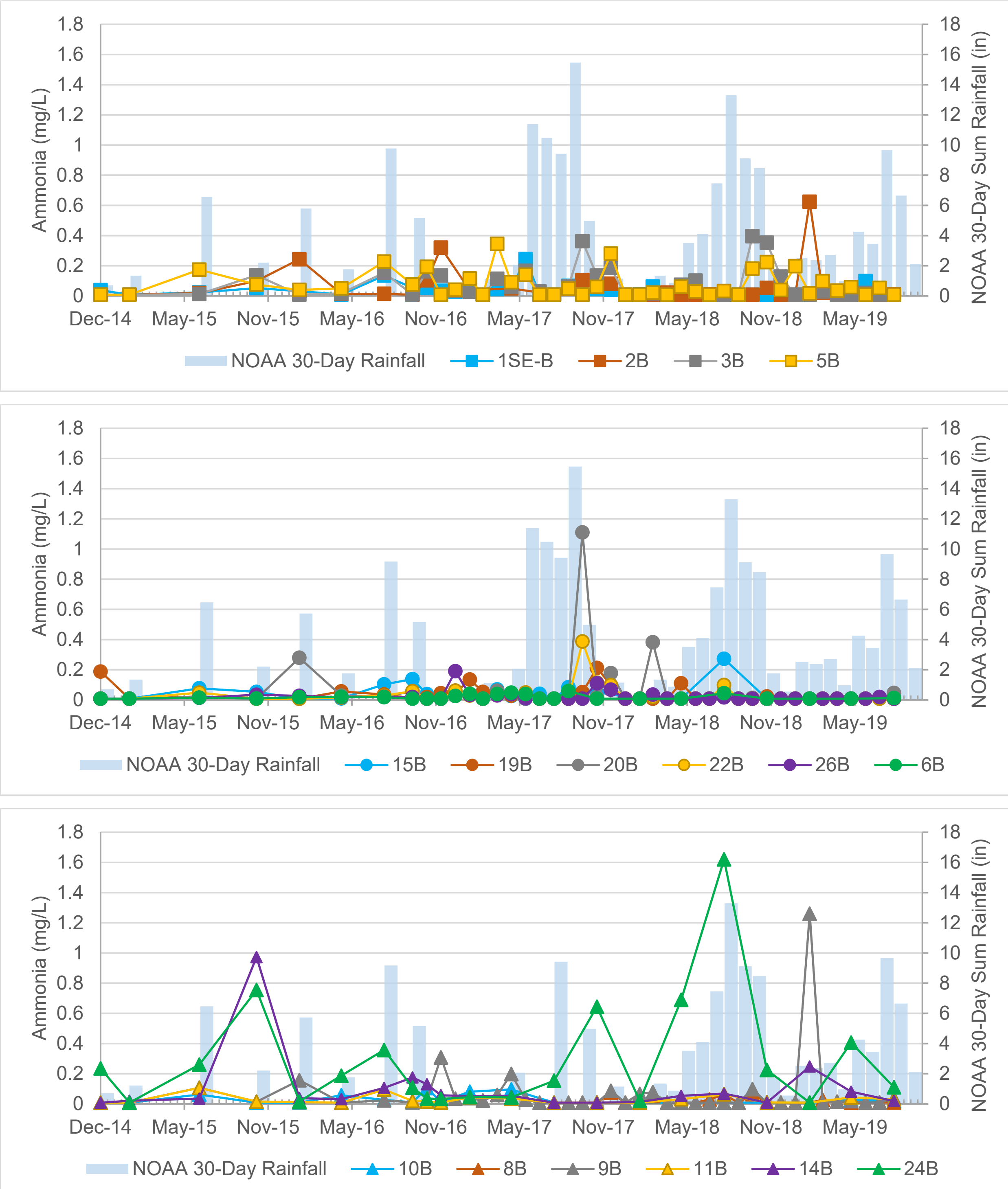


Figure 12. **Time series plots of ammonia nitrogen and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).**

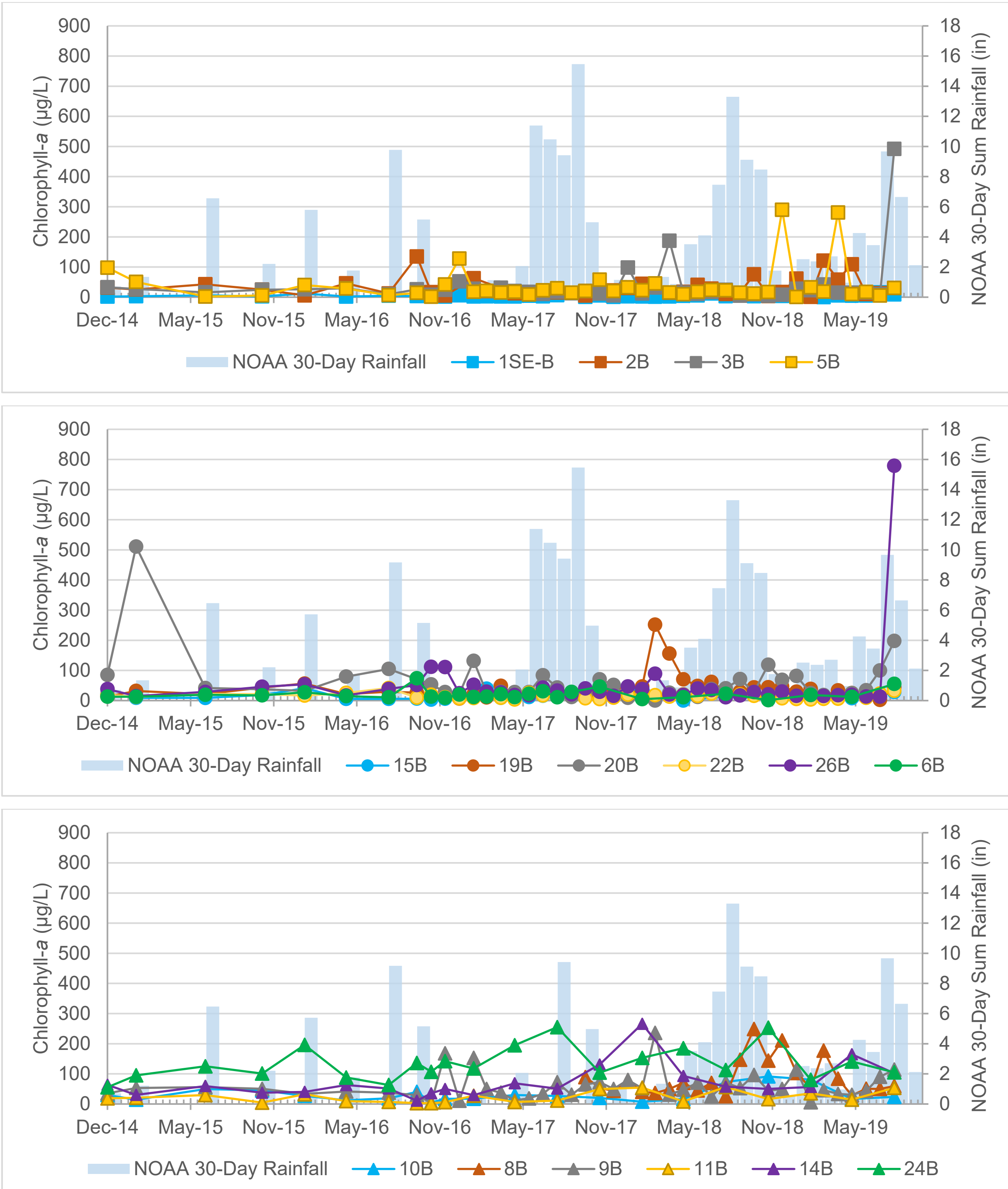


Figure 13. Time series plots of chlorophyll-*a* and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

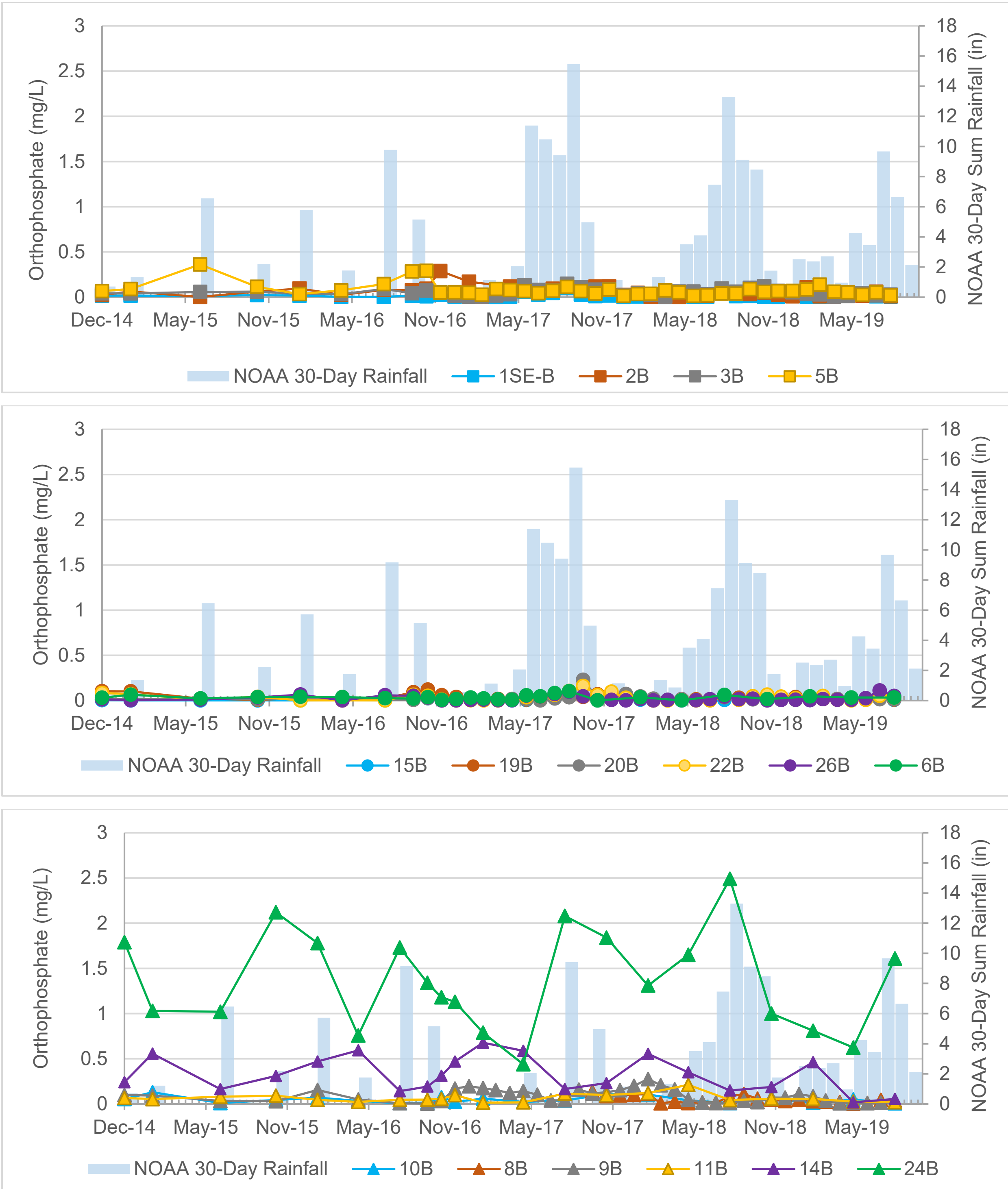


Figure 14. Time series plots of orthophosphate and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

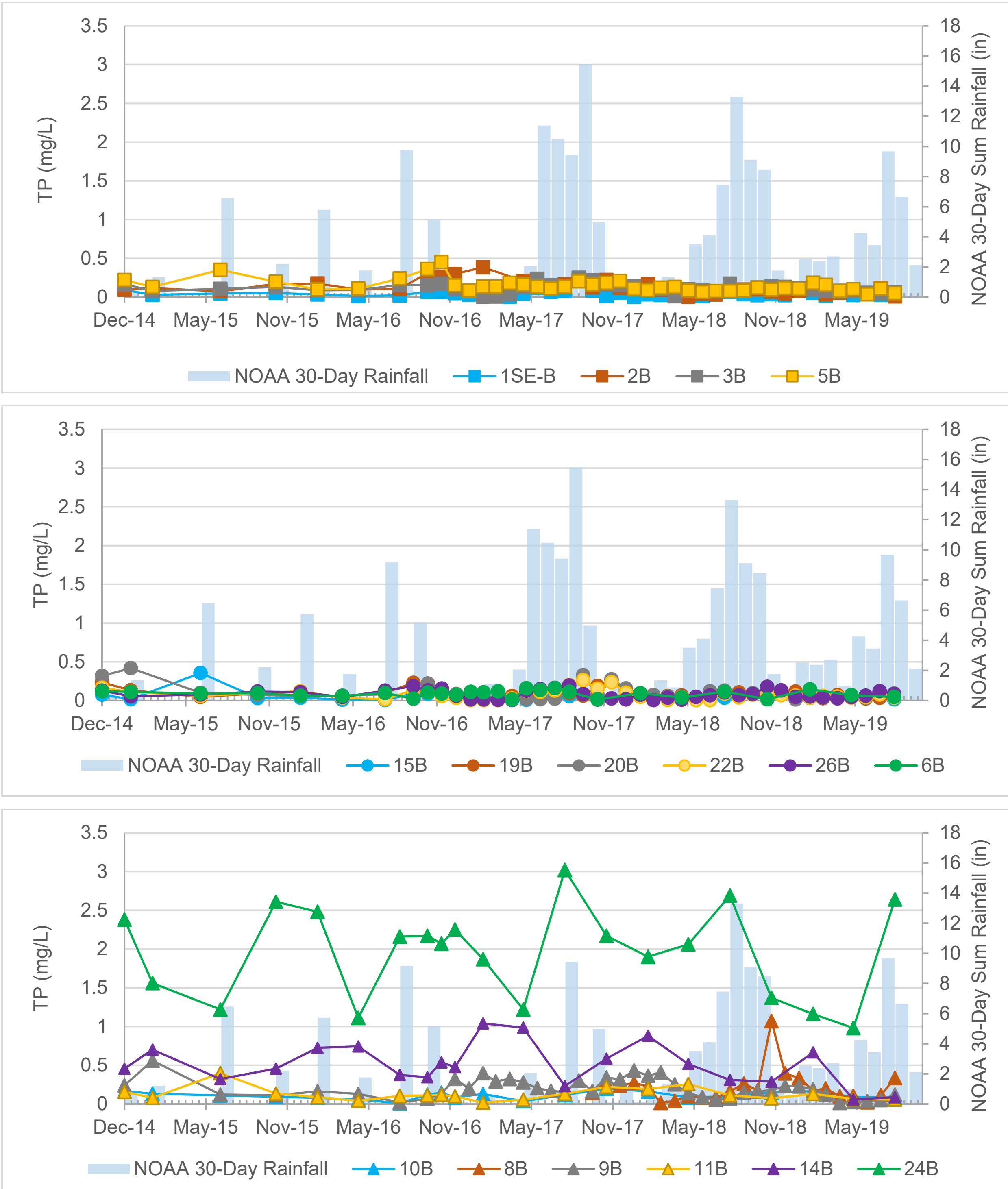


Figure 15. Time series plots of total phosphorus and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

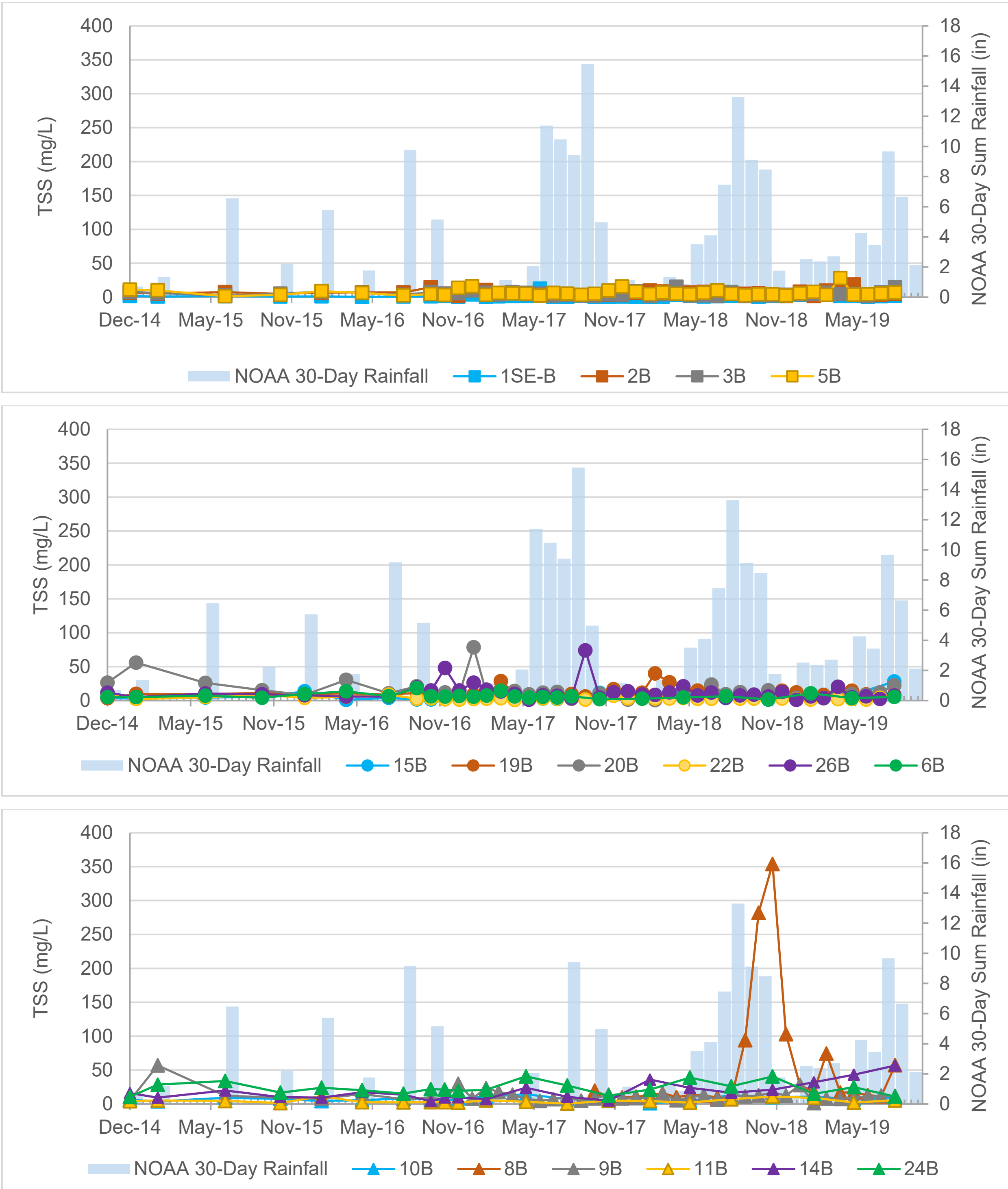


Figure 16. Time series plots of total suspended solids and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

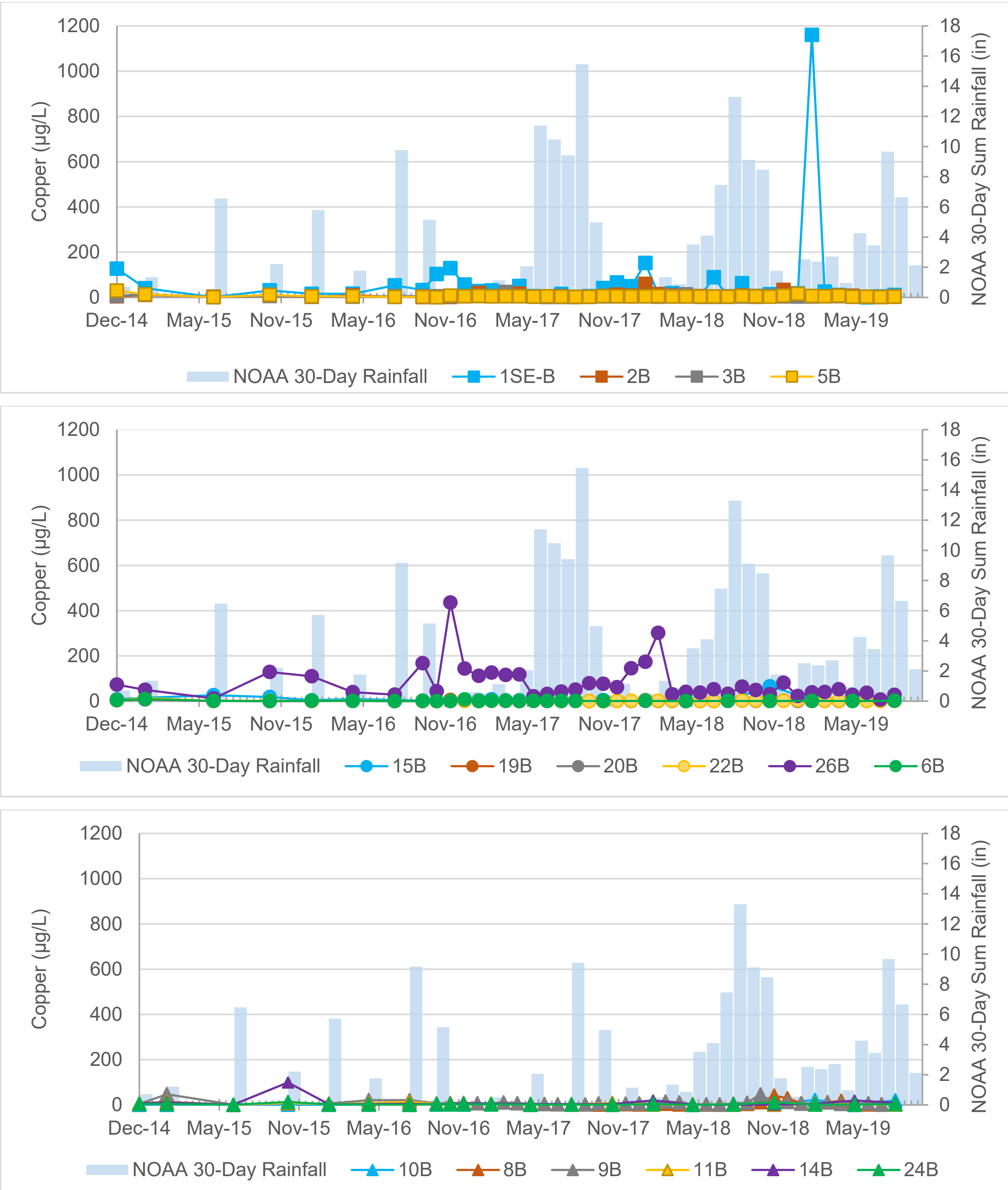


Figure 17. Time series plots of copper and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

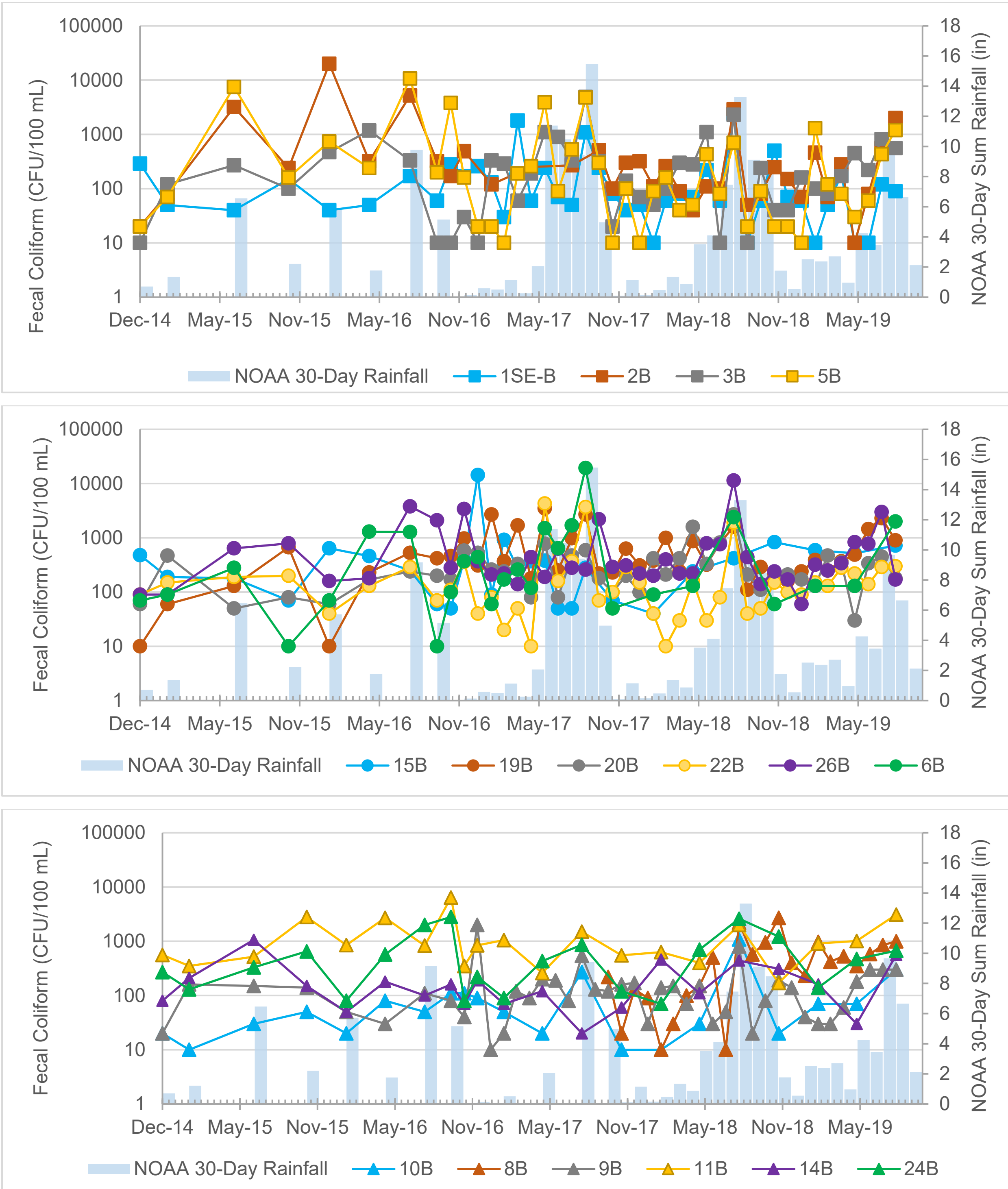


Figure 18. Time series semi-log scale plots of fecal coliform colony forming units (CFU) per mL and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

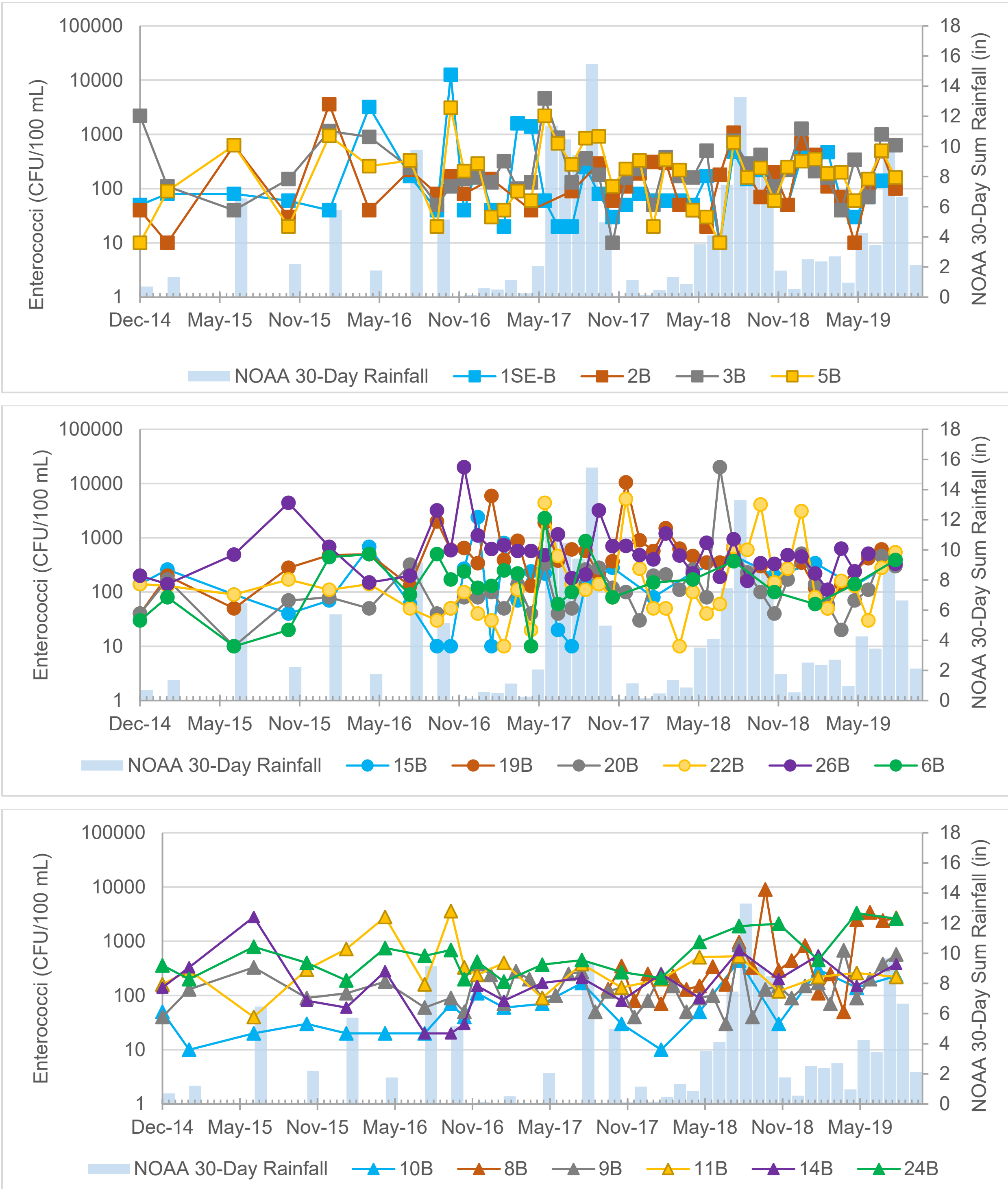


Figure 19. Time series semi-log scale plots of enterococci CFU per mL and prior 30-day sum NOAA rainfall from December 2014 through August 2019 at lakes that ultimately drain to Moorings Bay (top), Gordon River (middle), or Naples Bay/Gulf of Mexico (bottom).

2.2 Discussion

2.2.1 Summary of Stormwater Lake Results from FY 2015 through FY 2019

Monitoring results from data collected at stormwater lakes were reviewed to identify any outliers or visual trends within the data collected from FY 2015 to 2019 amongst the various stations. Class III Surface Water Quality Standards are used to compare collected data against as reference only. The City is not required to achieve these values during this reporting period. Field parameter measurements (temperature, dissolved oxygen, pH, specific conductivity [SC], salinity, and turbidity) recorded at lakes within the same drainage basins were variable over the sampling period (Figures 2 to 8).

Temperature appears to be slightly higher during the wet season within all drainage basins, as expected (Figure 2). Dissolved oxygen (concentration and percent saturation) was variable among the drainage basins with periods of both super saturation (well over 100 percent saturation at the surface) and hypoxia (concentrations below 2 mg/L) mainly prevalent within lakes draining either to Gordon River or Naples Bay/Gulf of Mexico (Figures 3 and 4). Over the FY 2015 through 2019 monitoring period, all but three lakes (1SE-B, 2B, and 10B) had at least one dissolved oxygen saturation below the Class III standards (time of day corrected daily average) for fresh (greater than 38 percent) and marine (greater than 42 percent) waters. Levels of pH remained consistent in stations draining to both Moorings Bay and Naples Bays/Gulf of Mexico, while the lakes draining to the Gordon River were more variable (Figure 5). Eight of the sixteen lakes (15B, 19B, 20B, 9B, 14B, 24B, 2B, 5B) had measurements of pH above the Class III standard maximum of 8.5 from FY 2015 to 2019 (Figure 5).

Based on SC measurements, two of the sampling stations (10B and 14B) are typically identified as “predominately marine” (indicated by gray-shaded row headings in Table 2) according to the FDEP classification of specific conductivities greater than 4,580 µS/cm (62-302.200(30), F.A.C.); the remaining fourteen stormwater lakes have exhibited freshwater conductivities at the time of sampling (Figure 6). Five lakes, one draining to Napes Bay (24B), one draining to the Gordon River (22B), and three draining to Moorings Bay (1SE-B, 2B, and 3B) had SC measures above the Class III Freshwater Standard of 1,275 µS/cm during various sampling events from FY 2015 through 2019 (Figure 6). A very high measurement in 1SE-B occurred during February 2019. This elevated value was most likely caused by treatment with copper sulfate (based on the very elevated copper concentration and blue color of the lake), which would increase the overall ions in the lake, and consequently SC. Salinity followed the same patterns as SC at all stations (Figure 7).

Turbidity measured at all but four lakes, two draining to Gordon River (19B and 20B) and two draining to the Gulf of Mexico (8B and 9B) were within the Class III Standards for fresh and marine waters, (less than or equal to 29 NTU above background or less than or equal to 29 NTU if no established background for both fresh and marine waters, Figure 8).

Nutrient parameters (TN, TP, chlorophyll-*a*) were variable by station and drainage basin from FY 2015 through 2019. TN was elevated at some stations within each drainage basin over the five year sampling period, but the five-year mean was fairly consistent at stations draining to Moorings Bay and the Gordon River (average between 0.94 and 1.89 mg/L, Table 2). TN concentrations were higher in general at lakes draining to the Gulf of Mexico or Naples Bay (Figure 9), with the highest five-year average observed in 24B (3.70 mg/L) followed by 8B (3.04 mg/L)

TP concentrations for sites draining to Moorings Bay and Gordon River were consistently below 0.2 mg/L for the duration of the five year sampling period, with the five-year mean below 0.11 mg/L at all stations (Table 2, Figure 15). One of the stormwater lakes draining to Naples Bay, 24B, had higher overall TP concentrations with a five-year mean of 1.96 mg/L and a maximum concentration of 3.02 mg/L (Table 2).

Chlorophyll-*a* concentrations at stormwater lakes draining to Moorings Bay, were the lowest in lake 1SE-B, while the other three lakes had various spikes in chlorophyll-*a* over the five-year sampling period (Figure 13). Stations that ultimately drain to the Gordon River had variable chlorophyll-*a* concentrations, with most ranging from a minimum of undetected (0.25 µg/L) to 779 µg/L; higher concentrations were consistently noted at 20B with a very high spike at 26B during August 2019 (Figure 13). Stations that ultimately drain to Naples Bay and the Gulf of Mexico had variable chlorophyll-*a* concentrations ranging from around 2.59 to 255 µg/L over the five-year period (Figure 13).

Copper concentrations at lakes discharging to the same drainage basin seem to generally keep a similar pattern, one exception being station 26B (draining to the Gordon River) which had consistently higher concentrations overall including a maximum of 436 µg/L. Lake 1SE-B, draining to Moorings Bay, had a maximum copper concentration of 1160 µg/L during the February 2019 event (Figure 17). Spikes of this nature would indicate recent dosing of copper sulfate.

Fecal coliform and enterococci colony counts were variable throughout the FY 2015 to 2019 sampling period with isolated spikes in colony count appearing to occur after stormwater inflows (Figures 18 and 19). Fecal coliform values did have a slight upward visual trend for most of the stormwater lakes draining into Moorings Bay during the wet season (June to September). Enterococci values showed small isolated spikes throughout the sampling period as a likely response to increased rainfall.

2.2.2 Summary of Stormwater Lake Statistical Analysis

In order to determine if there were changes in water quality data in the lakes over the five year sampling period along with differences among lakes draining to the same basin, different statistical analysis were run on the data. First, to better illustrate if there were differences in the data collected annually between stations within each basin, box plots were created to visually compare the data, with the boxes representing the 25-75% spread of the results, a median line indicated, and the whiskers representing the 5% and 95% spread of the results (see Appendix A.1). Second, a correlation analysis was performed using the 30-day sum of rainfall prior to the sampling event and all the water quality parameters at each lake. The goal of this analysis was to determine if rainfall was a driver in the water quality results collected during each monitoring event. Third, to determine if there were statistically significant increasing or decreasing trends over the five year sampling period, a Mann Kendall (annual Kendall) analysis was performed using the annual median values for each lake. Finally, to determine if there were differences among the various lakes draining to the major basins (Moorings Bay, Gordon River, or Naples Bay/Gulf of Mexico), a one-way analysis of variance (ANOVA) was performed comparing all lakes within each basin utilizing the complete data set. Results of each of the analysis are discussed below.

Box Plots

Box plots were created for each of the three drainage basins, Moorings Bay, Gordon River, and Naples Bay/Gulf of Mexico, to more easily compare the ranges of results by parameter and for each station. Box plots were variable throughout the FY 2015 to 2019 analysis period, with data collected after 2017 having a smaller distribution for most parameters (Appendix A.1, Figures A-1 to A-54). Data for temperature, DO, pH, and SC had the largest variability regardless of drainage basin. Concentrations of TN, nitrate-nitrite, and TKN had more consistent results with a narrow range for three of the five years collected (2017-2019) compared to the previously discussed parameters. Chlorophyll-*a*, TP, orthophosphate, and TSS also had a fairly consistent spread with isolated spikes from 2017 to 2019. The wide range in copper concentrations in lakes 26B and 1SE-B correspond to multiple elevated measurements (most likely caused by repeated treatment with copper sulfate). Finally, bacterial ranges for both fecal coliform and enterococci for lakes draining to Moorings Bay had less variability during 2017-2019, while lakes draining to Naples Bay had the greatest variability and range during 2017-2019. Box plots are useful to visually determine if one particular lake had a higher concentration overall, or for a specific year and can be used for management recommendations for a particular water quality parameter. They can also be used to determine if concentrations at all lakes draining to the same basin are equally high or low.

Spearman's Rank Correlation

A Spearman's Rank Correlation was used as most of the water quality and rainfall data was not normally distributed. This analysis was performed in order to determine the strength of the relationship between rainfall sums 30-days prior to sampling and each water quality parameter at each lake station. Spearman's Rank coefficients (r_s) above 0.50 generally represent a strong relationship between rainfall and the water quality variable, indicating rainfall accounts for at least half of the driving factor in increases or decreases in that parameter. In Tables 3 to 5, all significant correlations ($p < 0.05$) are in bold red. Negative correlations indicate that as rainfall increases, the particular water quality parameter concentration decreases, and positive correlations indicate that as rainfall increases, the particular water quality parameter concentration also increases.

In general, if there was a relationship with a water quality parameter and rainfall, it tended to be the same between lakes, with few exceptions (Tables 3 to 5). For lakes draining to Moorings Bay, there was a positive correlation between 30-day NOAA rainfall and temperature, orthophosphate, fecal coliform, and enterococci (Spearman's Rank Correlation, $p < 0.05$, Table 3) in at least one lake. This would indicate when there were higher rainfall totals, these parameters had elevated concentrations. Conversely, there was a negative correlation between 30-day NOAA rainfall and DO, pH, SC, salinity, TN, nitrate-nitrite, TKN, TSS, copper, and hardness indicating when rainfall was elevated, these concentrations were lower (Spearman's Rank Correlation, $p < 0.05$). Chlorophyll-*a* had a positive correlation with rainfall at 1SE-B, but a negative correlation with rainfall at 5B (Table 3).

Similar to lakes draining to Moorings Bay, the lakes draining to the Gordon River also had a negative correlation between 30-day NOAA rainfall and DO, pH, SC, salinity, TN, nitrate-nitrite, TKN, TSS, copper, ammonia, and turbidity (Spearman's Rank Correlation, $p < 0.05$, Table 4). These parameters saw a decrease in concentration with higher rainfall totals. There was also a positive correlation between 30-day NOAA rainfall and temperature, chlorophyll-*a*, orthophosphate, TP, fecal coliform, and enterococci (Spearman's Rank Correlation, $p < 0.05$), indicating higher concentrations with higher rainfall totals. There was a positive correlation between rainfall and turbidity at 22B, but a negative correlation between rainfall and turbidity at 26B (Table 4). In this case, either relationship is plausible as higher rainfall events could wash more sediment into the lake which would increase the turbidity, and less rainfall and lower lake levels could increase turbidity as materials would have less volume to be diluted in.

The lakes draining to Naples Bay or the Gulf of Mexico an opposite relationship (negative instead of positive) between orthophosphate and TP and rainfall than the other drainage basins. This could possibly indicate a phosphorus dilution instead of an input to these lakes as was the case in the other basins. There was a negative correlation between 30-day NOAA rainfall and pH, SC, salinity, TN, TKN, orthophosphate, TP, copper, and hardness (Spearman's Rank Correlation, $p < 0.05$, Table 5). There was a positive correlation between 30-day NOAA rainfall and temperature, turbidity, ammonia, chlorophyll-*a*, fecal coliform, and enterococci (Spearman's Rank Correlation, $p < 0.05$). For nitrate-nitrite, there was a negative correlation with rainfall at 14B but a positive correlation with rainfall at 24B (Table 5).

Table 3. Spearman's Rank Correlations between water quality and 30-day NOAA rainfall at lakes draining to Moorings Bay from December 2014 to September 2019.

Parameter Type	Parameter	1SE-B		2B		3B		5B	
		r_s	N	r_s	N	r_s	N	r_s	N
Field Parameters	Temperature	**0.60**	43	**0.57**	37	**0.60**	43	**0.58**	43
	DO (%Sat)	-0.29	43	0.17	37	**-0.49**	43	-0.10	43
	DO (mg/L)	**-0.52**	43	0.06	37	**-0.57**	43	-0.23	43
	pH	**-0.48**	43	-0.12	37	**-0.37**	43	**-0.31**	43
	SC	**-0.43**	43	**-0.57**	37	**-0.52**	43	**-0.68**	43
	Salinity	**-0.44**	43	**-0.47**	37	**-0.58**	43	**-0.58**	43
	Turbidity	0.13	43	0.00	37	-0.14	43	**-0.43**	43
Lab Parameters	TN	-0.23	42	**-0.39**	36	-0.21	42	**-0.67**	42
	Nitrate-Nitrite	-0.04	42	**-0.37**	36	0.03	42	-0.22	42
	TKN	-0.24	42	**-0.33**	36	-0.28	42	**-0.66**	42
	Ammonia	-0.07	42	-0.26	36	-0.09	42	0.00	42
	Chlorophyll-*a*	**0.48**	42	-0.06	36	-0.23	42	**-0.39**	42
	Orthophosphate	**0.43**	42	-0.19	36	**0.40**	42	0.05	42
	TP	0.27	42	-0.28	36	0.19	42	-0.16	42
	TSS	0.13	42	-0.01	36	-0.28	42	**-0.32**	42
	Copper	**-0.54**	42	**-0.48**	36	**-0.56**	42	**-0.50**	42
	Fecal Coliform	-0.03	42	0.23	36	**0.59**	42	**0.51**	42
	Enterococci	0.04	42	0.28	36	**0.41**	42	**0.31**	42
	Total Hardness	-0.30	28	-0.38	25	**-0.55**	28	**-0.44**	28

All significant correlations ($p < 0.05$) are in **bold red**.

Table 4. Spearman's Rank Correlations between water quality and 30-day NOAA rainfall at lakes draining to the Gordon River from December 2014 to September 2019.

Parameter Type	Parameter	6B		15B		19B		20B		22B		26B	
		r_s	N	r_s	N	r_s	N	r_s	N	r_s	N	r_s	N
Field Parameters	Temperature	**0.57**	27	**0.65**	27	**0.57**	43	**0.58**	43	**0.60**	43	**0.57**	43
	DO (%Sat)	-0.001	27	-0.22	27	0.07	43	-0.07	43	-0.19	43	**-0.61**	43
	DO (mg/L)	-0.10	27	-0.34	27	-0.03	43	-0.18	43	**-0.31**	43	**-0.61**	43
	pH	**-0.52**	27	-0.14	27	-0.25	43	-0.12	43	-0.24	43	**-0.38**	43
	SC	**-0.76**	27	**-0.57**	27	**-0.55**	43	**-0.64**	43	**-0.70**	43	-0.12	43
	Salinity	**-0.72**	27	**-0.55**	27	**-0.54**	43	**-0.63**	43	**-0.70**	43	-0.08	43
	Turbidity	-0.10	27	-0.29	27	0.01	43	0.01	43	**0.43**	43	**-0.37**	43
Lab Parameters	TN	**-0.42**	27	-0.30	27	**-0.36**	42	-0.17	42	-0.25	42	**-0.52**	42
	Nitrate-Nitrite	-0.04	27	-0.26	27	**-0.41**	42	0.10	42	-0.16	42	-0.16	42
	TKN	**-0.44**	27	-0.02	27	**-0.31**	42	-0.21	42	-0.22	42	**-0.49**	42
	Ammonia	0.29	27	0.20	27	**-0.32**	42	0.06	42	-0.02	42	-0.09	42
	Chlorophyll-*a*	0.32	27	0.11	27	0.15	42	0.09	42	**0.45**	42	-0.22	42
	Orthophosphate	**0.54**	27	-0.14	27	-0.09	42	-0.06	42	0.11	42	**0.68**	42
	TP	0.24	27	-0.09	27	-0.16	42	-0.11	42	0.15	42	**0.42**	42
	TSS	0.05	27	-0.07	27	-0.17	42	-0.03	42	0.19	42	**-0.49**	42
	Copper	0.03	27	-0.37	27	**-0.31**	42	0.22	42	-0.17	42	**-0.55**	42
	Fecal Coliform	**0.54**	27	0.05	27	0.20	42	0.13	42	**0.37**	42	**0.32**	42
	Enterococci	0.18	27	-0.09	27	-0.10	42	**0.33**	42	**0.33**	42	-0.23	41
	Total Hardness	-0.44	16	-0.47	16	-0.28	28	**-0.61**	28	**-0.76**	28	0.04	28

All significant correlations ($p < 0.05$) are in **bold red**.

Table 5. Spearman's Rank Correlations between water quality and 30-day NOAA rainfall at lakes draining to Naples Bay/Gulf of Mexico from December 2014 to September 2019.

Parameter Type	Parameter	8B		9B		10B		11B		14B		24B	
		r_s	N	r_s	N	r_s	N	r_s	N	r_s	N	r_s	N
Field Parameters	Temperature	**0.61**	24	**0.59**	43	**0.53**	21	**0.57**	21	**0.56**	21	**0.57**	21
	DO (%Sat)	-0.19	24	-0.10	43	0.14	21	-0.28	21	-0.12	21	-0.29	21
	DO (mg/L)	-0.35	24	-0.16	43	0.04	21	-0.31	21	-0.33	21	-0.36	21
	pH	**-0.50**	24	**-0.31**	43	-0.07	21	-0.21	21	-0.26	21	-0.10	21
	SC	**-0.57**	24	**-0.52**	43	**-0.63**	21	**-0.65**	21	**-0.62**	21	**-0.53**	21
	Salinity	**-0.62**	24	**-0.55**	43	**-0.63**	21	**-0.66**	21	**-0.56**	21	**-0.56**	21
	Turbidity	0.12	23	-0.23	43	0.25	21	0.30	21	**0.49**	21	-0.06	21
Lab Parameters	TN	-0.18	23	**-0.35**	42	-0.02	21	0.05	21	-0.18	21	0.31	21
	Nitrate-Nitrite	0.02	23	-0.03	42	-0.35	21	0.11	21	**-0.46**	21	**0.56**	21
	TKN	-0.16	23	**-0.35**	42	-0.01	21	0.02	21	-0.13	21	0.20	21
	Ammonia	0.19	23	-0.19	42	-0.10	21	**0.51**	21	0.16	21	0.33	21
	Chlorophyll-*a*	0.01	23	-0.05	42	**0.47**	21	0.16	21	0.04	21	0.15	21
	Orthophosphate	-0.08	23	**-0.51**	42	**-0.69**	21	-0.22	21	**-0.61**	21	0.29	21
	TP	-0.22	23	**-0.55**	42	**-0.48**	21	0.004	21	**-0.58**	21	0.28	21
	TSS	0.09	23	-0.21	42	0.37	21	0.004	21	0.27	21	0.23	21
	Copper	-0.30	23	**-0.38**	42	-0.04	21	-0.35	21	-0.40	21	-0.29	21
	Fecal Coliform	**0.52**	23	0.23	42	0.43	21	0.43	21	0.08	21	**0.68**	21
	Enterococci	**0.48**	23	0.06	42	0.32	21	0.17	21	0.23	21	**0.58**	21
	Total Hardness	**-0.67**	18	**-0.52**	28	-0.64	7	-0.44	16	**-0.83**	6	**-0.60**	16

All significant correlations ($p < 0.05$) are in **bold red**.

Mann Kendall

The annual Kendall Tau analysis (or Mann Kendall) looks for general increasing or decreasing linear trends over time. This analysis was used because of changes to the sampling frequency over the monitoring period. Individual seasons (in the form of months or a wet/dry season) could not be established as there was only quarterly data collected at all lakes in FY 2015 and FY 2016, and not all lakes were then sampled monthly after that time period. The fiscal year median was calculated for each parameter at each lake, and then analyzed to determine the presence of statistically significant increasing or decreasing trends. If there was a statistically significant ($p < 0.05$) increasing or decreasing trend for a particular parameter, then a slope of change in concentration annually over time was calculated. Results by drainage basin are presented in Tables 6 to 8.

For lakes draining to Moorings Bay, there were some parameters with increasing or decreasing trends. The slope of increase observed in pH of 0.05 SU/yr at 1SE-B and 0.09 SU/yr at 3B was within the error of the multi-parameter datasonde used to take the measurements and is not of concern at this time (Mann Kendall, $p < 0.05$, Table 6). Other parameters had a statistically significant decreasing trend over time (chlorophyll-*a*, nitrate-nitrite, orthophosphate, TP, TSS, and copper) which were in an appropriate direction and are not of concern. The statistically significant increase in water temperature at 5B (slope 1.19 °C/yr) should be monitored closely; while not a concern at this time, continual increases in temperature will not be good for overall lake condition.

For the lakes draining to the Gordon River, there were only statistically significant decreasing trends for nutrient parameters and total suspended solids (Mann Kendall, $p < 0.05$, Table 7). These decreases for TP (6B, slope -0.01 mg/L/yr), TSS (20B, slope -3.96 mg/L/yr), TN (22B, slope -0.48 mg/L/yr and 26B, slope -0.07 mg/L/yr), and TKN (26B, slope -0.07 mg/L/yr) are all in an appropriate direction. They all indicate concentrations of nutrients and TSS are gradually decreasing at various lakes draining to the Gordon River over the five-year sampling period.

More statistically significant trends were observed for lakes draining to Naples Bay or the Gulf of Mexico (Table 8). There were decreases in SC and salinity at 9B (slopes -22.56 µS/cm/yr and -0.01 ppt/yr) which were both in a desired direction. Similar to other observed increases in pH, the increasing trend observed at 11B (slope 0.07 SU/yr) is not of concern as it is within the standard error of the datasonde. However, the statistically significant decrease in DO saturation at 9B (slope -15.32 %/yr) and concentration at 9B and 10B (slopes -1.53 and -0.95 mg/L/yr) should be monitored in the future to make sure the DO does not continue to decrease in subsequent years. Conversely, the increases observed in TN (11B, slope 0.09 mg/L/yr), TKN (11B, slope 0.07 mg/L/yr), ammonia (11B, slope 0.003 mg/L/yr), copper (10B, slope 0.66 µg/L/yr), and enterococci (24B, slope 167.5 cfu/100mL/yr) should also be closely monitored in future years to ensure the trend does not continue (Mann Kendall, $p < 0.05$, Table 8).

Table 6. Annual Kendall Tau results of annual medians from FY 2015 to FY 2019 for lakes draining to Moorings Bay.

Parameter Type	Parameter	1SE-B			2B			3B			5B		
		Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope
Field Parameters	Temperature	0.60	0.14		0.60	0.14		0.60	0.14	N/A	**0.80**	**0.05**	**1.19**
	DO (%Sat)	0.20	0.62	N/A	0.40	0.33		**-0.80**	**0.05**	**-3.74**	0.60	0.14	
	DO (mg/L)	0.00	1.00		0.40	0.33		-0.60	0.14	N/A	0.40	0.33	
	pH	**0.80**	**0.05**	**0.05**	0.60	0.14		**0.80**	**0.05**	**0.09**	0.60	0.14	
	SC	0.20	0.62		-0.60	0.14		-0.60	0.14		-0.20	0.62	
	Salinity	-0.20	0.62	N/A	-0.60	0.14		-0.20	0.62		0.00	1.00	
	Turbidity	0.00	1.00		0.60	0.14		-0.20	0.62		-0.20	0.62	N/A
Lab Parameters	TN	-0.32	0.44		0.40	0.33		-0.20	0.62	N/A	-0.32	0.44	
	Nitrate-Nitrite	**-1.00**	**0.01**	**-0.03**	0.00	1.00	N/A	0.00	1.00		-0.60	0.14	
	TKN	-0.20	0.62		0.40	0.33		-0.53	0.20		-0.60	0.14	
	Ammonia	-0.32	0.44	N/A	-0.36	0.38		-0.32	0.44		0.00	1.00	
	Chlorophyll-*a*	0.20	0.62		0.00	1.00		**-1.00**	**0.01**	**-3.55**	-0.40	0.33	
	Orthophosphate	**-0.80**	**0.05**	**-0.001**	-0.20	0.62		0.20	0.62	N/A	-0.60	0.14	
	TP	0.00	1.00		-0.20	0.62		-0.40	0.33		**-0.80**	**0.05**	**-0.03**
	TSS	0.20	0.62		-0.60	0.14		**-0.80**	**0.05**	**-0.48**	-0.40	0.33	N/A
	Copper	-0.40	0.33	N/A	0.40	0.33		**-1.00**	**0.01**	**-0.55**	**-0.80**	**0.05**	**-0.35**
	Fecal Coliform	0.00	1.00		0.00	1.00		-0.11	0.80	N/A	-0.20	0.62	N/A
	Enterococci	0.20	0.62		0.40	0.33		0.40	0.33		0	1.00	

All significant correlations ($p < 0.05$) and trend slopes are in **bold red**.

Table 7. Annual Kendall Tau results of annual medians from FY 2015 to FY 2019 for lakes draining to the Gordon River.

Parameter Type	Parameter	6B			15B			19B			20B			22B			26B		
		Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope
	Temperature	0.20	0.62		0.60	0.14		-0.20	0.62		0.40	0.33		0.40	0.33		0.40	0.33	
	DO (%Sat)	-0.60	0.14		0.20	0.62		0.20	0.62		-0.60	0.14		-0.40	0.33		-0.40	0.33	
	DO (mg/L)	-0.60	0.14		0.00	1.00		0.20	0.62		-0.60	0.14		-0.60	0.14		-0.40	0.33	
Field Parameters	pH	0.60	0.14		0.60	0.14		0.40	0.33		-0.60	0.14		0.20	0.62	N/A	0.74	0.07	N/A
	SC	0.00	1.00		-0.60	0.14		-0.40	0.33		-0.20	0.62		0.00	1.00		0.40	0.33	
	Salinity	0.11	0.80		-0.32	0.44		0.26	0.53		-0.32	0.44		0.00	1.00		0.60	0.14	
	Turbidity	-0.60	0.14	N/A	0.20	0.62		0.40	0.33		-0.60	0.14		-0.60	0.14		-0.40	0.33	
	TN	-0.20	0.62		0.00	1.00		0.11	0.80		-0.40	0.33	N/A	**-0.80**	**0.05**	**-0.48**	**-1.00**	**0.01**	**-0.07**
	Nitrate-Nitrite	0.00	1.00		-0.20	0.62		-0.60	0.14		0.53	0.20		-0.20	0.62		0.40	0.33	N/A
	TKN	-0.20	0.62		0.20	0.62	N/A	0.40	0.33	N/A	-0.60	0.14		-0.40	0.33		**-0.80**	**0.05**	**-0.07**
	Ammonia	-0.36	0.38		-0.22	0.58		-0.32	0.44		-0.32	0.44		-0.12	0.77		-0.36	0.38	
	Chlorophyll-*a*	0.40	0.33		0.40	0.33		0.20	0.62		-0.60	0.14		-0.60	0.14		-0.20	0.62	
Lab Parameters	Ortho-phosphate	-0.20	0.62		0.32	0.44		-0.60	0.14		-0.32	0.44		0.00	1.00		-0.40	0.33	
	TP	**-0.80**	**0.05**	**-0.01**	-0.40	0.33		-0.60	0.14		-0.40	0.33		-0.60	0.14	N/A	-0.20	0.62	
	TSS	-0.40	0.33		0.40	0.33		0.40	0.33		**-1.00**	**0.01**	**-3.96**	-0.60	0.14		-0.40	0.33	N/A
	Copper	0.20	0.62		-0.20	0.62		-0.20	0.62		0.00	1.00		0.00	1.00		-0.20	0.62	
	Fecal Coliform	0.00	1.00	N/A	0.20	0.62		0.40	0.33		0.40	0.33	N/A	-0.32	0.44		0.00	1.00	
	Enterococci	-0.20	0.62		0.60	0.14		0.20	0.62		0.60	0.14		0.00	1.00		0.20	0.62	

All significant correlations ($p < 0.05$) and trend slopes are in **bold red**.

Table 8. Annual Kendall Tau results of annual medians from FY 2015 to FY 2019 for lakes draining Naples Bay/Gulf of Mexico.

Parameter Type	Parameter	8B	9B			10B			11B			14B			24B		
			Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope	Tau	p-value	Slope
Field Parameters	Temperature	Insufficient Data-Only 2 years- Unable to run analysis.	0.40	0.33	N/A	0.20	0.62	N/A	0.60	0.14		0.60	0.14		0.60	0.14	
	DO (%Sat)		**-1.00**	**0.01**	**-15.32**	-0.60	0.14		-0.60	0.14	N/A	-0.40	0.33		-0.60	0.14	
	DO (mg/L)		**-0.80**	**0.05**	**-1.53**	**-0.80**	**0.05**	**-0.95**	-0.60	0.14		-0.40	0.33		-0.60	0.14	
	pH		-0.20	0.62	N/A	0.20	0.62		**0.80**	**0.05**	**0.07**	-0.20	0.62		0.00	1.00	
	SC		**-0.95**	**0.02**	**-22.56**	-0.60	0.14		0.20	0.62		-0.20	0.62		-0.20	0.62	
	Salinity		**-1.00**	**0.01**	**-0.01**	-0.60	0.14		0.20	0.62	N/A	-0.40	0.33		-0.20	0.62	
	Turbidity		0.00	1.00		0.60	0.14		0.60	0.14		0.60	0.14		0.00	1.00	
Lab Parameters	TN		-0.60	0.14		0.20	0.62		**1.00**	**0.01**	**0.09**	0.40	0.33		0.20	0.62	
	Nitrate-Nitrite		-0.20	0.62		0.53	0.20	N/A	-0.60	0.14	N/A	0.20	0.62	N/A	-0.40	0.33	N/A
	TKN		-0.60	0.14		0.20	0.62		**0.80**	**0.05**	**0.07**	0.40	0.33		0.20	0.62	
	Ammonia		-0.12	0.77		0.11	0.80		**0.80**	**0.05**	**0.003**	0.00	1.00		0.00	1.00	
	Chlorophyll-*a*		0.00	1.00	N/A	-0.20	0.62		0.20	0.62		0.20	0.62		0.20	0.62	
	Orthophosphate		-0.20	0.62		-0.32	0.44		-0.20	0.62		-0.20	0.62		-0.20	0.62	
	TP		-0.20	0.62		0.00	1.00		-0.20	0.62		-0.20	0.62		-0.40	0.33	
	TSS		0.00	1.00		0.40	0.33		0.60	0.14	N/A	0.40	0.33		-0.20	0.62	
	Copper		0.40	0.33		**0.80**	**0.05**	**0.66**	-0.60	0.14		-0.20	0.62		-0.40	0.33	
	Fecal Coliform		0.20	0.62		0.32	0.44	N/A	0.20	0.62		0.20	0.62		0.40	0.33	
	Enterococci		0.11	0.80		0.74	0.07		-0.11	0.80		0.20	0.62		**0.80**	**0.05**	**167.5**

All significant correlations ($p < 0.05$) and trend slopes are in **bold red**.

ANOVA

The ANOVA was used to determine if there were differences in water quality parameters among stations in each of the drainage basins. Based on the parameter, this analysis could also be used to determine if a specific lake is contributing a higher concentration to the drainage basin and may need treatment.

For lakes draining to Moorings Bay, half of the parameters had statistically significant differences among stations (ANOVA, $p < 0.05$, Table 9). Lake 1SE-B had the lowest concentrations of all the lakes draining to Moorings Bay for chlorophyll-*a*, orthophosphate, TP, and TSS (ANOVA, $p < 0.05$, Duncan's post hoc test, $p < 0.05$). Conversely, copper was the highest at 1SE-B (Duncan's post hoc test, $p < 0.05$). Dissolved oxygen concentration and saturation were also significantly different among stations with increases from 3B, to 1SE-B, to 5B, to 2B (Duncan's post hoc test, $p < 0.05$). Turbidity was found to be different among stations with 2B having the highest values and 1SE-B the lowest (Duncan's post hoc test, $p < 0.05$). Hardness was also different among stations with 2B and 5B having the lowest concentrations and 3B and 1SE-B having the highest (Duncan's post hoc test, $p < 0.05$). Based on these results, copper at 1SE-B should be carefully monitored (difference may be caused by the large spike observed during the February 2019 monitoring event) to ensure that it truly is not a problem at this lake draining to Moorings Bay.

Even though there were more lakes draining to the Gordon River, it was generally the same few lakes that had either the highest or lowest concentrations for the 13 parameters with significant differences among stations (ANOVA, $p < 0.05$, Table 10). Dissolved oxygen concentration and saturation were different among stations, with the highest values at 20B followed by 19B (Duncan's post hoc test, $p < 0.05$). Lake 22B had the highest SC, salinity, and total hardness of the six lakes (Duncan's post hoc test, $p < 0.05$, Table 10). TN and TKN were the highest at 20B along with turbidity (Duncan's post hoc test, $p < 0.05$). The values of pH were generally more variable, with the highest values at 9B and 20B and the lowest values at 22B and 6B (Duncan's post hoc test, $p < 0.05$). Chlorophyll-*a* and orthophosphate were found to be the lowest at 15B (Duncan's post hoc test, $p < 0.05$). Finally, copper was the highest at 26B (Duncan's post hoc test, $p < 0.05$), so either more samples should be collected here, or management activities should be taken to reduce the overall copper concentration in this lake.

For lakes draining to Naples Bay or the Gulf of Mexico, all but two parameters (temperature and copper) had statistical differences among stations (ANOVA, $p < 0.05$, Table 11). In general, nutrients (TN, nitrate-nitrite, TKN, ammonia, orthophosphate, and TP) including pH and chlorophyll-*a* were the highest at 24B (Duncan's post hoc test, $p < 0.05$). Other parameters had different lakes that were either higher or lower (Table 11). SC and salinity were the highest at 10B and 14B, fecal coliform was the highest at 11B, TSS was highest at 8B, and total hardness was the highest at 14B (Duncan's post hoc test, $p < 0.05$). The lowest turbidity concentrations occurred at 11B and the lowest counts of enterococci colonies were observed at 10B (Duncan's post hoc test, $p < 0.05$). Dissolved oxygen concentration and saturation was the highest at 20B followed by 19B (Duncan's post hoc test, $p < 0.05$).

Table 9. Summary of ANOVA results for lakes draining to Moorings Bay from December 2014 to September 2019.

Parameter Type	Parameter	F	p-value
Field Parameters	Temperature	0.57	0.64
	DO (%Sat)	**7.18**	**0.0002**
	DO (mg/L)	**5.31**	**0.002**
	pH	**8.74**	**0.00002**
	SC	2.31	0.08
	Salinity	2.40	0.07
	Turbidity	**13.60**	**<0.0001**
Lab Parameters	TN	1.94	0.13
	Nitrate-Nitrite	2.41	0.07
	TKN	1.85	0.14
	Ammonia	1.77	0.15
	Chlorophyll-*a*	**3.73**	**0.01**
	Orthophosphate	**11.70**	**<0.0001**
	TP	**15.632**	**<0.0001**
	TSS	**15.71**	**<0.0001**
	Copper	**3.71**	**0.01**
	Fecal Coliform	1.64	0.18
	Enterococci	0.38	0.77
	Total Hardness	**4.93**	**0.003**

Parameters with significant differences among lakes ($p < 0.05$) are in **bold red**.

Table 10. Summary of ANOVA results for lakes draining to the Gordon River from December 2014 to September 2019.

Parameter Type	Parameter	F	p-value
Field Parameters	Temperature	1.58	0.17
	DO (%Sat)	**7.87**	**<0.0001**
	DO (mg/L)	**7.09**	**<0.0001**
	pH	**12.90**	**<0.0001**
	SC	**45.36**	**<0.0001**
	Salinity	**43.96**	**<0.0001**
	Turbidity	**9.55**	**<0.0001**
Lab Parameters	TN	**7.84**	**<0.0001**
	Nitrate-Nitrite	1.12	0.35
	TKN	**8.09**	**<0.0001**
	Ammonia	1.16	0.33
	Chlorophyll-*a*	**3.35**	**0.01**
	Orthophosphate	**2.64**	**0.02**
	TP	1.71	0.13
	TSS	**7.48**	**<0.0001**
	Copper	**33.17**	**<0.0001**
	Fecal Coliform	1.09	0.37
	Enterococci	0.93	0.46
	Total Hardness	**25.70**	**<0.0001**

Parameters with significant differences among lakes ($p < 0.05$) are in **bold red**.

Table 11. Summary of ANOVA results for lakes draining to Naples Bay/Gulf of Mexico from December 2014 to September 2019.

Parameter Type	Parameter	F	p-value
Field Parameters	Temperature	0.36	0.87
	DO (%Sat)	**8.55**	**<0.0001**
	DO (mg/L)	**7.81**	**<0.0001**
	pH	**9.22**	**<0.0001**
	SC	**149.52**	**<0.0001**
	Salinity	**123.83**	**<0.0001**
	Turbidity	**7.27**	**<0.0001**
Lab Parameters	TN	**19.47**	**<0.0001**
	Nitrate-Nitrite	**2.88**	**0.02**
	TKN	**19.57**	**<0.0001**
	Ammonia	**5.67**	**<0.0001**
	Chlorophyll-*a*	**16.13**	**<0.0001**
	Orthophosphate	**117.37**	**<0.0001**
	TP	**153.81**	**<0.0001**
	TSS	**5.46**	**<0.0001**
	Copper	1.90	0.10
	Fecal Coliform	**9.49**	**<0.0001**
	Enterococci	**4.21**	**0.001**
	Total Hardness	**189.15**	**<0.0001**

Parameters with significant differences among lakes ($p < 0.05$) are in **bold red**.

3 Pump Stations

3.1 Water Quality Summaries

The following table and time series plots summarize both field and lab water quality measurements collected quarterly by Cardno staff at the three City pump stations (Figure 1) from December 2014 to September 2019. The quarterly sampling events occurred in November, February, May, and August of every fiscal year with the exception of the December 2014 event in FY 2015.

All FY 2015 to 2019 water quality monitoring samples were collected quarterly from the wet wells at each pump station. Table 4 includes a summary of total number of sampling events as well as minimums, maximums, and five-year means for total nitrogen, total phosphorus and copper. Results of all sampled water quality parameters are displayed in time series plots in Sections 3.1.1 and 3.1.2 (Figures 20-45).

Table 12. Minimums, maximums, and five-year means of total nitrogen, total phosphorus, and copper for PW-Pump, 11-Pump, and 14-Pump in Naples, Florida measured quarterly from December 2014 to September 2019.

Lake Name	Monitoring Station	Sample Period	Number of Samples	Total Nitrogen (mg/L)			Total Phosphorus (mg/L)			Copper (µg/L)		
				Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Public Works Pump	PW-Pump	Dec 14-Aug 19	20	0.93	1.90	1.30	U (0.054)	0.273	0.11	U (0.346)	21.4	5.23
Cove Pump	11-Pump	Dec 14-Aug 19	20	1.10	1.86	1.42	0.084	0.211	0.15	U (0.346)	15.5	2.78
Port Royal Pump	14-Pump	Dec 14-Aug 19	20	0.99	4.91	1.84	0.151	1.21	0.46	U (0.242)	19.3	3.33

Gray shaded rows indicate monitoring stations that typically have specific conductivities of 4580 µS/cm or higher; Class III Marine Standards are used as reference values only.

3.1.1 Time Series Plots of Field Parameters

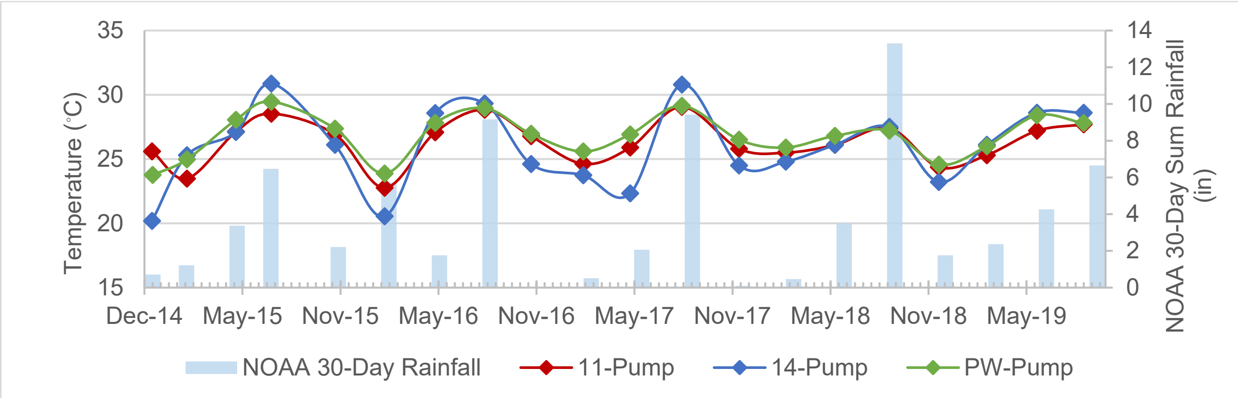


Figure 20. Time series plots of water temperature and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

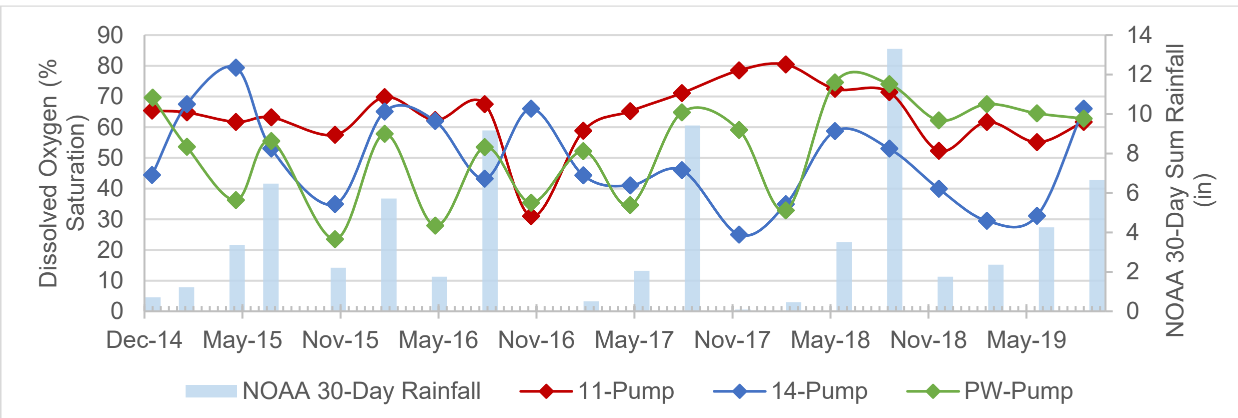


Figure 21. Time series plots of dissolved oxygen (% saturation) and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

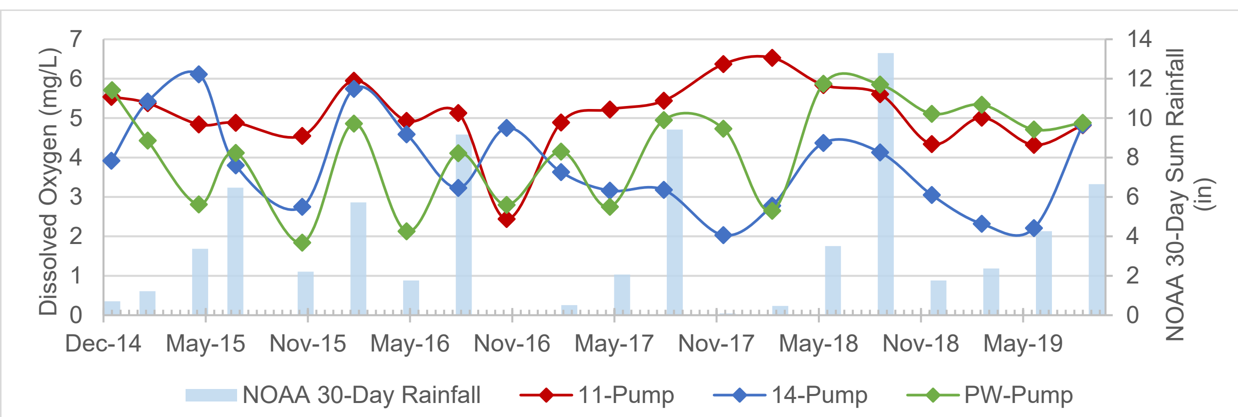


Figure 22. Time series plots of dissolved oxygen (concentration) and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

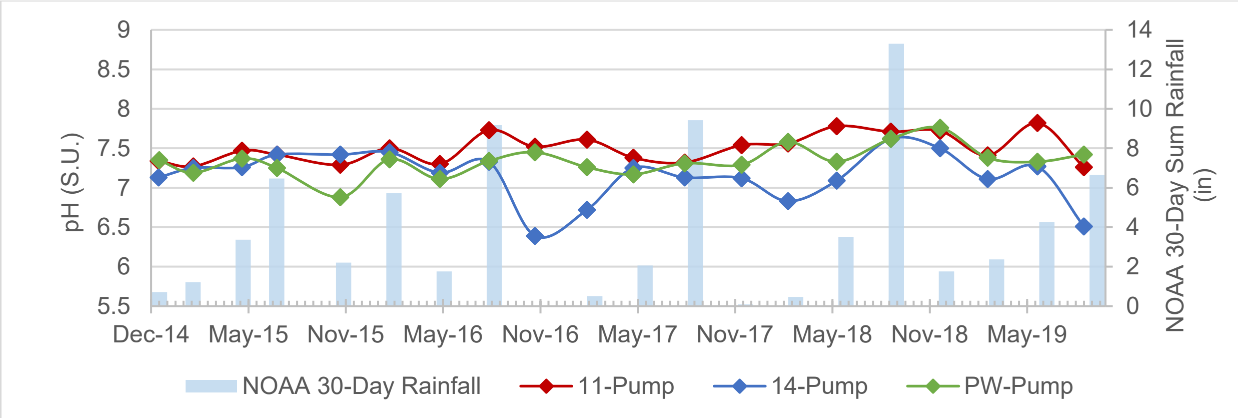


Figure 23. Time series plots of pH and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

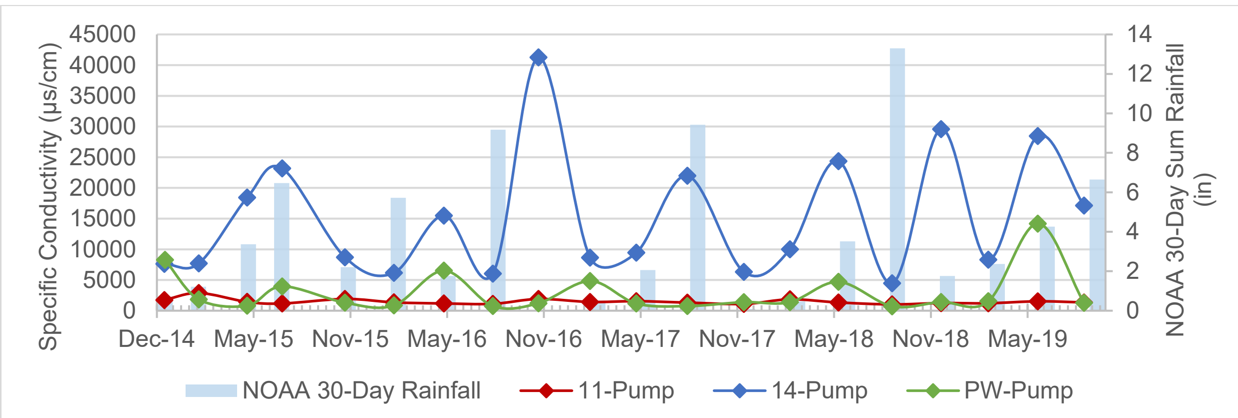


Figure 24. Time series plots of specific conductivity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

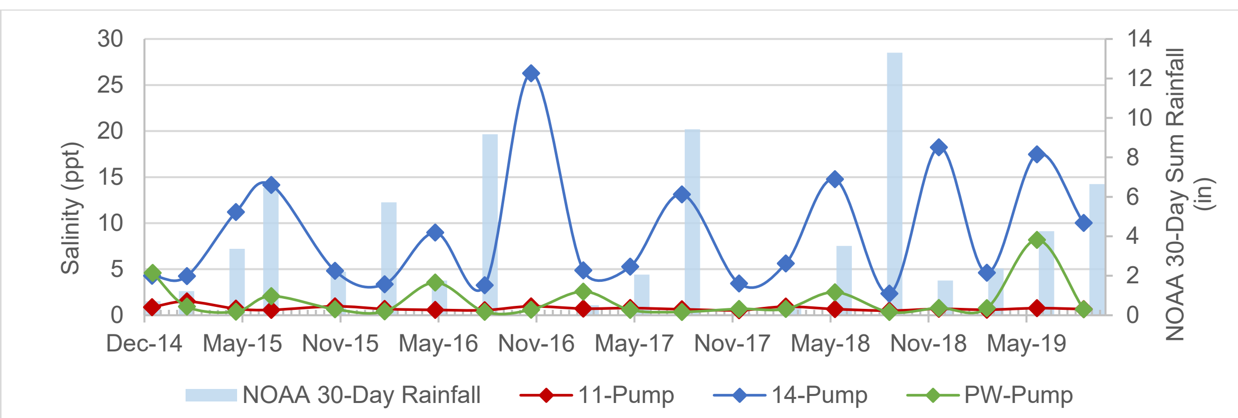


Figure 25. Time series plots of salinity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

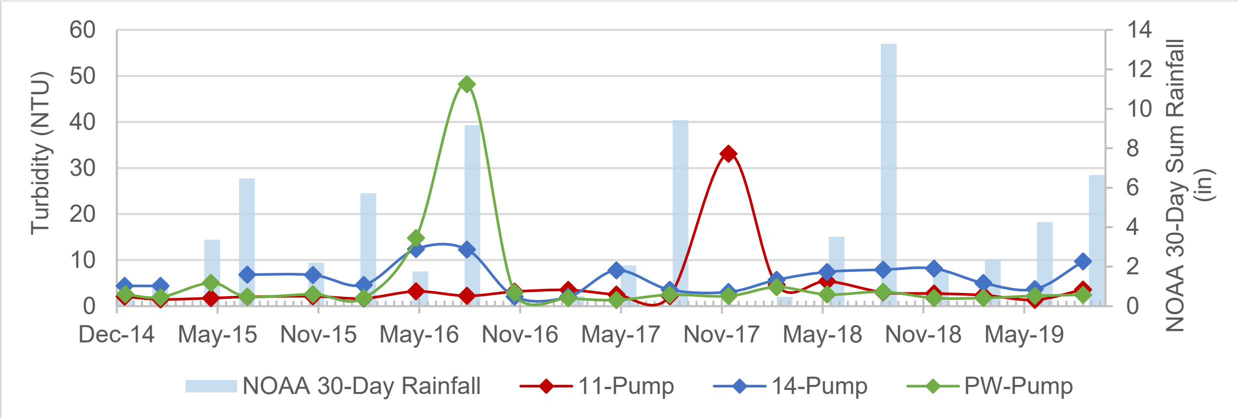


Figure 26. Time series plots of turbidity and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

3.1.2 Time Series Plots of Lab Parameters

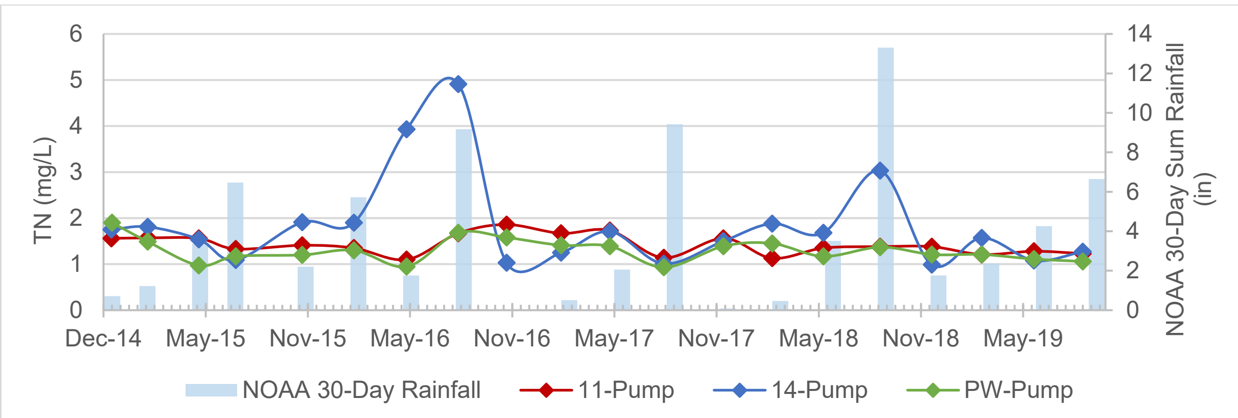


Figure 27. Time series plots of total nitrogen and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

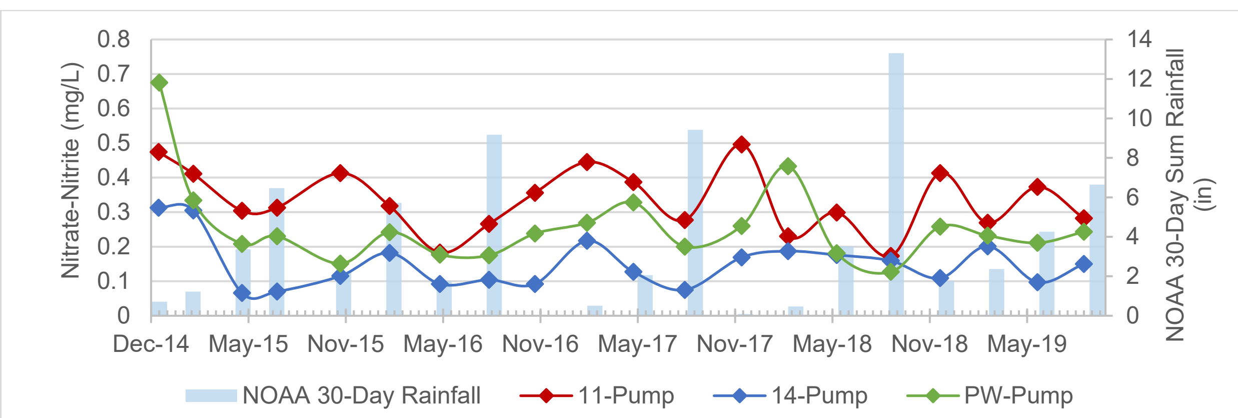


Figure 28. Time series plots of nitrate-nitrite and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

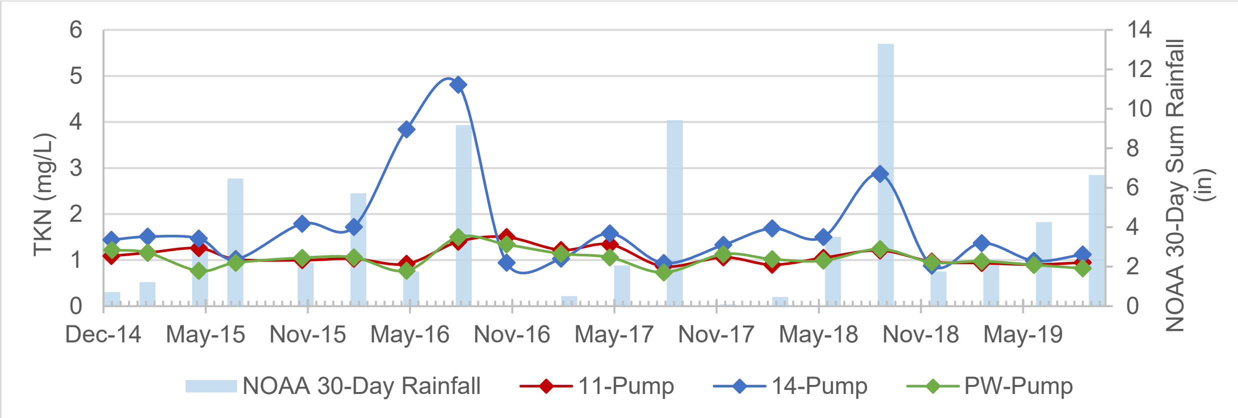


Figure 29. Time series plots of Total Kjeldahl Nitrogen and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

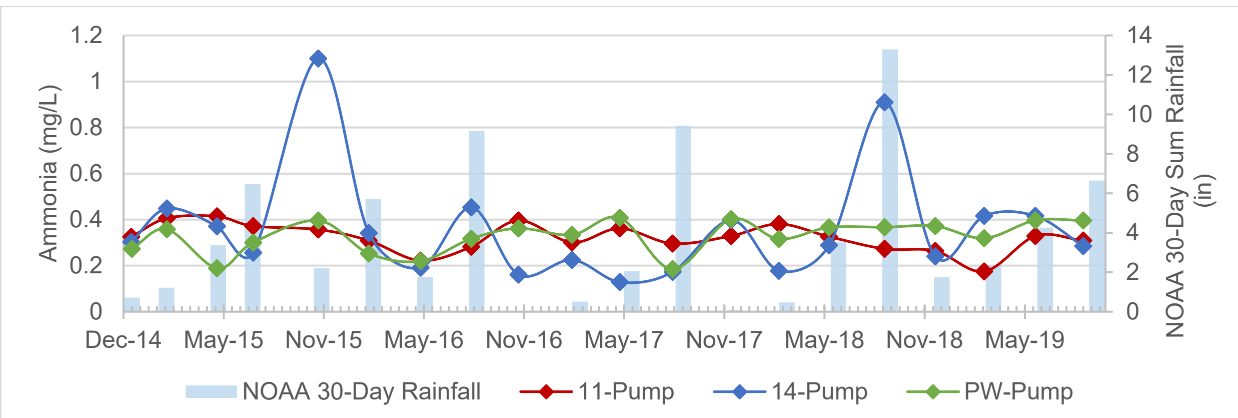


Figure 30. Time series plots of ammonia nitrogen and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

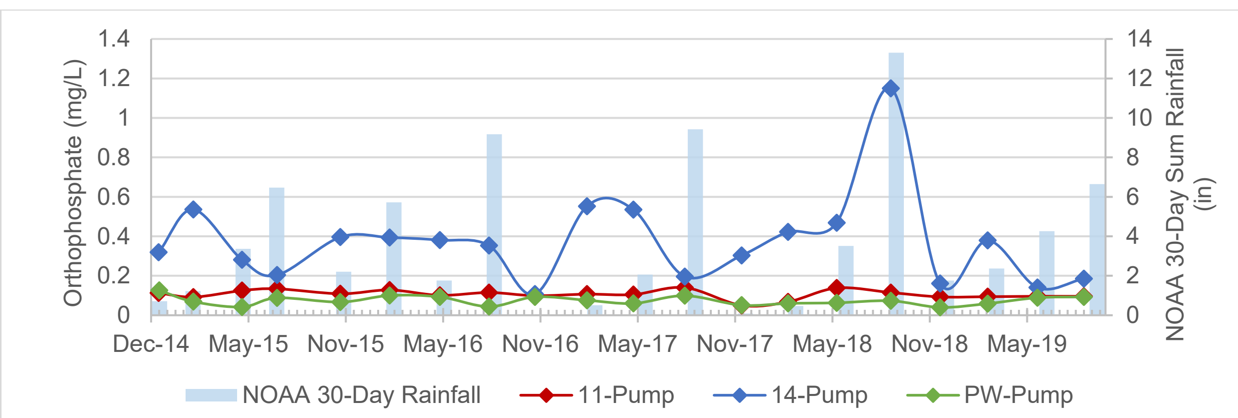


Figure 31. Time series plots of orthophosphate and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

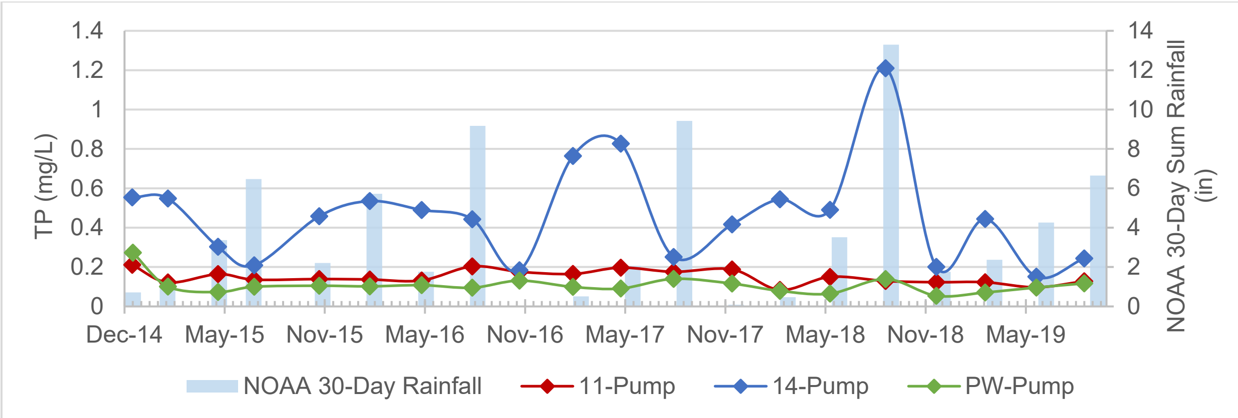


Figure 32. Time series plots of total phosphorus and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

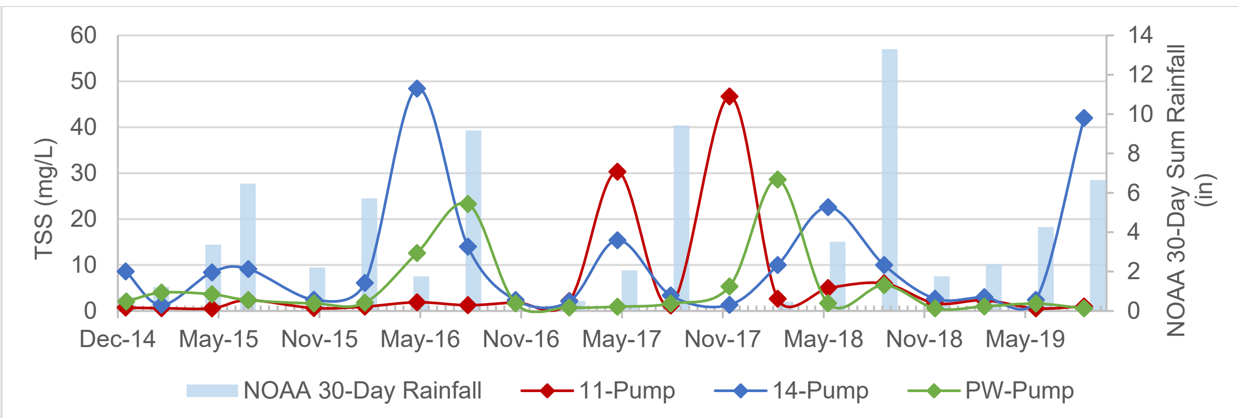


Figure 33. Time series plots of total suspended solids and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

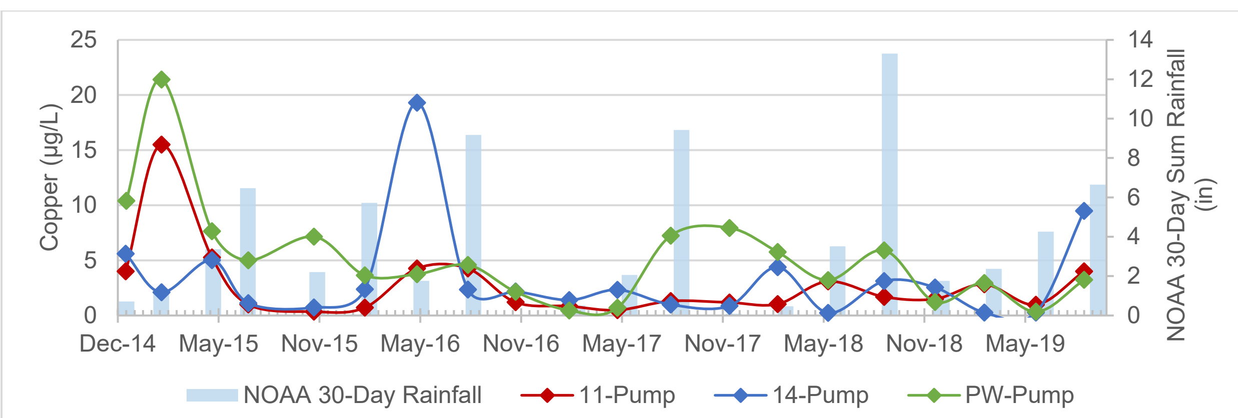


Figure 34. Time series plots of copper and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

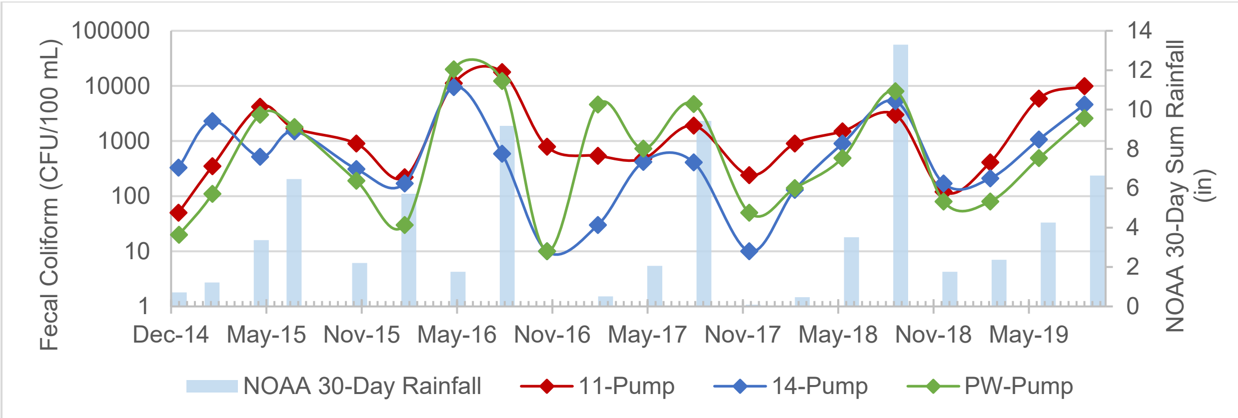


Figure 35. Time series semi-log scale plots of fecal coliform and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

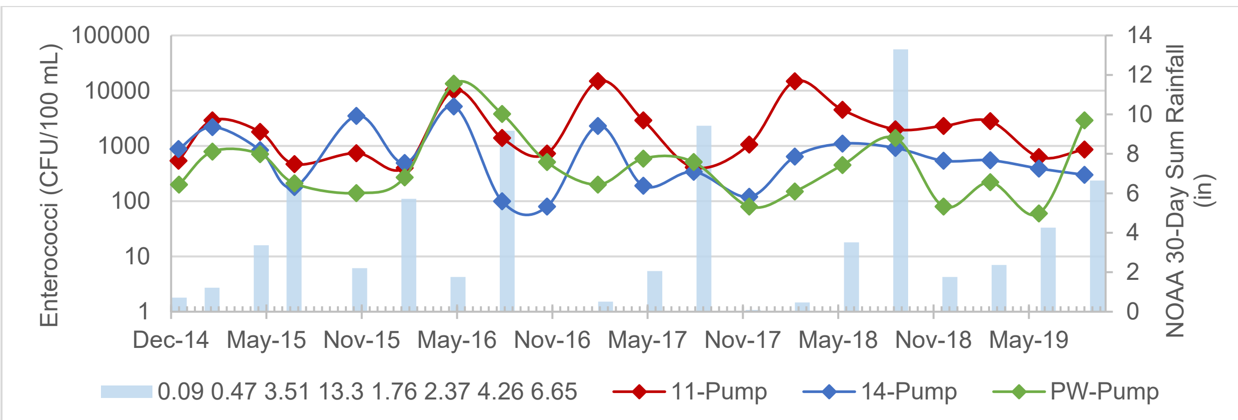


Figure 36. Time series semi-log scale plots of enterococci and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump, 11-Pump, and 14-Pump.

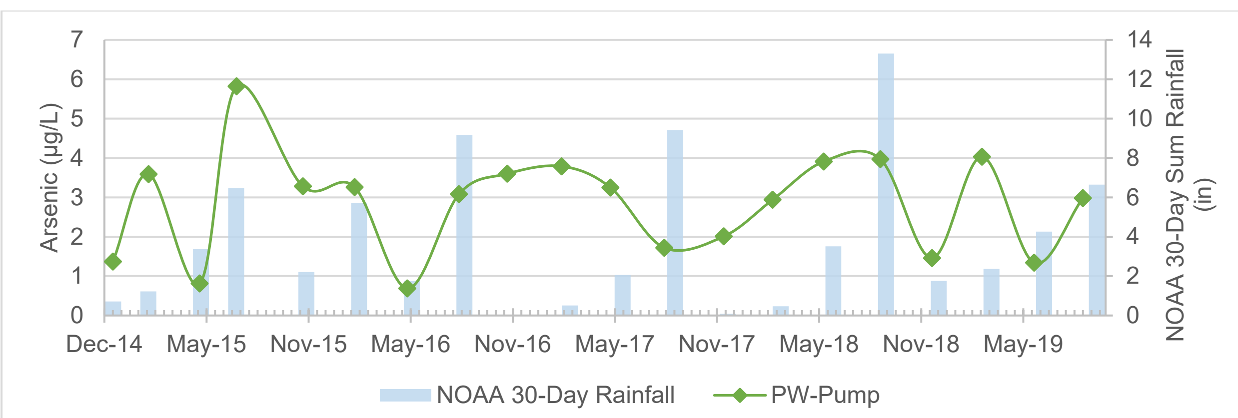


Figure 37. Time series plots of arsenic and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

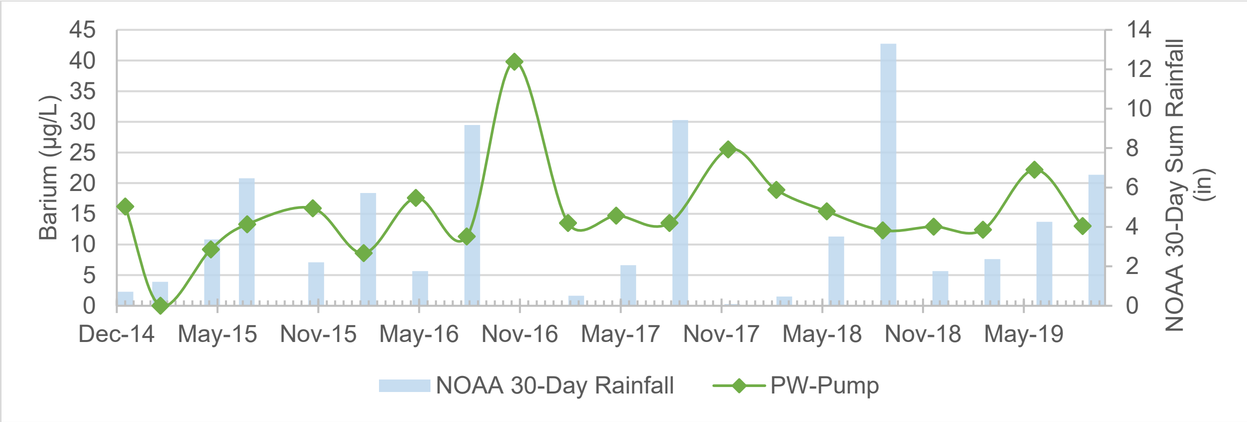


Figure 38. Time series plots of barium and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

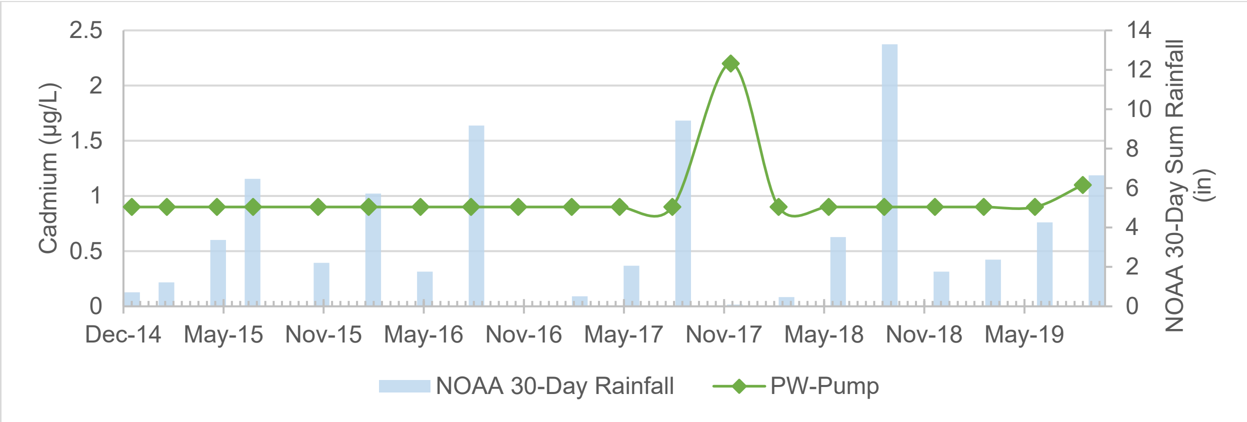


Figure 39. Time series plots of cadmium and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

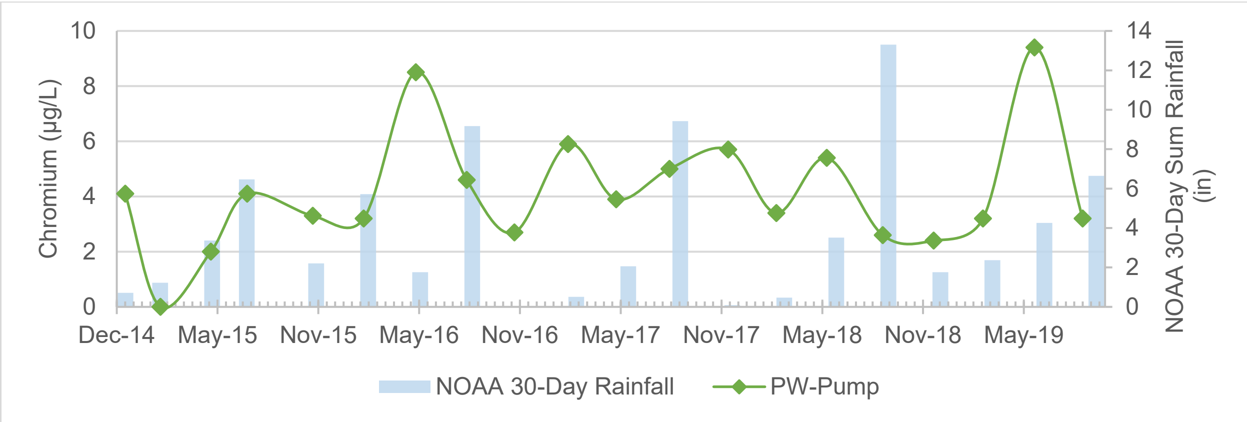


Figure 40. Time series plots of chromium and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

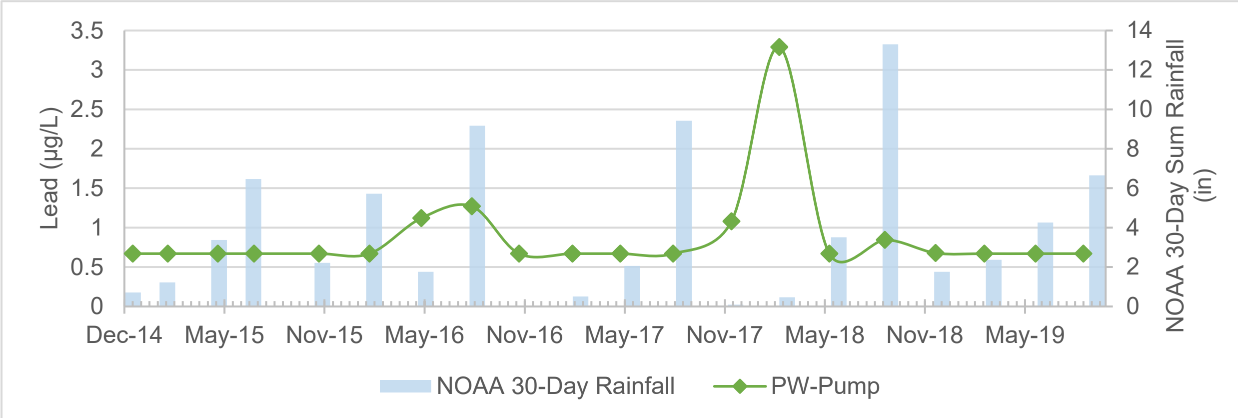


Figure 41. **Time series plots of lead and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.**

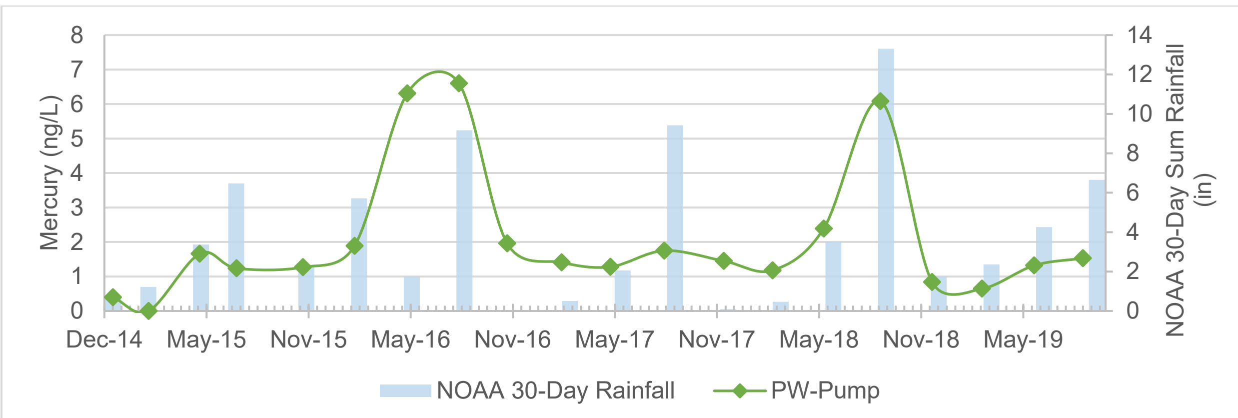


Figure 42. **Time series plots of mercury and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.**

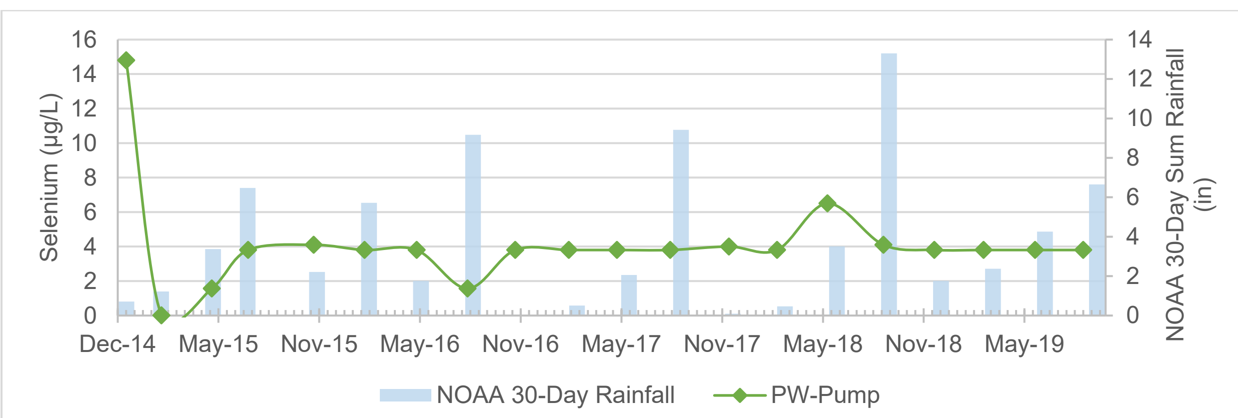


Figure 43. **Time series plots of selenium and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.**

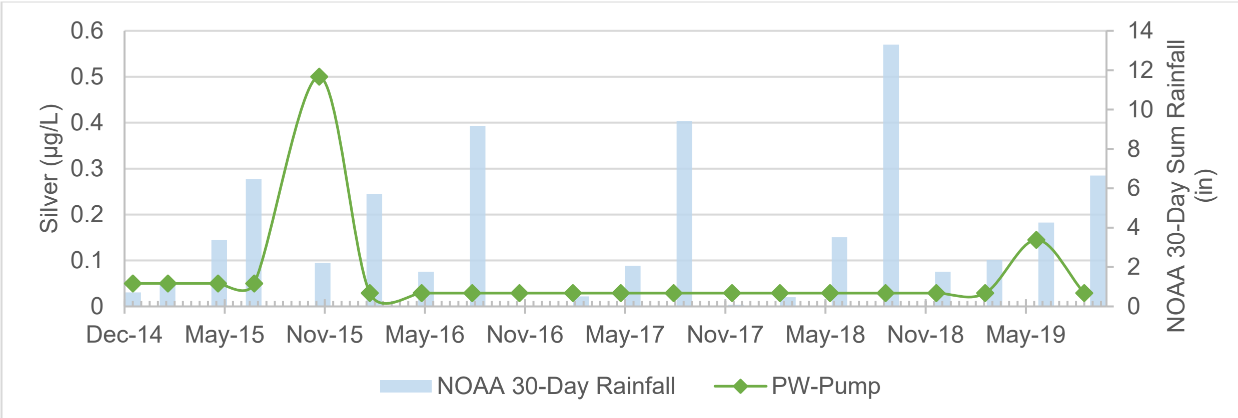


Figure 44. Time series plots of silver and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

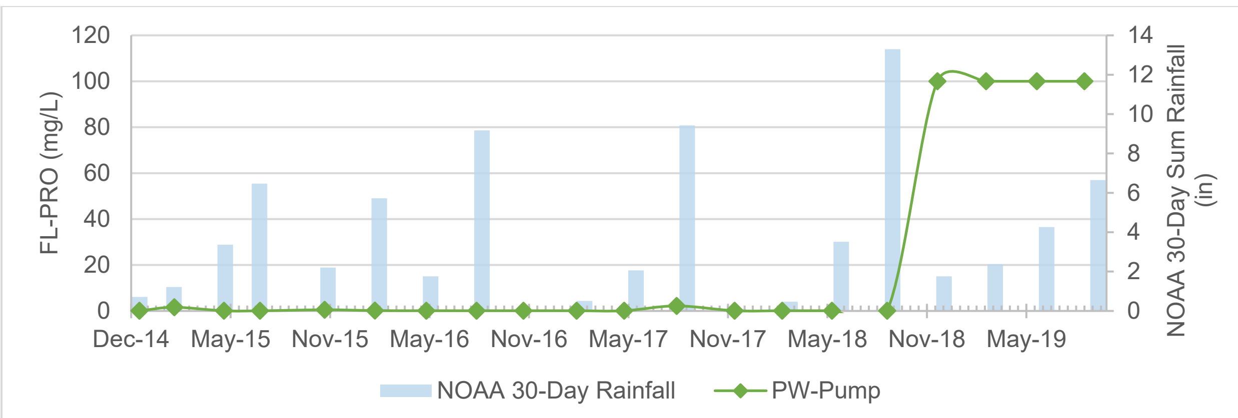


Figure 45. Time series plots of petroleum range organics and prior 30-day sum NOAA rainfall from December 2014 through September 2019 at PW-Pump.

3.2 Discussion

3.2.1 Summary of Pump Station Results from FY 2015 through FY 2019

Monitoring data collected at pump stations were reviewed and summarized by parameter. Pump station field measurements typically followed wet and dry seasonal trends. Temperature measurements at all pump stations increased in the wet season with the highest measurements in August 2019 with the exception of PW-Pump (highest temperature in May 2019). Dissolved oxygen at 14-Pump was elevated during the wet season with an increased surface water flow (months where flow was recorded during sampling events, Table 4 and Figures 21 and 22). Levels of pH were consistent during the FY 2015 to 2019 sampling period, with lower values recorded at 14-Pump and higher values at 11-Pump (Figure 23). SC and salinity measurements at 14-Pump were higher than the other pump stations (Figures 24 and 25). Based on SC measurements, water quality measurements taken at 14-Pump were always characterized as being "predominately marine" according to the FDEP classification of specific conductivities greater than 4,580 µS/cm (62-302.200(30), F.A.C.). All turbidity measurements were well below the Class III reference value of 29 NTU during all sampling events from FY 2015 through 2019, with the exception of the August 2016 measurement at PW-Pump and the November 2017 measurement at 14-Pump (Figure 26).

Nitrogen (TN, TKN, nitrate-nitrate, and ammonia) and phosphorus (TP and orthophosphate) concentrations were low and showed little variability at 11-Pump and PW-Pump stations (Figures 27 to 32). For comparison, the Naples Bay Numeric Nutrient Criteria for TN and TP are 0.57 mg/L and 0.045 mg/L, respectively (Rule 62-302.532; F.A.C.).

Copper concentrations typically stayed near/below 3 µg/L at pump stations 11-Pump and 14-Pump with few exceptions (Figure 34). At 14-Pump, copper concentrations were elevated and a maximum concentration of 9.48 µg/L was observed in August 2019 (Figure 34). The copper results reported were analyzed using the SM3113B method and methodology was altered depending on a monitoring station's corresponding SC measurement.

Fecal coliform and enterococci colony counts were elevated at all three pump stations above the Class III reference value of 800 cfu/100mL daily limit. All pump station data was variable but showed elevated values at all locations during the rainy season (Figure 35 and Figure 36). Both fecal coliform and enterococci responded to increases in rainfall with generally increased values. Maximum enterococci values were 2,900 cfu/100mL at PW-Pump in August 2019 and 2,800 cfu/100mL at 11-Pump in February 2019. The seasonal variation in the bacteria data indicates that the primary driver of the increase in fecal coliform and enterococci concentrations appears to be rainfall.

Further sampling events are recommended to assess trends and variance of fecal coliform and enterococci. In addition, implementation of regular city street sweeping clean-ups, public education on proper handling of pet waste and lawn grass clippings, and routine inspections are possible effective management strategies to consider in reducing fecal bacteria concentrations in storm water systems.

Elevated concentrations were detected at the PW-Pump station with arsenic being above 3 µg/L, barium above 10 µg/L, and mercury above 1 ng/L during various monitoring event (Figures 37, 38, and 42); none of these elevated values exceeded Class I or III Surface Water Quality Reference values (Rule 62-302.530, F.A.C.). All other heavy metal measurements were either non-detected or between the minimum detection limit (MDL) and practical quantitation limit (PQL) of the methodology.

3.2.2 Summary of Pump Station Statistical Analysis

Similar to the stormwater lakes, in order to determine if there were changes in water quality data in the pump stations over the five year sampling period along with differences among pump stations, different statistical analysis were run on the data. First, to better illustrate if there were differences in the data collected annually between pump stations, box plots were created to visually compare the data, with the boxes representing the 25-75% spread of the results, a median line indicated, and the whiskers representing the 5% and 95% spread of the results (see Appendix A.2). Second, a correlation analysis was performed using the 30-day sum of rainfall prior to sampling event and each of the water quality parameters at each pump station. The goal of this analysis was to determine if rainfall was a driver in the water quality results collected during each monitoring event. Third, to determine if there were statistically significant increasing or decreasing trends over the five year sampling periods, a Mann Kendall (annual Kendall) analysis was performed using the annual median values for each pump station. Finally, to determine if there were differences among the pump stations, a one-way ANOVA (analysis of variance) was performed utilizing the complete data set. Results of each of the analysis are discussed below.

Box Plots

Box plots were created to visually compare the median and first and third quartile ranges at the three pump stations for each parameter for each fiscal year (Appendix A.2, Figures A-55 to A-71). Additional graphs were created for parameters just analyzed at PW-Pump to determine if there had been any changes in ranges of concentrations observed annually (Appendix A.2, Figures A-72 to A-80). Box plots of field data were variable at all pump stations from FY 2015 to 2019 with DO, temperature, and pH having large ranges at each pump station. Data collected at 14-Pump appeared to be the most variable regardless of field parameter collected. Concentrations of TN and TKN had little variability from FY 2015-2019 with the exception of 14-Pump which showed the largest variability in the 2016 and 2018 data. Data for nitrate-nitrite and TSS were variable at all pump stations and most years. Finally, bacterial ranges for both fecal coliform and enterococci varied the most in 2016, 2018, and 2019 by pump station. Enterococci had the largest spread of data during the 2016, 2017 and 2018 sampling years at 11-Pump. The remaining data for metals (arsenic, barium, cadmium, chromium, lead, mercury and selenium) were all collected at PW-pump and had a varying distribution of data from 2015 to 2019.

Spearman's Rank Correlation

Similar to the stormwater lakes, each of the parameters sampled at the three pump stations was compared with the NOAA rainfall sums 30-days prior to the sampling date to determine if it was correlated. In general, there were negative correlations between rainfall and SC, salinity, TN, nitrate-nitrite, hardness, and barium (PW-Pump only) with at least one of the pump stations (Spearman's Rank Correlation, $p < 0.05$, Table 13). Similar to the stormwater lakes, there was a positive correlation between rainfall and temperature (driven by higher temperatures generally observed during the wet season months), pH, orthophosphate, and fecal coliform (Spearman's Rank Correlation, $p < 0.05$). The remaining water quality parameters did not have a statistically significant positive or negative correlation with rainfall ($p > 0.05$).

Table 13. Spearman's Rank Correlations between water quality and 30-day NOAA rainfall at PW-Pump, 11-Pump, and 14-Pump from December 2014 to September 2019.

Parameter Type	Parameter	PW-Pump		11-Pump		14-Pump	
		r_s	N	r_s	N	r_s	N
Field Parameters	Temperature	**0.56**	20	**0.63**	20	**0.66**	20
	DO (%Sat)	0.43	20	0.16	20	0.17	20
	DO (mg/L)	0.35	20	-0.01	20	0.15	20
	pH	0.10	20	0.05	20	**0.48**	20
	SC	-0.44	20	**-0.46**	20	-0.08	20
	Salinity	-0.44	20	**-0.53**	20	-0.09	20
	Turbidity	0.11	20	-0.32	20	0.45	20
Lab Parameters	TN	**-0.49**	20	-0.33	20	0.10	20
	Nitrate-Nitrite	**-0.63**	20	**-0.53**	20	-0.35	20
	TKN	-0.30	20	-0.17	20	0.13	20
	Ammonia	-0.14	20	-0.34	20	0.32	20
	Orthophosphate	0.11	20	**0.62**	20	-0.06	20
	TP	0.04	20	-0.08	20	-0.13	20
	TSS	-0.05	20	-0.15	20	0.44	20
	Copper	0.00	20	0.11	20	-0.05	20
	Fecal Coliform	**0.55**	20	**0.55**	20	**0.59**	20
	Enterococci	0.37	20	-0.39	20	-0.14	20
	Total Hardness	-0.22	14	**-0.68**	16	-0.31	6
Additional Parameters	Arsenic	0.14	20				
	Barium	**-0.53**	20				
	Cadmium	-0.08	20				
	Chromium	-0.03	20				
	Lead	-0.12	20				
	Mercury	0.39	20				
	Selenium	-0.07	20				
	Silver	0.01	20				
	FL-PRO	0.15	20				

All significant correlations ($p < 0.05$) are in **bold red**.

Mann Kendall

There were few statistically significant increasing or decreasing trends observed over time at each of the pump stations (Mann Kendall, $p < 0.05$, Table 14). At PW-Pump, there was a statistically significant increasing trend in ammonia (slope 0.03 mg/L/yr), but the slope of increase is small and is not of concern at this time. At 11-Pump, there was a statistically significant increase in pH over time (slope 0.05 SU/yr); however, this annual increase is within the standard error of the datasonde and is not a concern at this time. There was also a statically significant decrease in TP at 11-Pump (slope 0.05 mg/L/yr) which is in the desired direction. At 14-Pump, there was a statistically significant decreasing trend in DO concentration and saturation (slopes -0.45 mg/L/yr and -5.94 percent/yr). While not a concern at this time, this trend should be monitored over time to make sure the slope does not continue to become more negative (additional annual reduction for these values) over time. The statistically significant decrease in copper at 14-Pump (slope -0.53 µg/L/yr) is in a desired direction and is not of concern.

Table 14. Annual Kendall Tau results of annual medians from FY 2015 to FY 2019 PW-Pump, 11-Pump, and 14-Pump.

<table>
<tr><th rowspan="2">Parameter Type</th><th rowspan="2">Parameter</th><th colspan="3">PW-Pump</th><th colspan="3">11-Pump</th><th colspan="3">14-Pump</th></tr>
<tr><th>Tau</th><th>p-value</th><th>Slope</th><th>Tau</th><th>p-value</th><th>Slope</th><th>Tau</th><th>p-value</th><th>Slope</th></tr>
<tr><td rowspan="7">Field Parameters</td><td>Temperature</td><td>0.00</td><td>1.00</td><td rowspan="10">N/A</td><td>-0.60</td><td>0.14</td><td rowspan="3">N/A</td><td>0.20</td><td>0.62</td><td>N/A</td></tr>
<tr><td>DO (%Sat)</td><td>0.40</td><td>0.33</td><td>-0.20</td><td>0.62</td><td>-1.00</td><td>0.01</td><td>-5.94</td></tr>
<tr><td>DO (mg/L)</td><td>0.40</td><td>0.33</td><td>-0.20</td><td>0.62</td><td>-0.80</td><td>0.05</td><td>-0.45</td></tr>
<tr><td>pH</td><td>0.40</td><td>0.33</td><td>0.80</td><td>0.05</td><td>0.05</td><td>-0.20</td><td>0.62</td><td rowspan="11">N/A</td></tr>
<tr><td>SC</td><td>0.20</td><td>0.62</td><td>-0.40</td><td>0.33</td><td rowspan="7">N/A</td><td>0.40</td><td>0.33</td></tr>
<tr><td>Salinity</td><td>0.20</td><td>0.62</td><td>-0.40</td><td>0.33</td><td>0.40</td><td>0.33</td></tr>
<tr><td>Turbidity</td><td>-0.40</td><td>0.33</td><td>0.60</td><td>0.14</td><td>0.20</td><td>0.62</td></tr>
<tr><td rowspan="10">Lab Parameters</td><td>TN</td><td>-0.20</td><td>0.62</td><td>-0.60</td><td>0.14</td><td>-0.20</td><td>0.62</td></tr>
<tr><td>Nitrate-Nitrite</td><td>-0.20</td><td>0.62</td><td>-0.20</td><td>0.62</td><td>-0.11</td><td>0.80</td></tr>
<tr><td>TKN</td><td>0.00</td><td>1.00</td><td>-0.40</td><td>0.33</td><td>-0.20</td><td>0.62</td></tr>
<tr><td>Ammonia</td><td>0.80</td><td>0.05</td><td>0.03</td><td>-0.60</td><td>0.14</td><td>0.20</td><td>0.62</td></tr>
<tr><td>Orthophosphate</td><td>-0.20</td><td>0.62</td><td rowspan="8">N/A</td><td>-0.80</td><td>0.05</td><td>-0.01</td><td>0.00</td><td>1.00</td></tr>
<tr><td>TP</td><td>-0.40</td><td>0.33</td><td>-0.40</td><td>0.33</td><td rowspan="5">N/A</td><td>0.20</td><td>0.62</td></tr>
<tr><td>TSS</td><td>-0.40</td><td>0.33</td><td>0.60</td><td>0.14</td><td>-0.40</td><td>0.33</td></tr>
<tr><td>Copper</td><td>-0.40</td><td>0.33</td><td>-0.40</td><td>0.33</td><td>-0.80</td><td>0.05</td><td>-0.53</td></tr>
<tr><td>Fecal Coliform</td><td>-0.60</td><td>0.14</td><td>0.20</td><td>0.62</td><td>0.00</td><td>1.00</td><td rowspan="2">N/A</td></tr>
<tr><td>Enterococci</td><td>-0.60</td><td>0.14</td><td>0.40</td><td>0.33</td><td>-0.40</td><td>0.33</td></tr>
<tr><td rowspan="9">Additional Parameters</td><td>Arsenic</td><td>0.11</td><td>0.80</td><td colspan="6" rowspan="9"></td></tr>
<tr><td>Barium</td><td>0.40</td><td>0.33</td></tr>
<tr><td>Cadmium</td><td colspan="3">Insufficient Data</td></tr>
<tr><td>Chromium</td><td>0.20</td><td>0.62</td><td rowspan="7">N/A</td></tr>
<tr><td>Lead</td><td>0.12</td><td>0.77</td></tr>
<tr><td>Mercury</td><td>0.00</td><td>1.00</td></tr>
<tr><td>Selenium</td><td>0.60</td><td>0.14</td></tr>
<tr><td>Silver</td><td>-0.63</td><td>0.12</td></tr>
<tr><td>FL-PRO</td><td>0.40</td><td>0.33</td></tr>
</table>

All significant correlations ($p < 0.05$) and trend slopes are in **bold red**.

ANOVA

There were statistically significant differences among the pump stations for 10 of the 18 parameters sampled from FY 2015 through FY 2019 (ANOVA, $p < 0.05$, Table 15). Overall, PW-Pump never had the highest or lowest concentrations of the three pump stations for any parameter. Dissolved oxygen saturation and concentration were the highest at 11-Pump (Duncan's post hoc test, $p < 0.05$). While not directly related, pH values and nitrate-nitrite concentrations were the highest at 11-Pump and the lowest at 14-Pump (Duncan's post hoc test, $p < 0.05$). The highest concentrations of SC, salinity, TN, TKN, orthophosphate, TP, and hardness were found at 14-Pump (Duncan's post hoc test, $p < 0.05$). The elevated SC, salinity, and hardness are related to 14-Pump being classified as generally marine waters, but should not be the driver for the higher nutrients observed.

Table 15. Summary of ANOVA results for City of Naples pump stations from December 2014 to September 2019.

Parameter Type	Parameter	F	p-value
Field Parameters	Temperature	0.74	0.48
	DO (%Sat)	**5.64**	**0.01**
	DO (mg/L)	**7.15**	**0.002**
	pH	**10.69**	**0.0001**
	SC	**29.79**	**<0.0001**
	Salinity	**27.00**	**<0.0001**
	Turbidity	0.35	0.71
Lab Parameters	TN	4.31	0.18
	Nitrate-Nitrite	**18.44**	**<0.0001**
	TKN	**7.16**	**0.002**
	Ammonia	0.48	0.62
	Orthophosphate	**30.68**	**<0.0001**
	TP	**33.14**	**<0.0001**
	TSS	1.66	0.20
	Copper	1.90	0.16
	Fecal Coliform	0.96	0.39
	Enterococci	2.94	0.61
	Total Hardness	**19.81**	**<0.0001**

Parameters with significant differences among pump stations ($p < 0.05$) are in **bold red**.

3.3 Pump Station Loading Summary

Estimated monthly loadings for parameters of concern to the City (nutrients, copper, and solids) were calculated for each of the three pump stations. This analysis was based on monthly discharge volume calculations from the three City pump stations, which are estimates based on the pump run time and maximum pump rate for each system. Therefore, this analysis may not reflect actual volumes from each pump station, and the loadings calculated using these volume estimates should be considered estimates of the maximum loads. Because water quality monitoring is conducted quarterly for each pump station rather than monthly, the quarterly concentration was assumed to represent each month during that calendar quarter.

Annual total loading (in pounds) is included for FY 2017 to 2019 for copper, total nitrogen, total phosphorus, and total suspended solids (Table 16). Table 17 shows the estimated monthly total loads (in pounds) from each pump station from October 2016 through May 2019 for copper, total nitrogen, total phosphorus, and total suspended solids. Data prior to FY 2017 is not included in the annual loading calculations as it was not comparable due to differences in sampling frequency and timing.

Table 16. Annual total loadings (in pounds) from City of Naples Pump Stations from FY 2017 to 2019.

Pump Station	Fiscal Year	Annual Loading (lbs)			
		Copper	Total Nitrogen	Total Phosphorus	Total Suspended Solids
PW-Pump	2017	67.55	10955.2	1449.1	16468.7
	2018	39.87	9450.3	741.7	49869.0
	2019*	5.41	4191.5	263.1	3780.8
11-Pump	2017	12.13	17005.0	2165.7	120683.2
	2018	33.74	25746.7	2647.0	277849.5
	2019*	20.00	14870.5	1313.8	17319.9
14-Pump	2017	3.55	2747.0	975.1	13694.1
	2018	5.91	5925.5	2059.0	29262.1
	2019*	1.64	1672.0	375.6	3746.8

*Does not include June to September totals.

Table 17. Monthly and annual total loadings (in pounds) from City of Naples Pump Stations from October 2016 to May 2019.

Pump Station	Month	Monthly Loading (lbs)			
		Copper	Total Nitrogen	Total Phosphorus	Total Suspended Solids
PW-Pump	October-16	0.80	589.0	48.8	615.1
	November-16	0.26	193.5	16.0	202.1
	December-16	0.21	152.3	12.6	159.1
	January-17	0.06	197.2	13.8	105.9
	February-17	0.02	46.6	3.3	25.0
	March-17	0.01	36.2	2.5	19.4
	April-17	0.10	197.8	13.0	131.4
	May-17	0.10	204.4	13.4	135.7
	June-17	0.45	893.4	58.5	593.2
	July-17	18.96	2443.4	366.6	4190.1
	August-17	18.96	2443.4	366.6	4190.1
	September-17	27.61	3557.9	533.9	6101.5
	October-17	9.46	1656.5	138.2	6351.8
	November-17	0.88	153.8	12.8	589.7
	December-17	3.90	682.1	56.9	2615.4
	January-18	1.00	251.0	13.7	4951.5
	February-18	0.80	201.1	11.0	3966.0
	March-18	2.93	738.2	40.2	14560.3
	April-18	2.21	804.8	44.7	1148.7
	May-18	2.28	831.6	46.2	1187.0
	June-18	2.46	897.9	49.9	1281.6
	July-18	4.17	966.2	98.0	3949.4
	August-18	4.17	966.2	98.0	3949.4
	September-18	5.61	1301.1	132.0	5318.3
	October-19	0.72	712.8	31.8	335.8
	November-19	0.11	109.6	4.9	51.6
	December-19	0.58	576.0	25.7	271.3
	January-19	1.74	715.2	42.0	591.1
	February-19	0.41	169.0	9.9	139.6
	March-19	1.43	585.7	34.4	484.1
	April-19	0.20	650.7	56.3	938.0
	May-19	0.21	672.4	58.2	969.2

Pump Station	Month	Monthly Loading (lbs)			
		Copper	Total Nitrogen	Total Phosphorus	Total Suspended Solids
11-Pump	October-16	0.86	1334.5	126.3	1334.5
	November-16	0.21	322.6	30.5	322.6
	December-16	0.27	419.7	39.7	419.7
	January-17	0.32	630.7	62.3	815.8
	February-17	0.30	600.1	59.3	776.2
	March-17	0.13	266.4	26.3	344.6
	April-17	0.45	1590.9	181.2	27864.4
	May-17	0.46	1644.0	187.2	28793.2
	June-17	0.84	2993.6	340.9	52430.7
	July-17	3.27	2841.5	438.7	2991.1
	August-17	3.27	2841.5	438.7	2991.1
	September-17	1.75	1519.6	234.6	1599.5
	October-17	3.14	4156.3	500.9	124422.3
	November-17	0.56	738.0	88.9	22093.0
	December-17	1.45	1918.0	231.1	57418.5
	January-18	0.47	508.6	37.8	1201.6
	February-18	0.37	400.5	29.8	946.3
	March-18	1.34	1460.1	108.5	3449.9
	April-18	4.22	1845.7	205.1	6835.9
	May-18	4.37	1907.2	211.9	7063.7
	June-18	4.58	1999.1	222.1	7404.1
	July-18	4.73	3861.2	360.9	16787.7
	August-18	4.73	3861.2	360.9	16787.7
	September-18	3.79	3090.9	288.9	13438.6
	October-19	2.22	2039.4	181.8	2468.0
	November-19	1.66	1529.5	136.3	1851.0
	December-19	2.21	2029.7	180.9	2456.3
	January-19	4.04	1727.0	175.6	3325.5
	February-19	3.63	1550.7	157.6	2986.1
	March-19	2.47	1056.4	107.4	2034.3
	April-19	1.86	2428.4	184.0	1081.4
	May-19	1.92	2509.3	190.2	1117.4

Pump Station	Month	Monthly Loading (lbs)			
		Copper	Total Nitrogen	Total Phosphorus	Total Suspended Solids
14-Pump	October-16	0.40	190.4	34.0	439.9
	November-16	0.27	126.2	22.5	291.5
	December-16	0.18	86.9	15.5	200.7
	January-17	0.13	114.6	70.0	193.5
	February-17	0.09	79.4	48.5	134.1
	March-17	0.09	77.5	47.4	130.9
	April-17	0.31	227.9	110.2	2052.6
	May-17	0.32	235.5	113.9	2121.0
	June-17	0.66	481.4	232.8	4335.1
	July-17	0.38	385.9	95.9	1299.2
	August-17	0.38	385.9	95.9	1299.2
	September-17	0.35	355.4	88.3	1196.4
	October-17	0.24	420.5	116.9	372.9
	November-17	0.13	230.5	64.1	204.4
	December-17	0.14	236.2	65.7	209.4
	January-18	0.73	313.4	90.7	1667.1
	February-18	0.56	240.9	69.7	1281.6
	March-18	0.67	287.5	83.2	1529.4
	April-18	0.05	352.8	103.1	4746.4
	May-18	0.05	364.6	106.6	4904.6
	June-18	0.04	282.2	82.5	3795.8
	July-18	1.07	1036.8	414.0	3421.7
	August-18	1.07	1036.8	414.0	3421.7
	September-18	1.16	1123.2	448.6	3707.1
	October-19	0.56	218.4	44.4	590.1
	November-19	0.41	160.3	32.6	433.1
	December-19	0.44	171.4	34.9	463.1
	January-19	0.05	260.5	73.7	497.9
	February-19	0.05	264.1	74.7	504.6
	March-19	0.04	222.8	63.0	425.8
	April-19	0.05	184.2	25.8	409.3
	May-19	0.05	190.3	26.6	422.9

4 References

AMEC Environmental & Infrastructure, Inc. 2012. City of Naples Stormwater Quality Analysis, Pollutant Loading and Removal Efficiencies. Technical Publication Submitted to the City of Naples, Florida. 95pp.

Gordon E, Stein S. 2007. Stormwater BMPs Selection, Maintenance and Monitoring. Santa Barbara (CA): Forrester Press.

APPENDIX

A

WATER QUALITY BOX PLOTS OF STORMWATER LAKES AND PUMP STATIONS FROM FY2015 TO FY2019

Appendix A
Water Quality Box Plots of Stormwater Lakes and Pump Stations from FY2015 to FY2019

A.1 Stormwater Lakes

A.1.1 Lakes Draining to Moorings Bay

Field Parameters

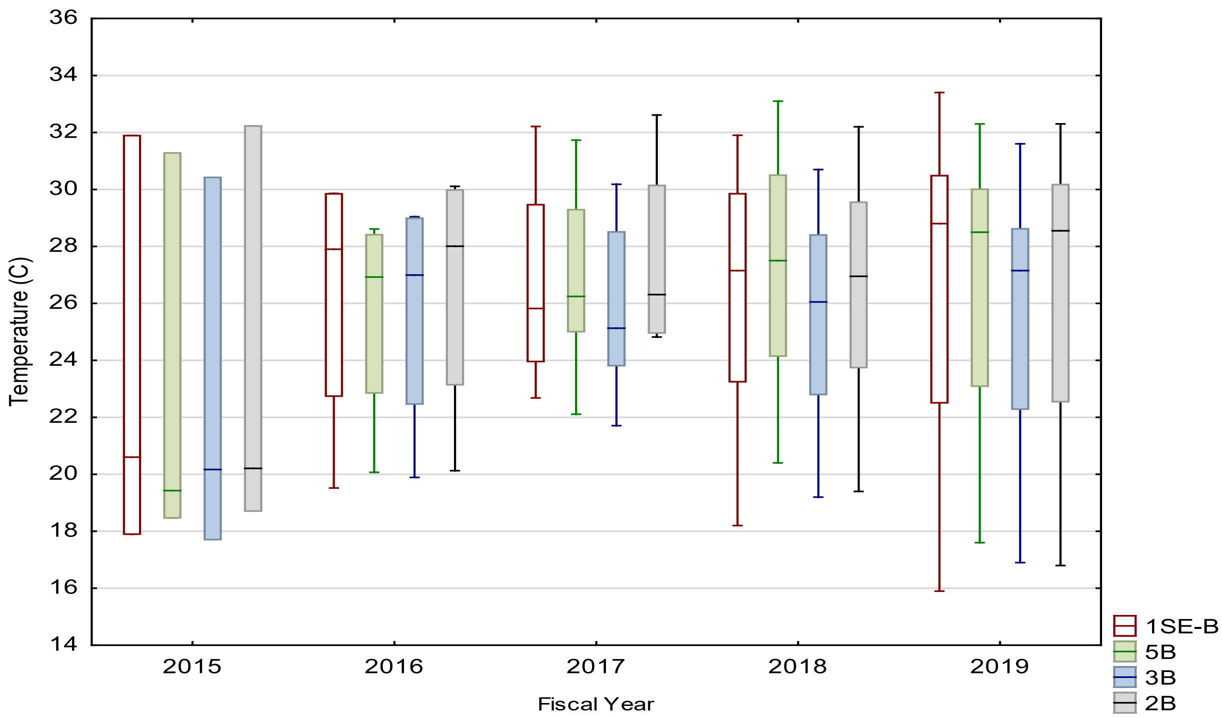


Figure A-1. Box plot of water temperature from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

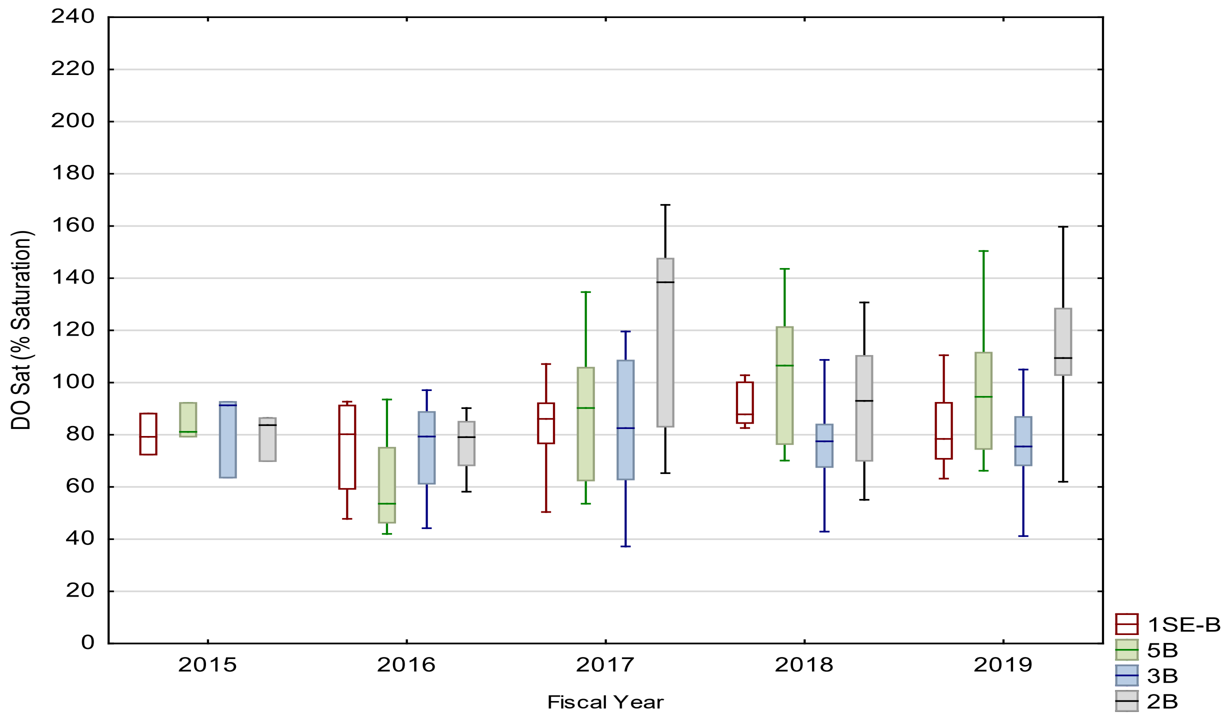


Figure A-2. Box plot of dissolved oxygen saturation from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

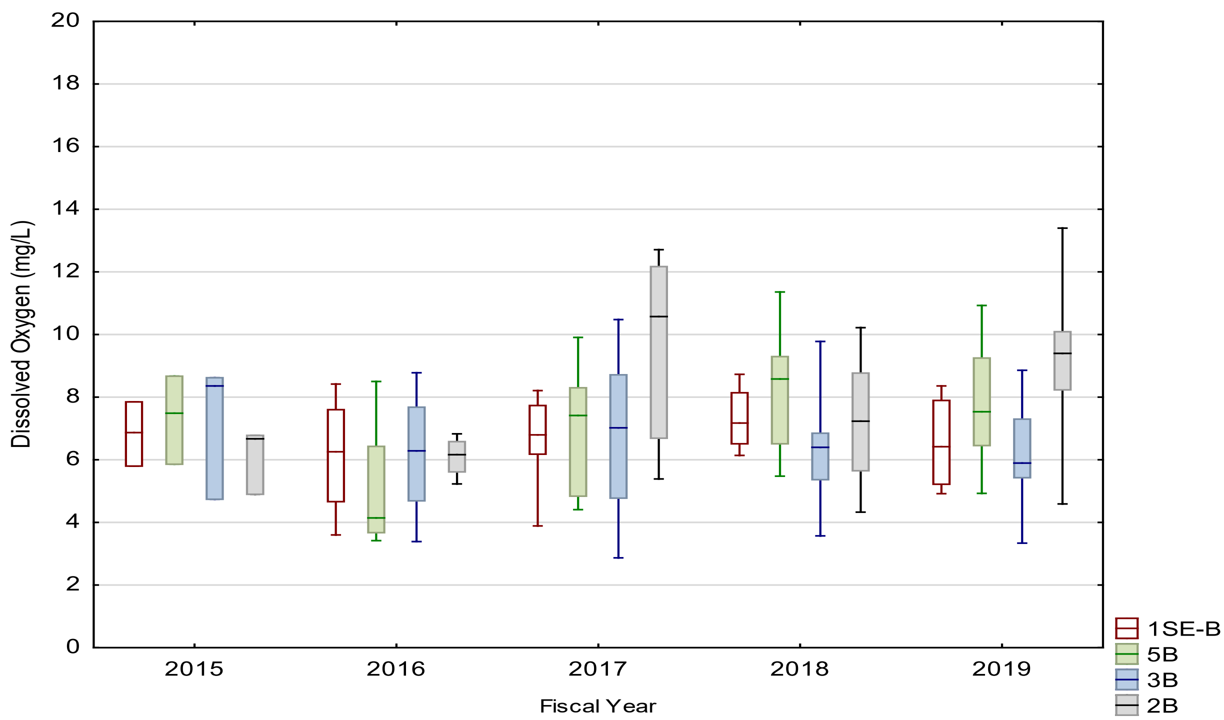


Figure A-3. Box plot of dissolved oxygen (mg/L) from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

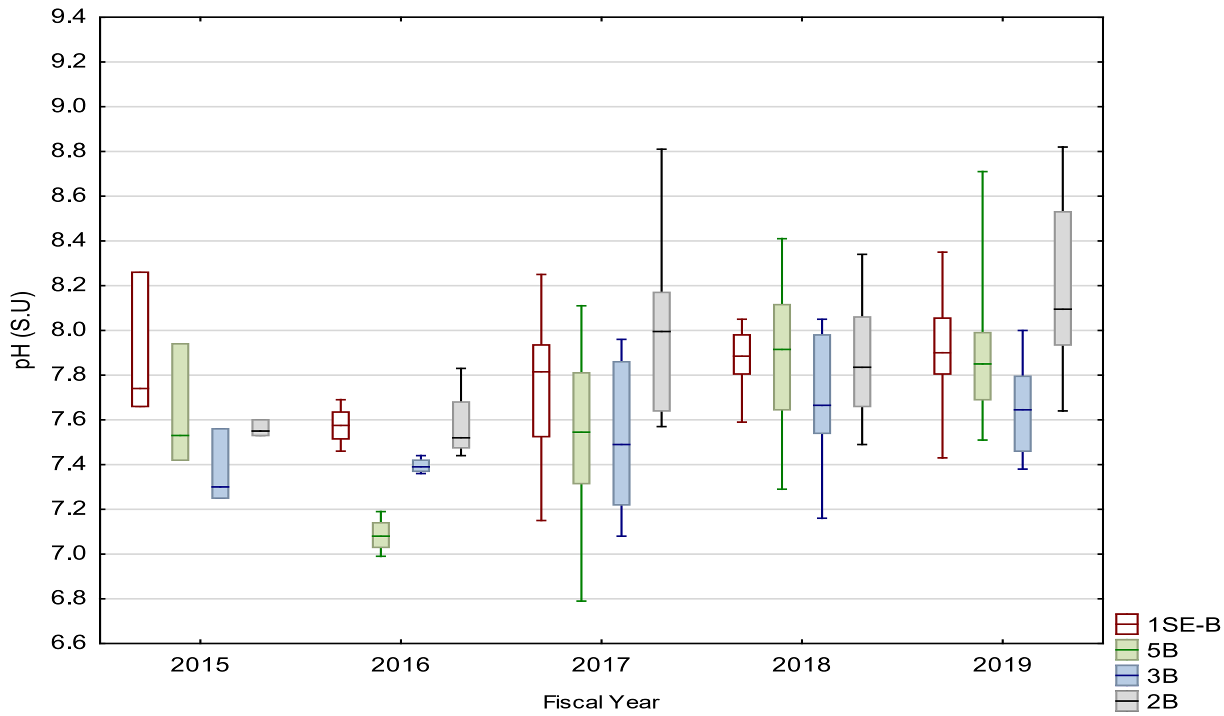


Figure A-4. Box plot of pH from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

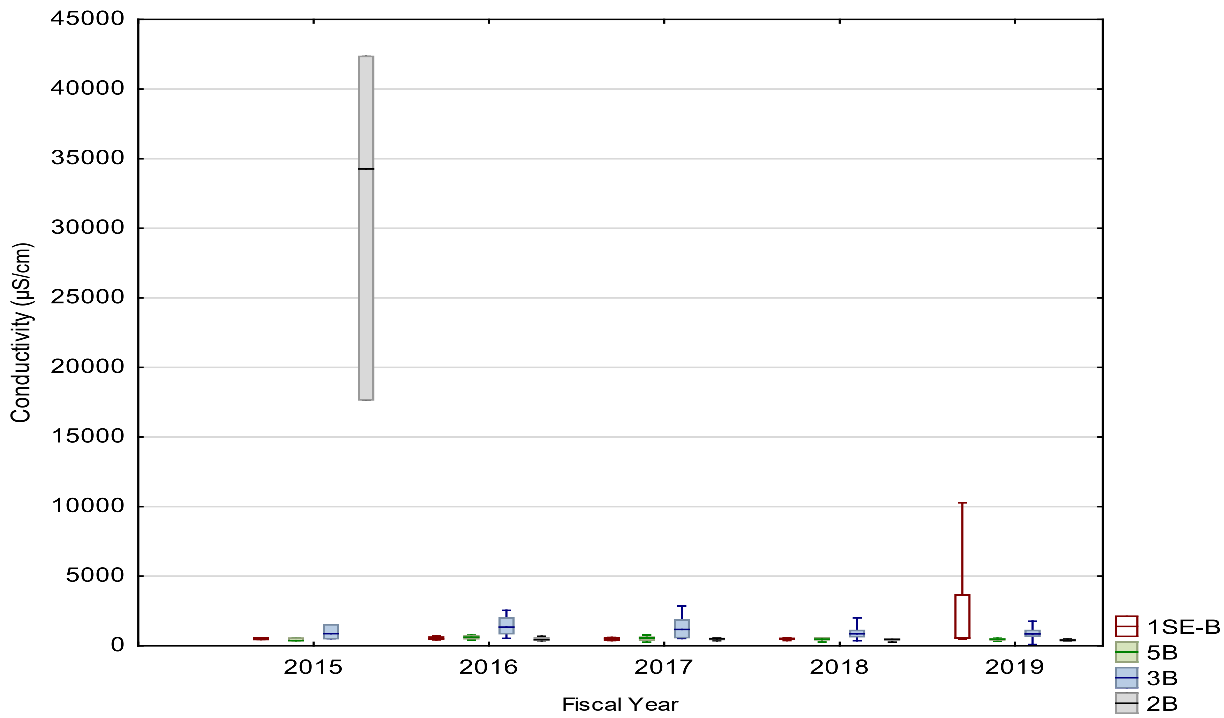


Figure A-5. Box plot of specific conductivity from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

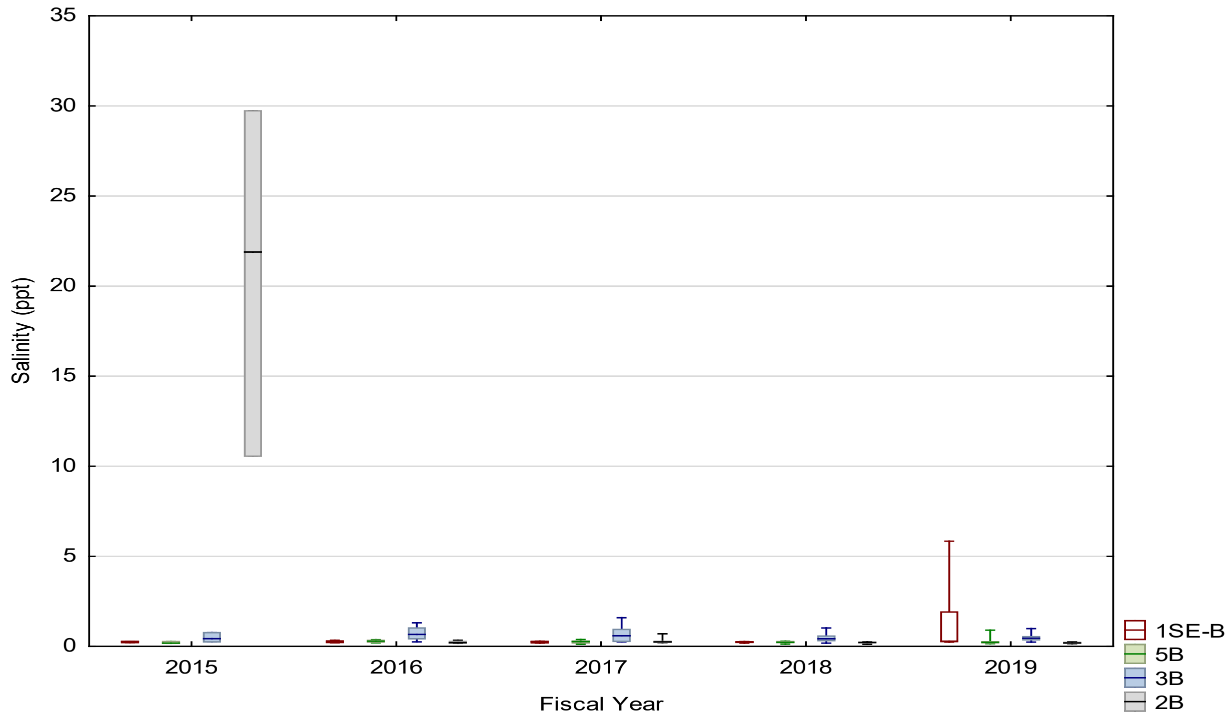


Figure A-6. Box plot of salinity from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

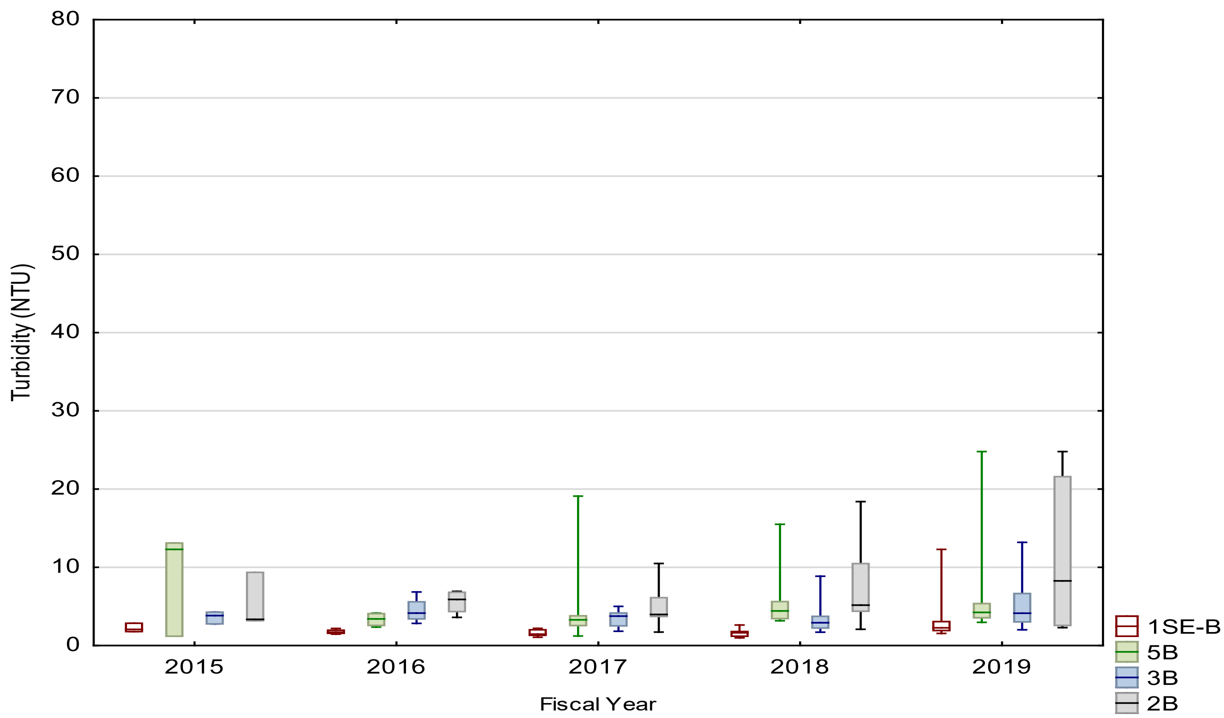


Figure A-7. Box plot of turbidity from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

Lab Parameters

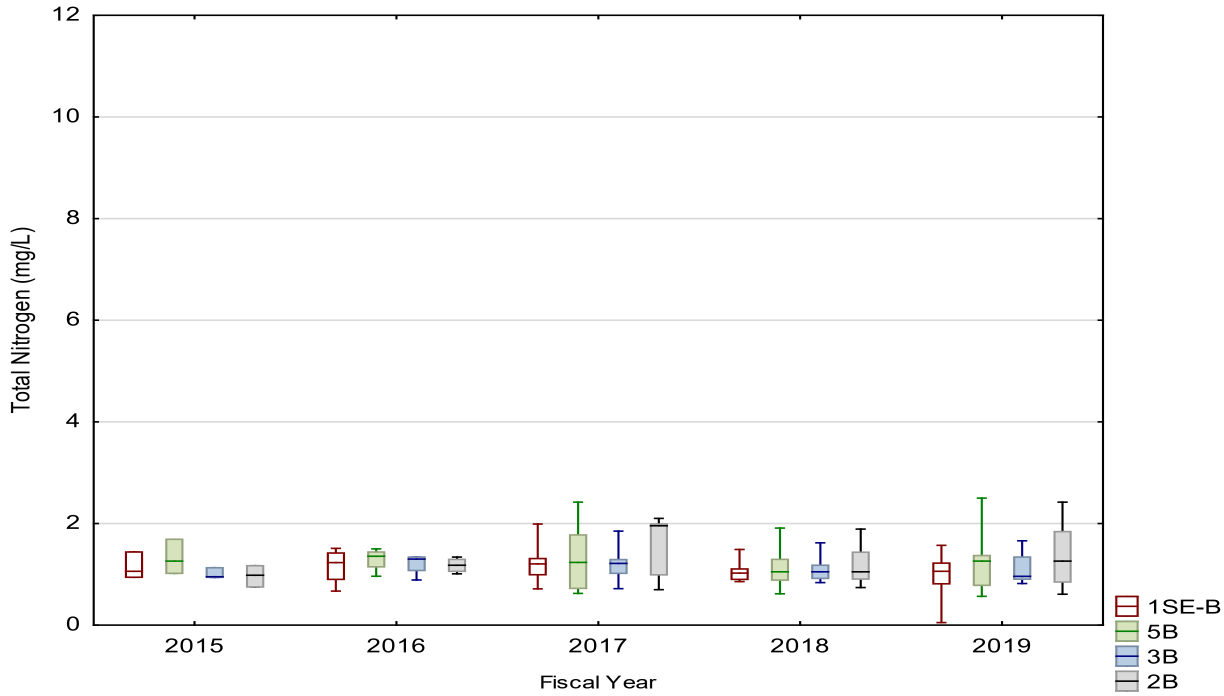


Figure A-8. Box plot of total nitrogen from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

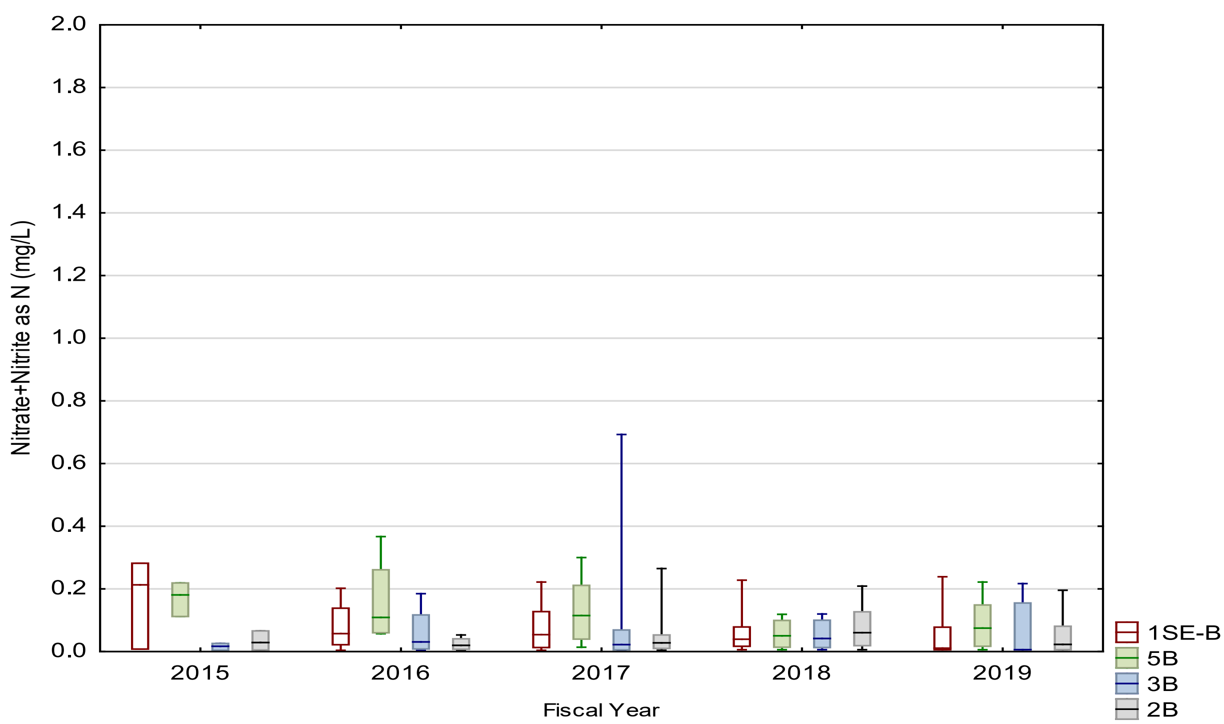


Figure A-9. Box plot of nitrate-nitrite from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

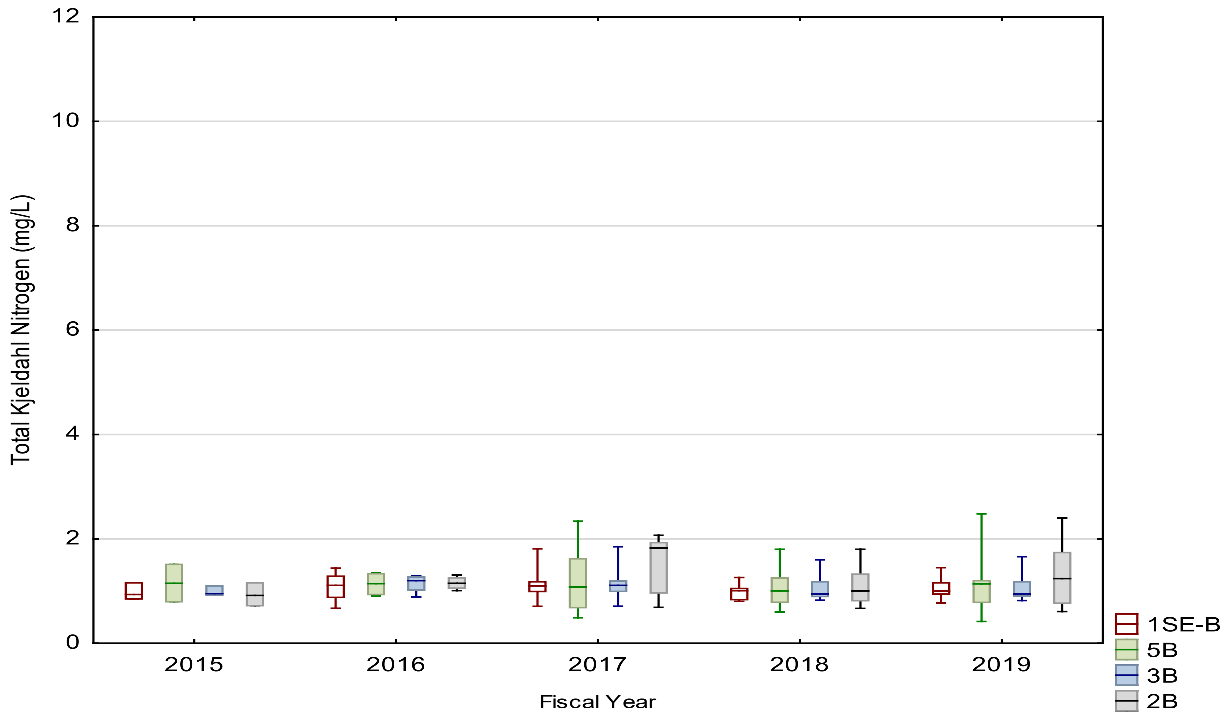


Figure A-10. Box plot of Total Kjeldahl Nitrogen from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

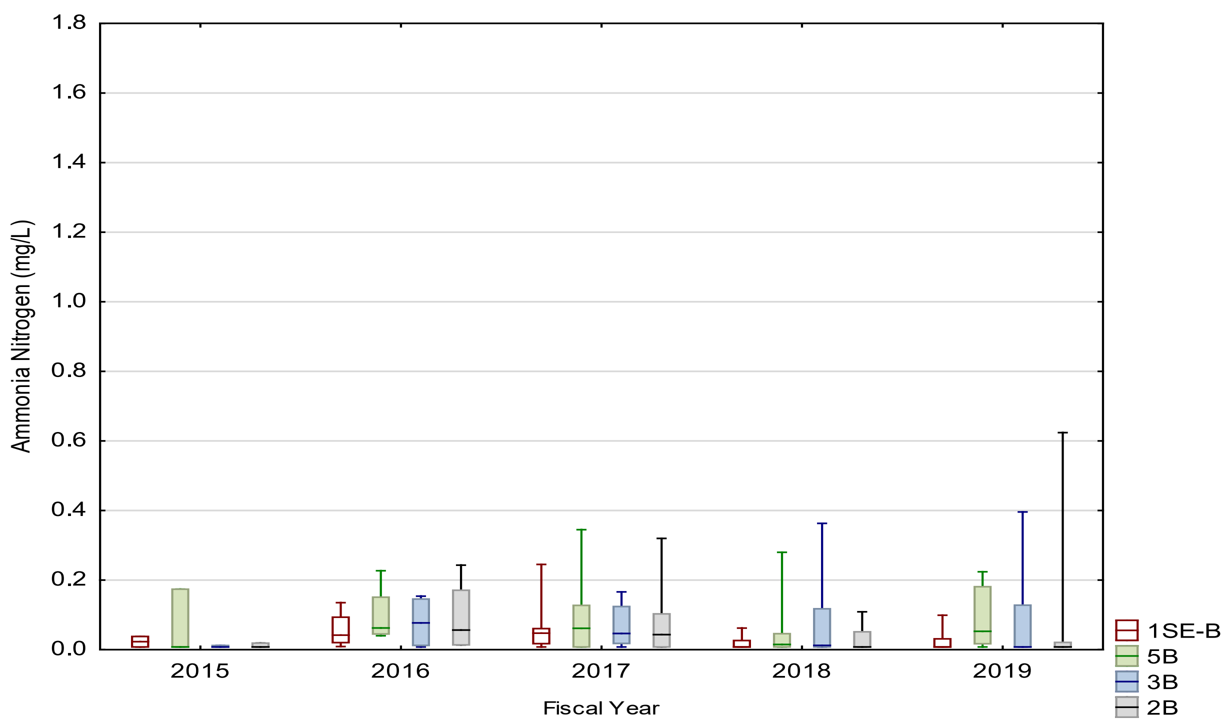


Figure A-11. Box plot of ammonia nitrogen from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

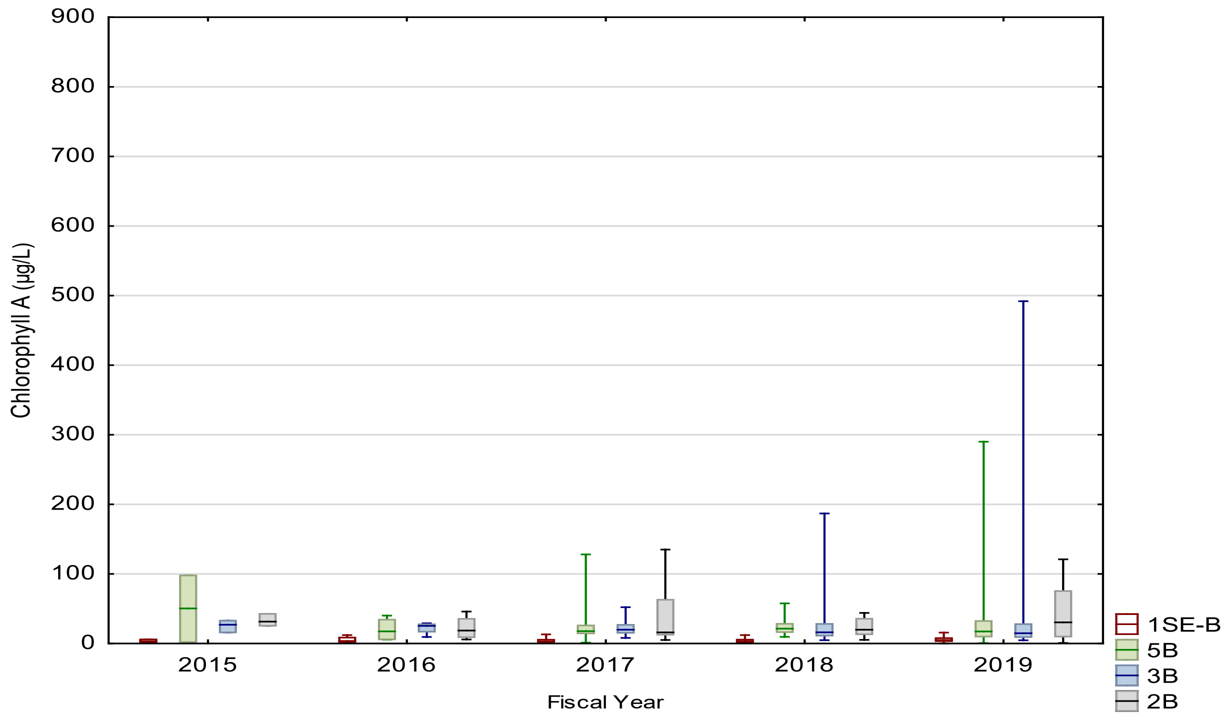


Figure A-12. Box plot of chlorophyll-*a* from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

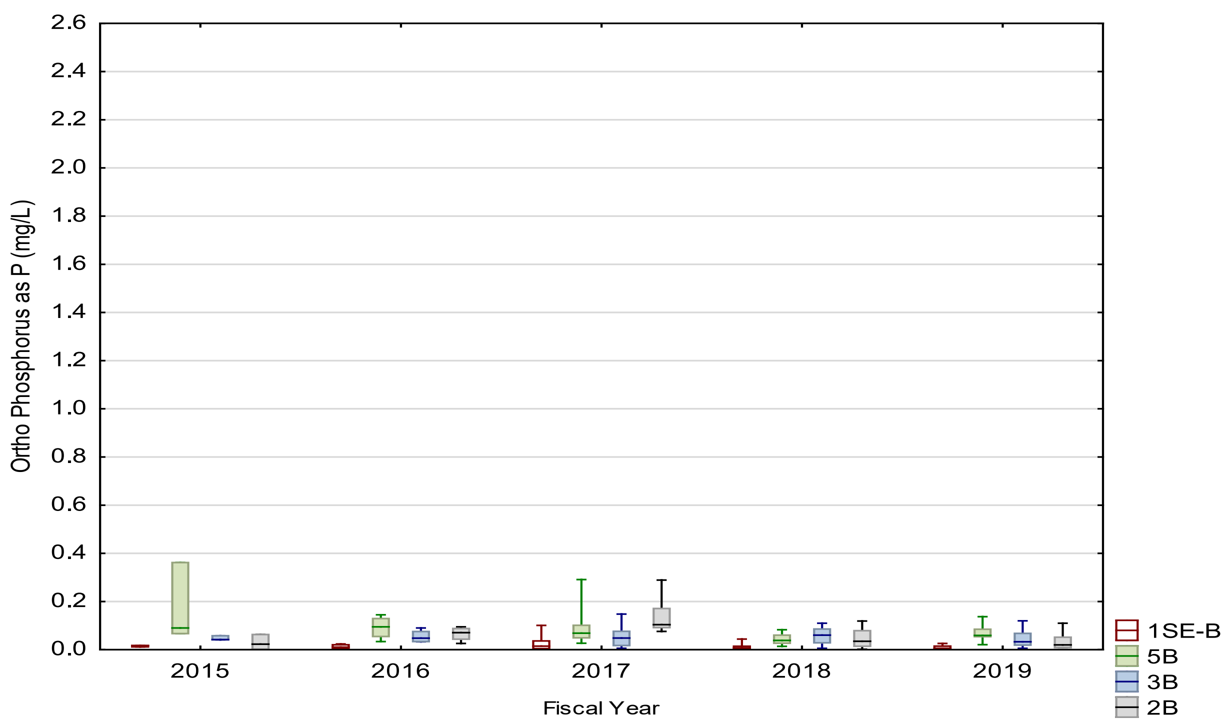


Figure A-13. Box plot of orthophosphate from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

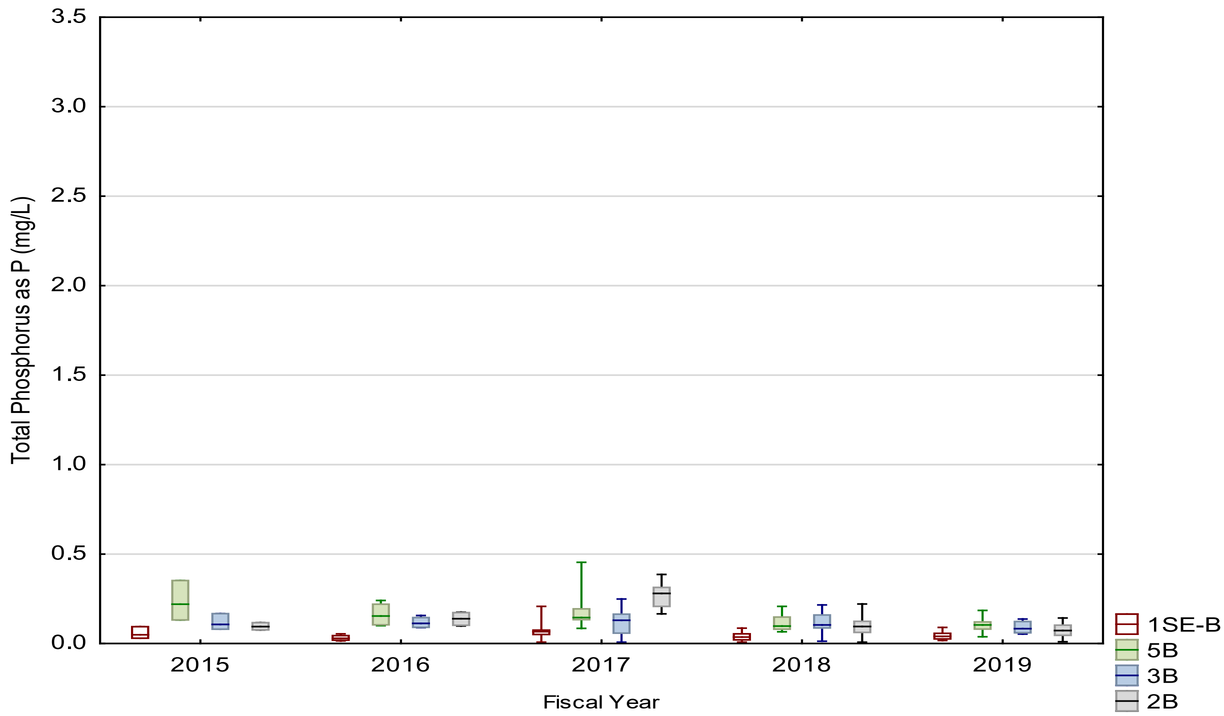


Figure A-14. Box plot of total phosphorus from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

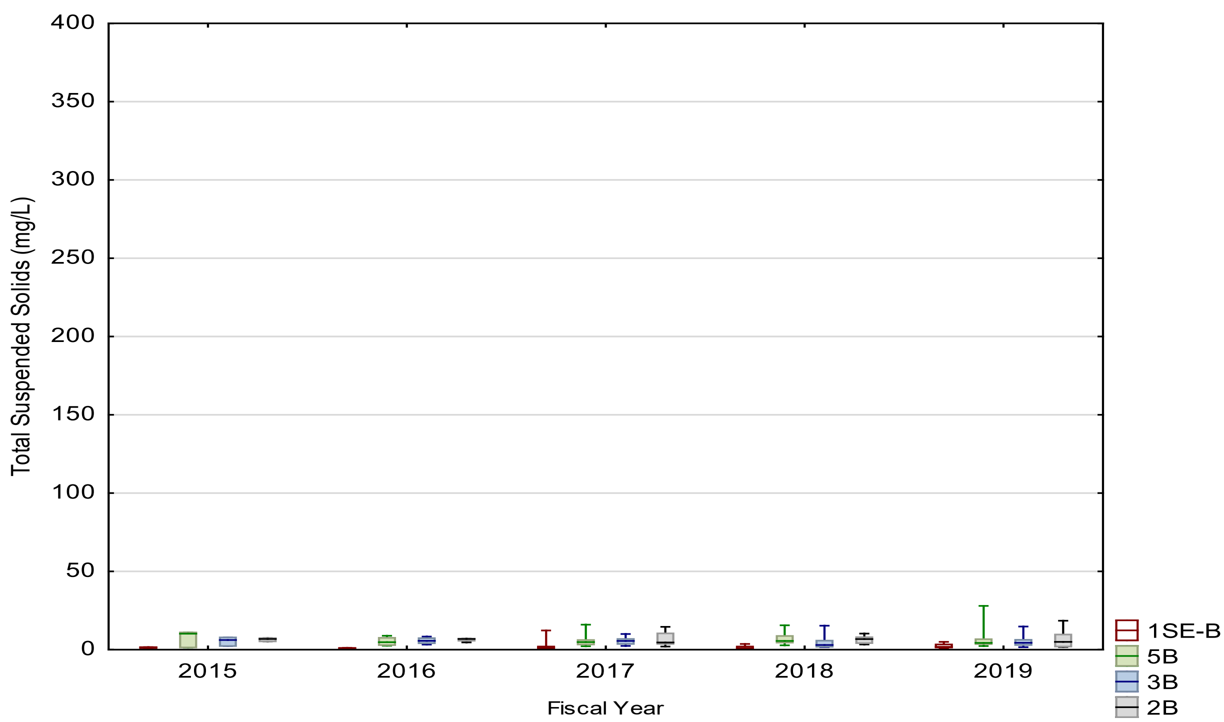


Figure A-15. Box plot of total suspended solids from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

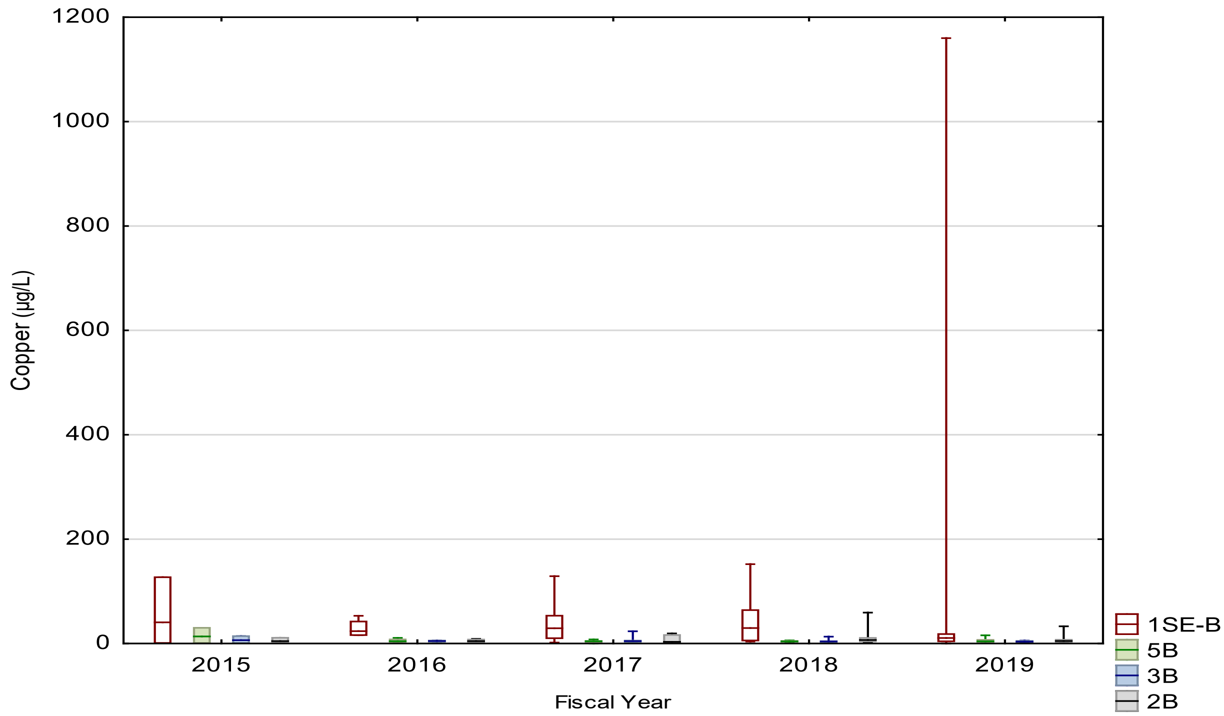


Figure A-16. Box plot of copper from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

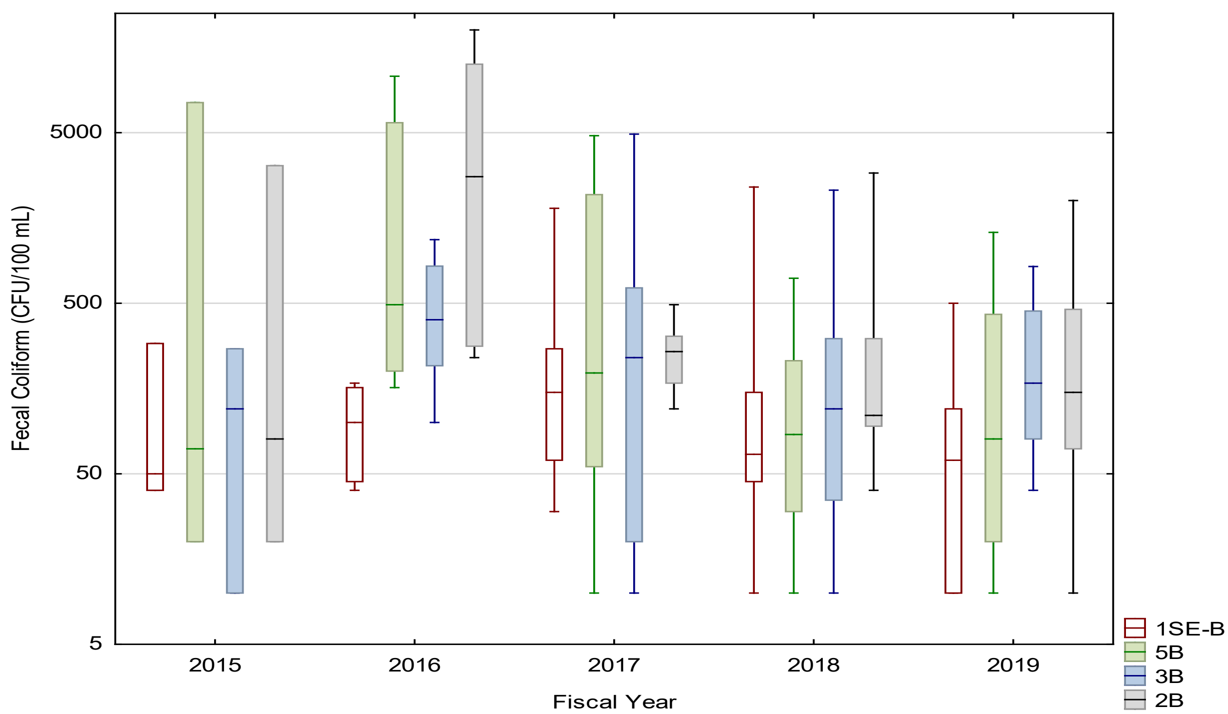


Figure A-17. Box plot of fecal coliform from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

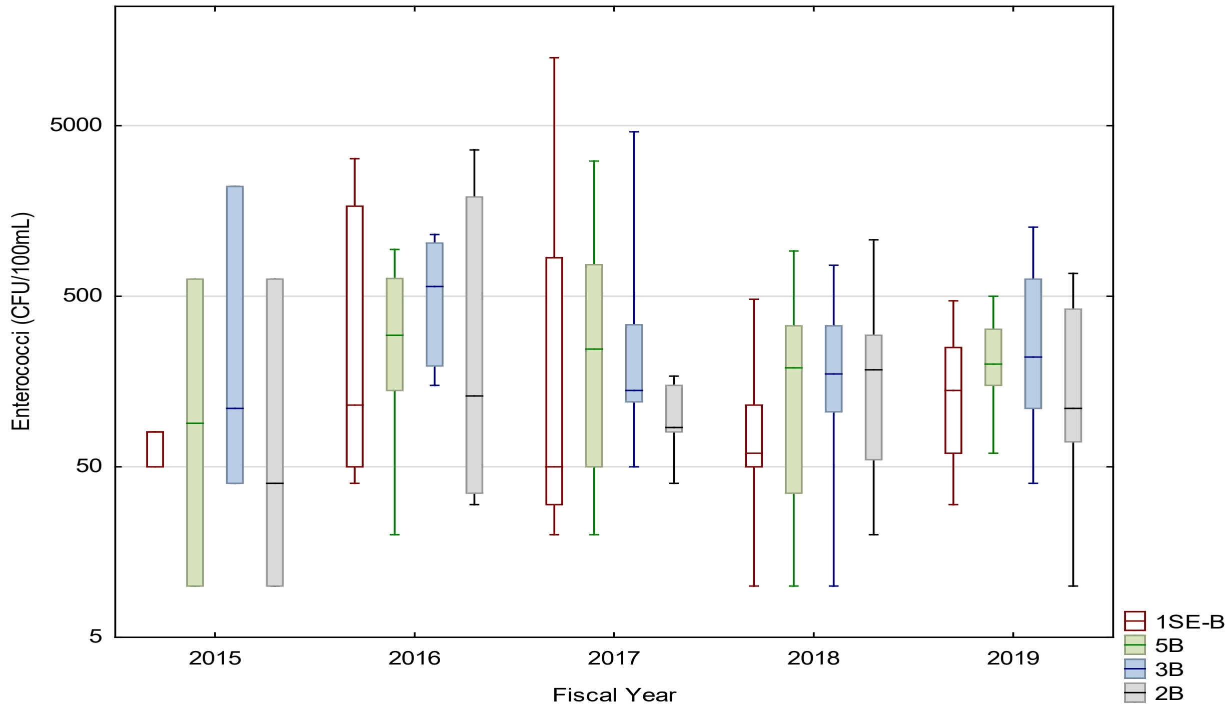


Figure A-18. Box plot of enterococci from FY 2015 to FY 2019 at lakes draining to Moorings Bay.

A.1.2 Lakes Draining to Gordon River

Field Parameters

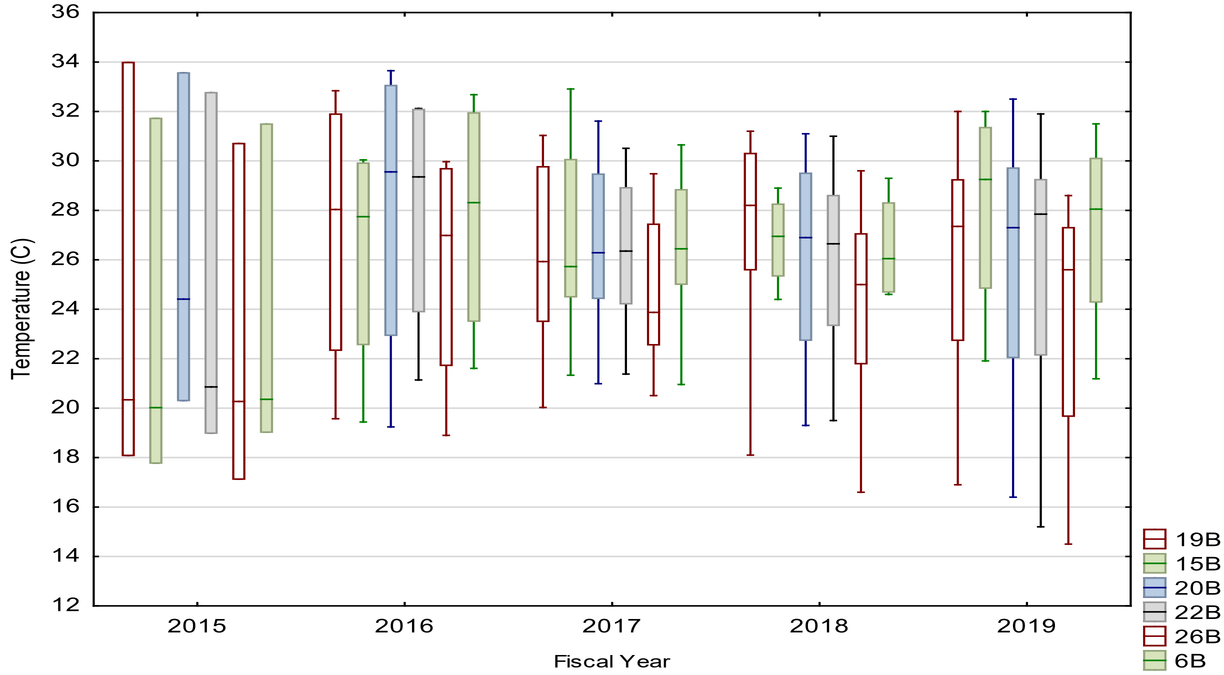


Figure A-19. Box plot of water temperature from FY 2015 to FY 2019 at lakes draining to Gordon River.

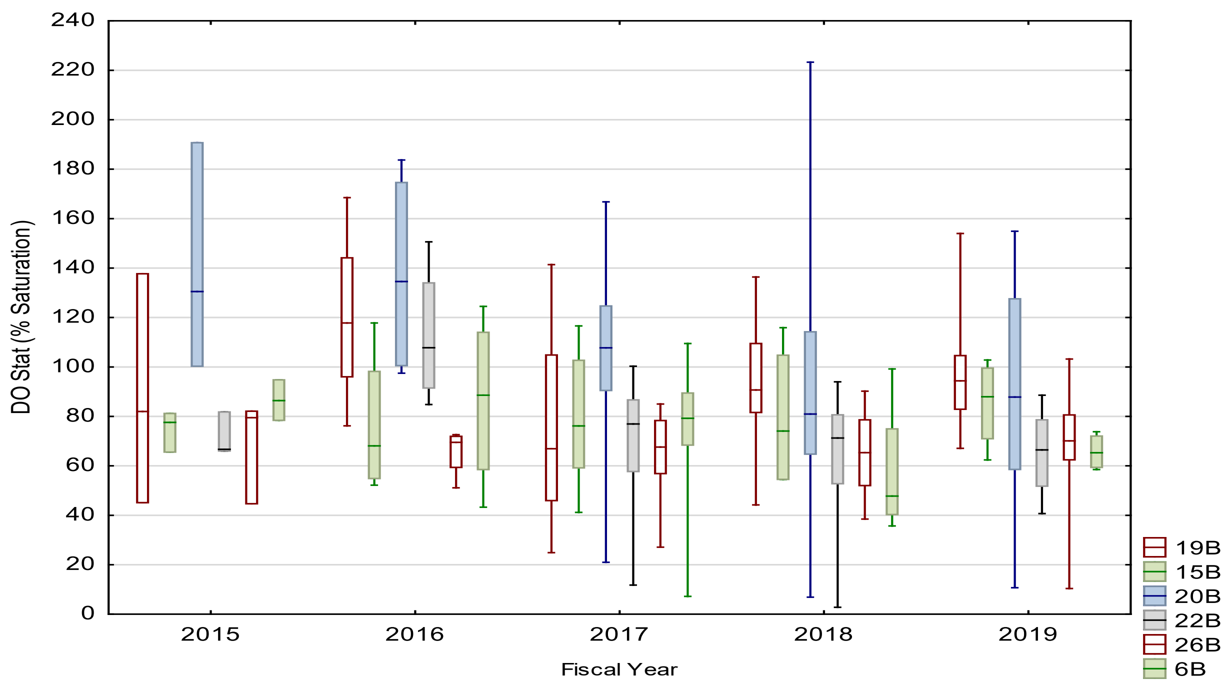


Figure A-20. Box plot of dissolved oxygen saturation from FY 2015 to FY 2019 at lakes draining to Gordon River.

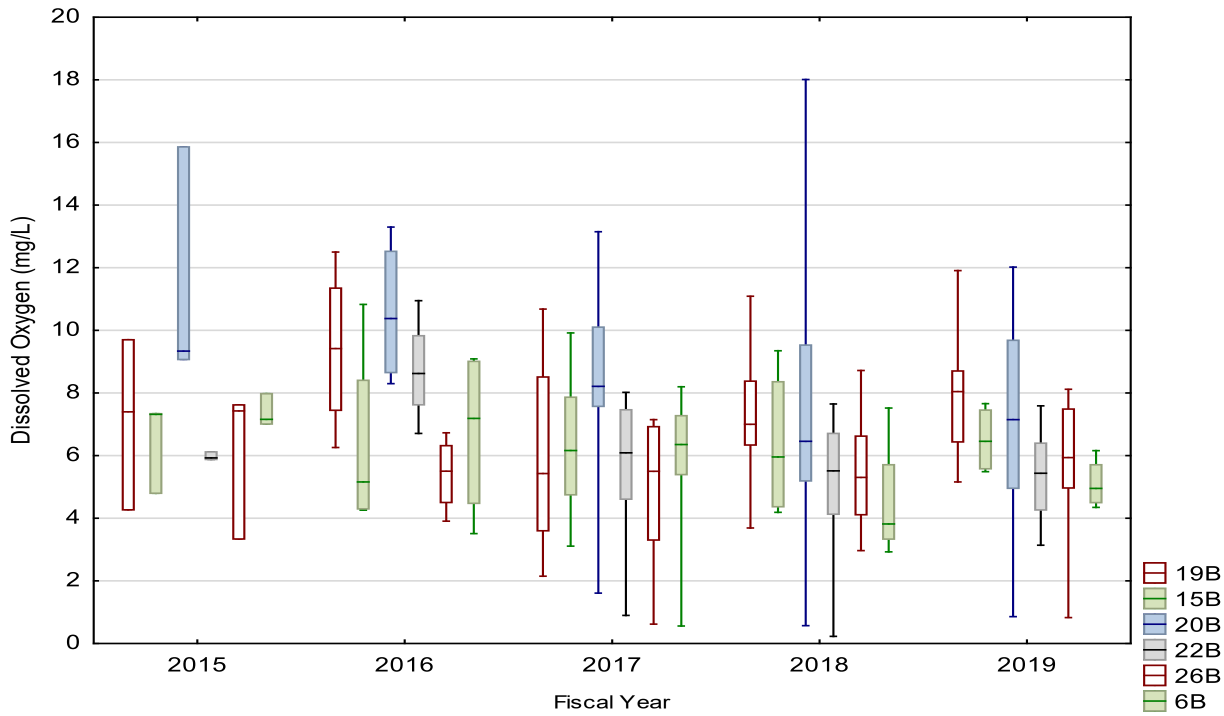


Figure A-21. Box plot of dissolved oxygen (mg/L) from FY 2015 to FY 2019 at lakes draining to Gordon River.

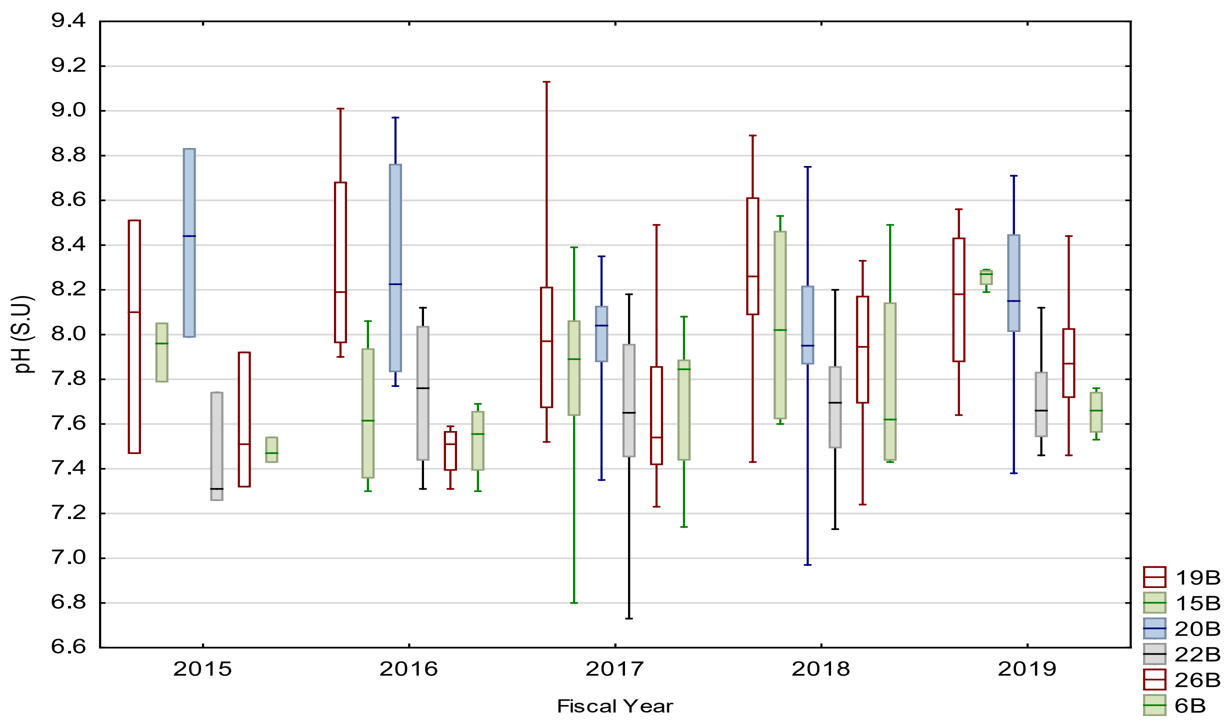


Figure A-22. Box plot of pH from FY 2015 to FY 2019 at lakes draining to Gordon River.

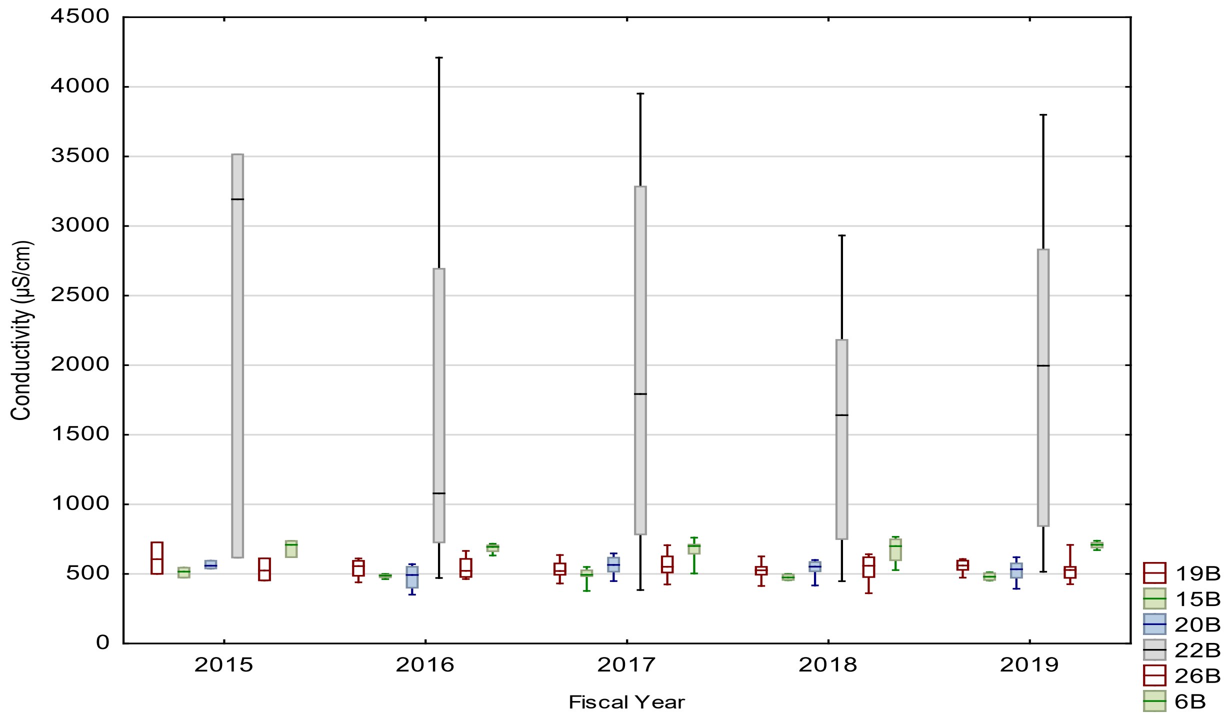


Figure A-23. Box plot of specific conductivity from FY 2015 to FY 2019 at lakes draining to Gordon River.

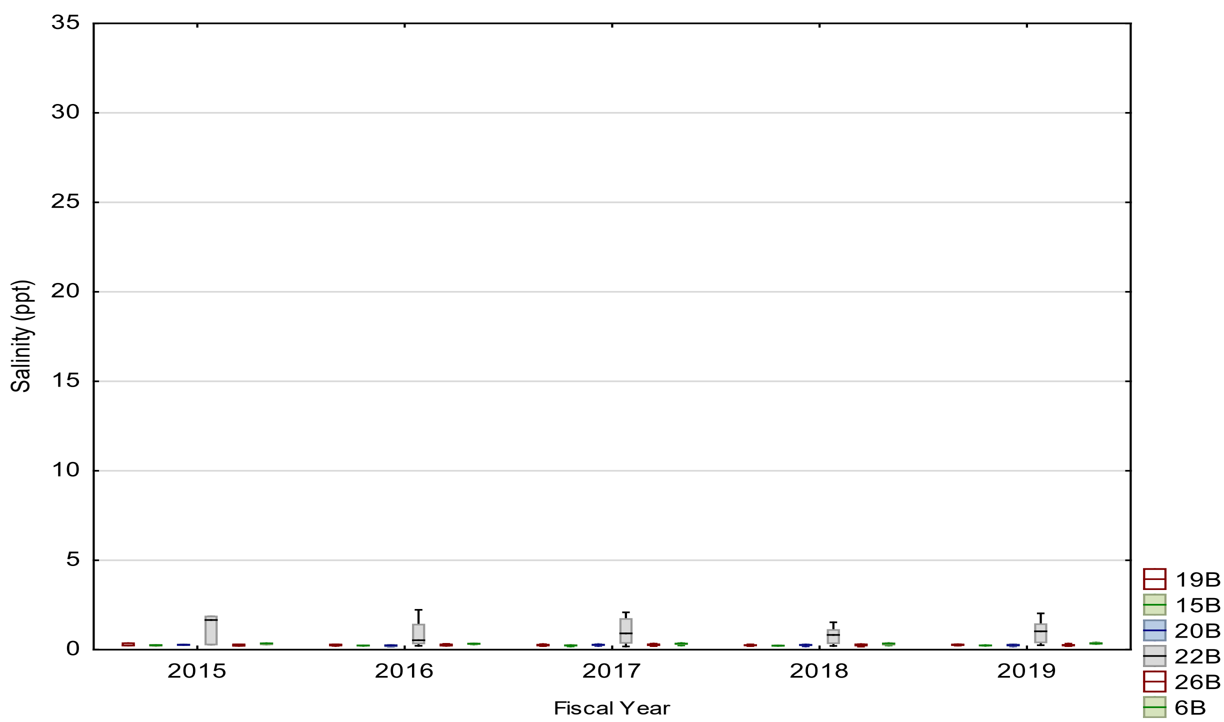


Figure A-24. Box plot of salinity from FY 2015 to FY 2019 at lakes draining to Gordon River.

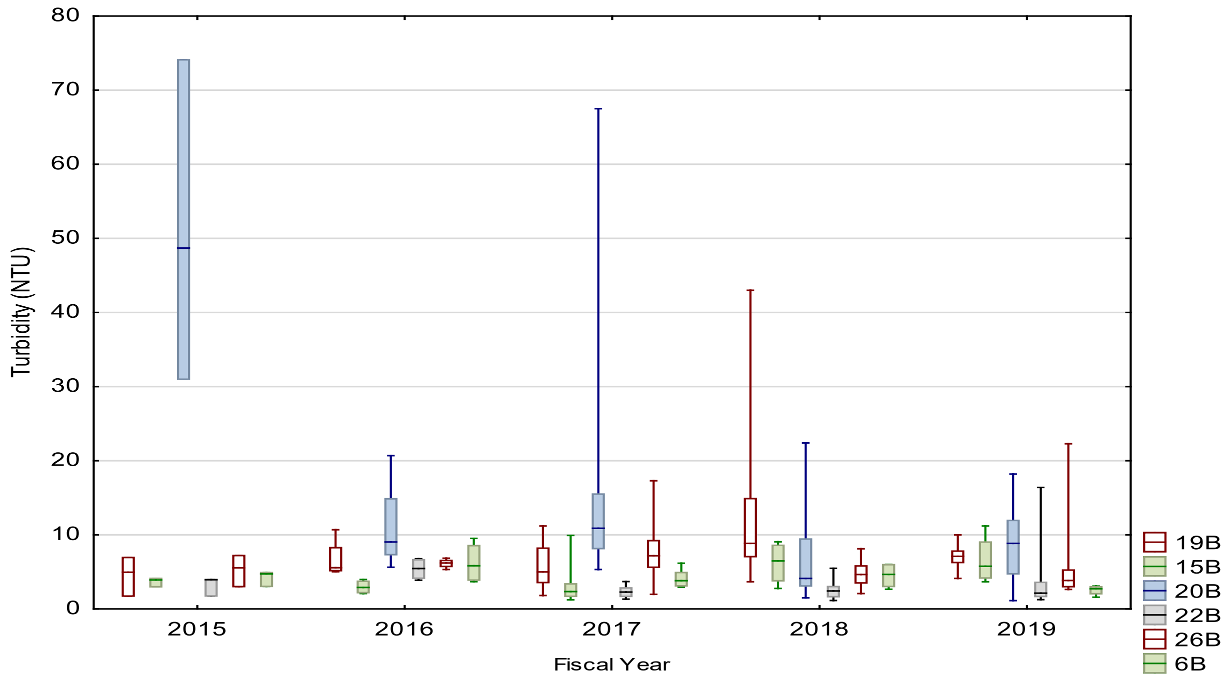


Figure A-25. Box plot of turbidity from FY 2015 to FY 2019 at lakes draining to Gordon River.

Lab Parameters

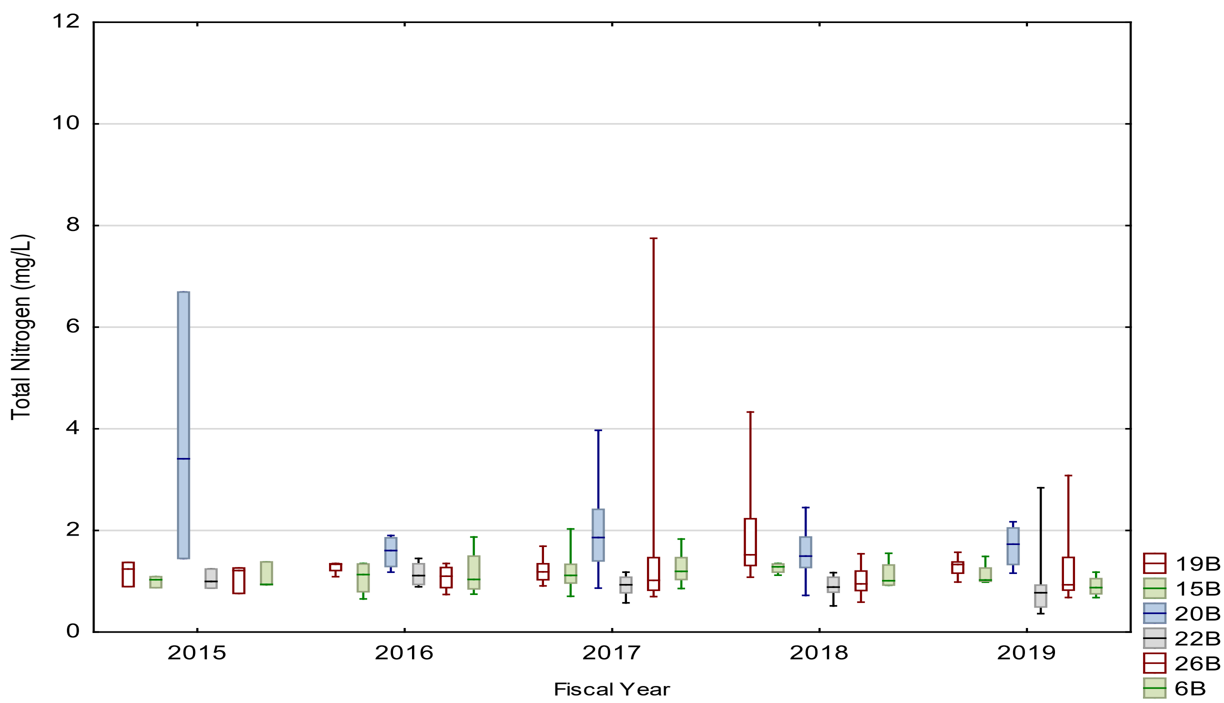


Figure A-26. Box plot of total nitrogen from FY 2015 to FY 2019 at lakes draining to Gordon River.

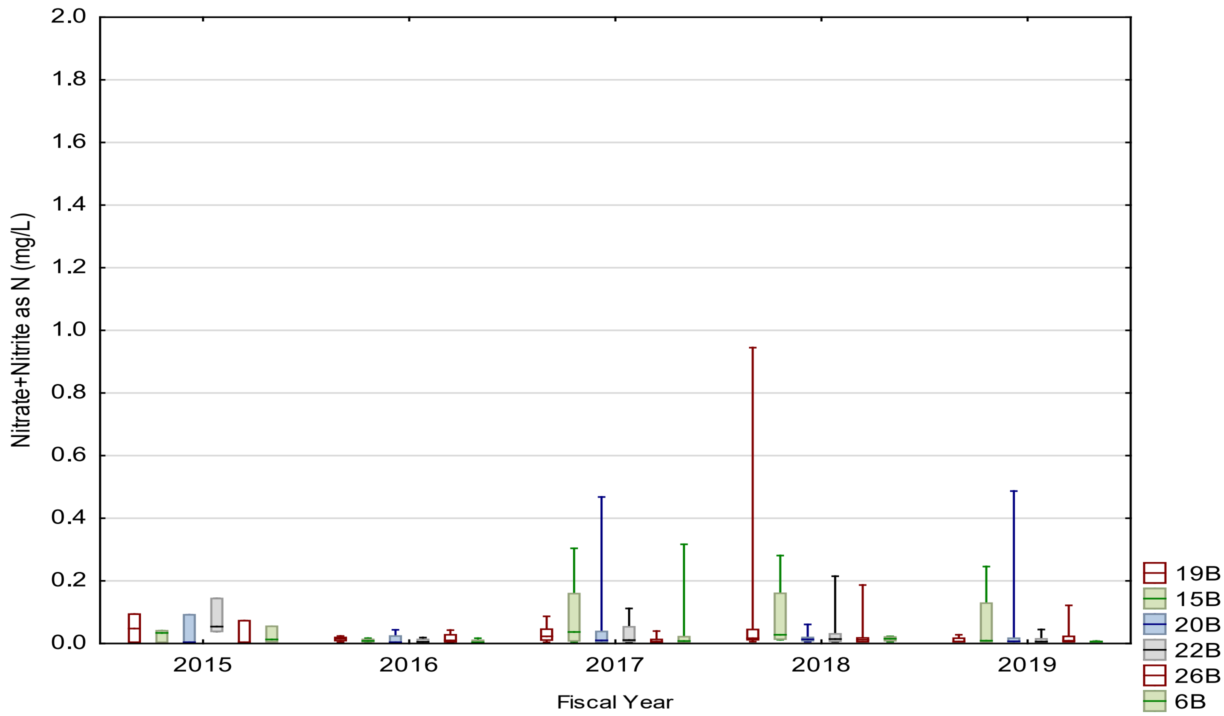


Figure A-27. Box plot of nitrate-nitrite from FY 2015 to FY 2019 at lakes draining to Gordon River.

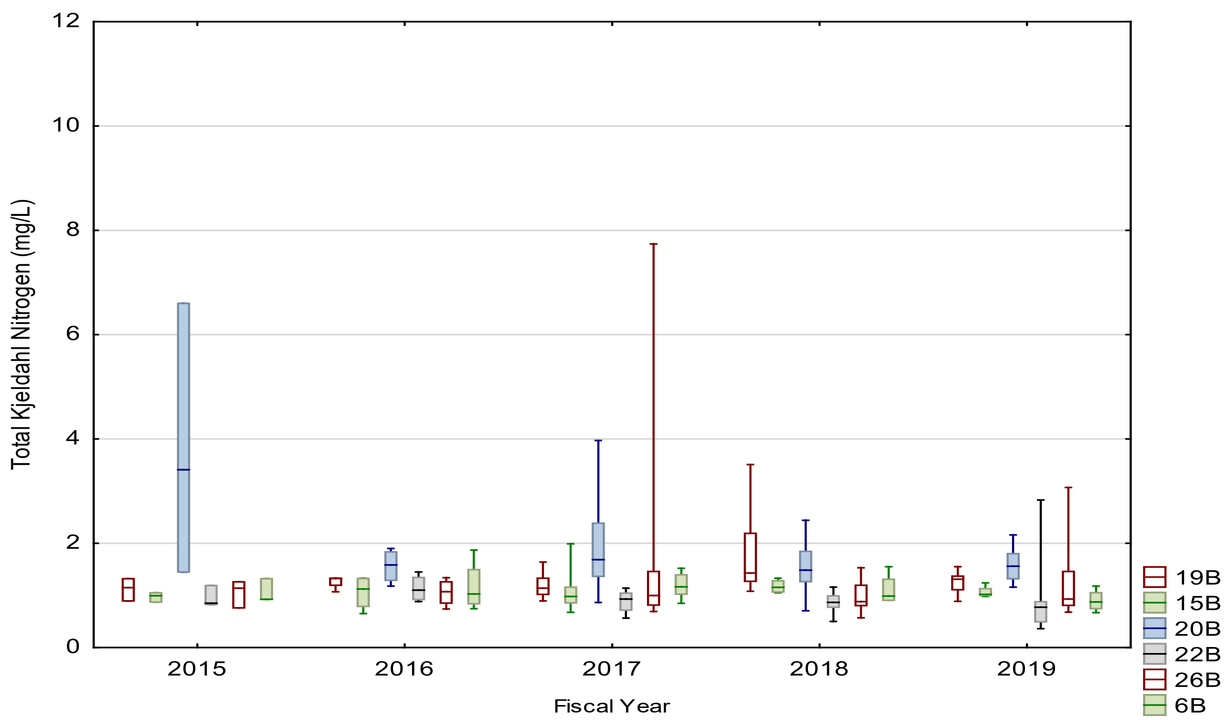


Figure A-28. Box plot of Total Kjeldahl Nitrogen from FY 2015 to FY 2019 at lakes draining to Gordon River.

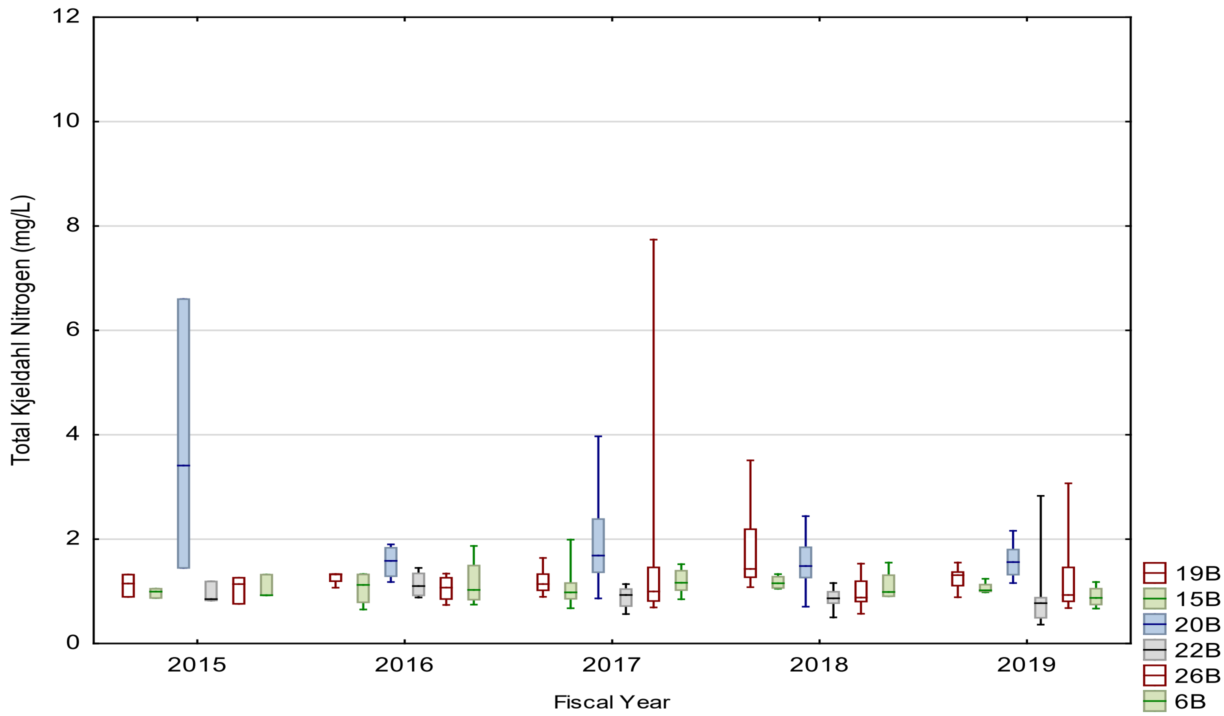


Figure A-29. Box plot of ammonia nitrogen from FY 2015 to FY 2019 at lakes draining to Gordon River.

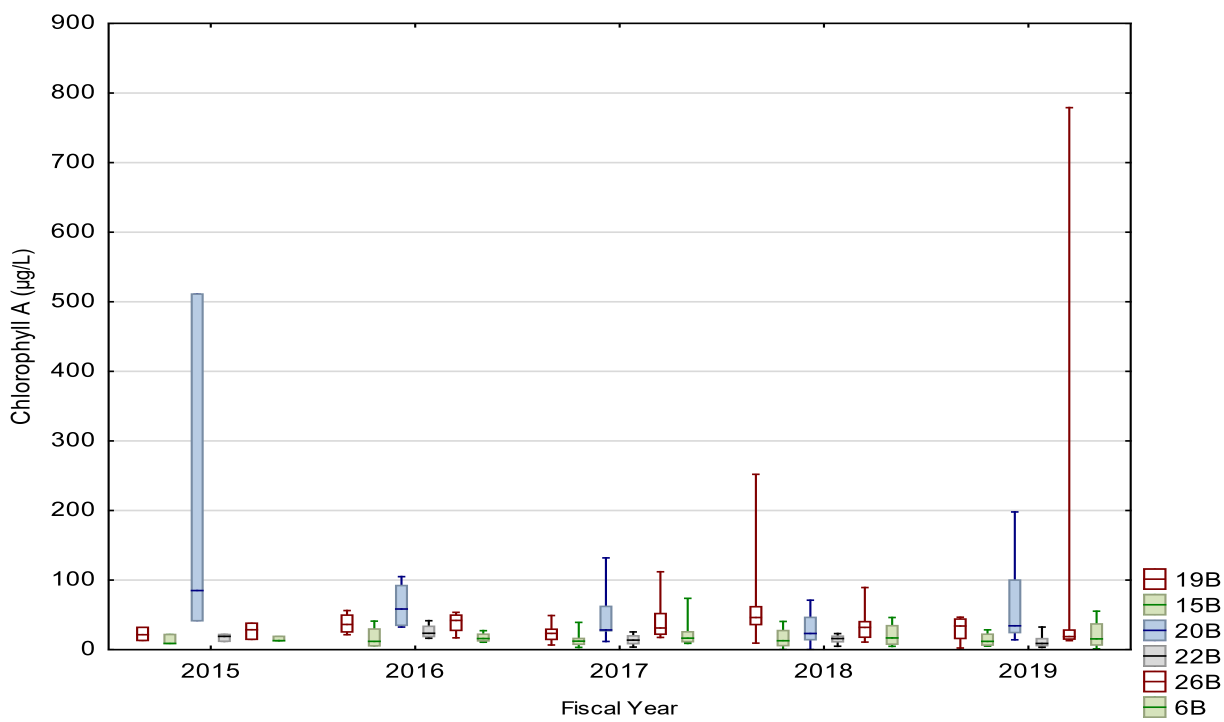


Figure A-30. Box plot of chlorophyll-*a* from FY 2015 to FY 2019 at lakes draining to Gordon River.

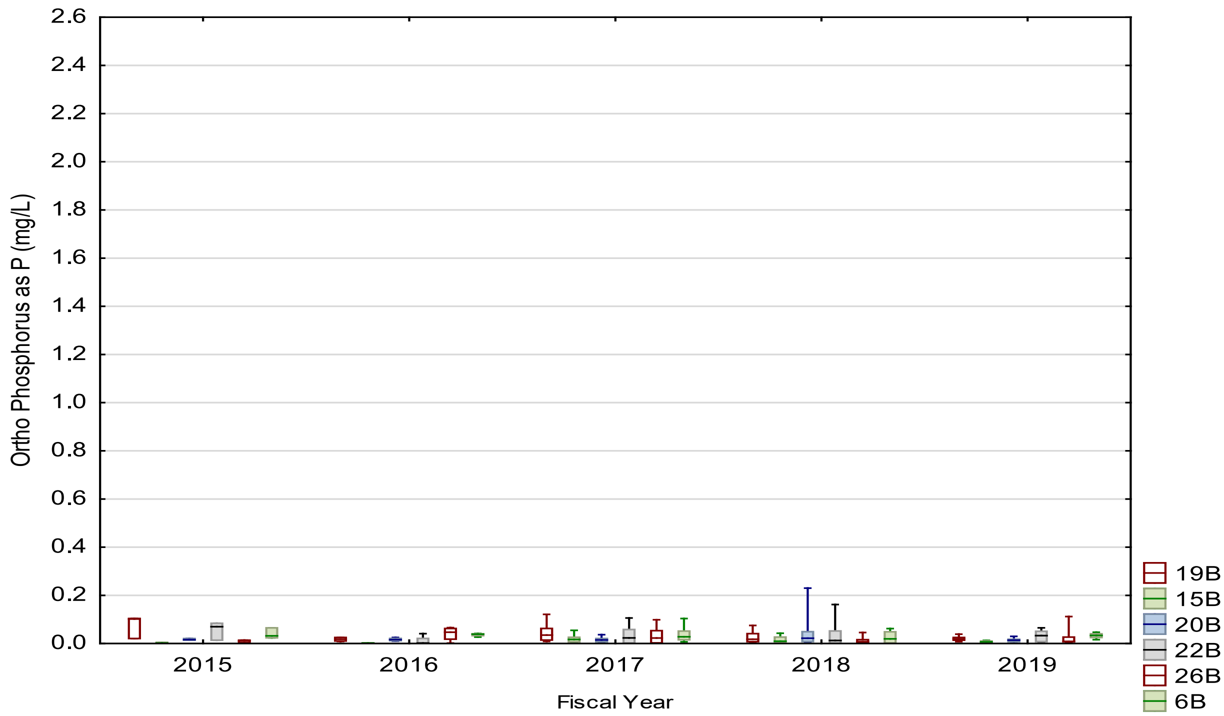


Figure A-31. Box plot of orthophosphate from FY 2015 to FY 2019 at lakes draining to Gordon River.

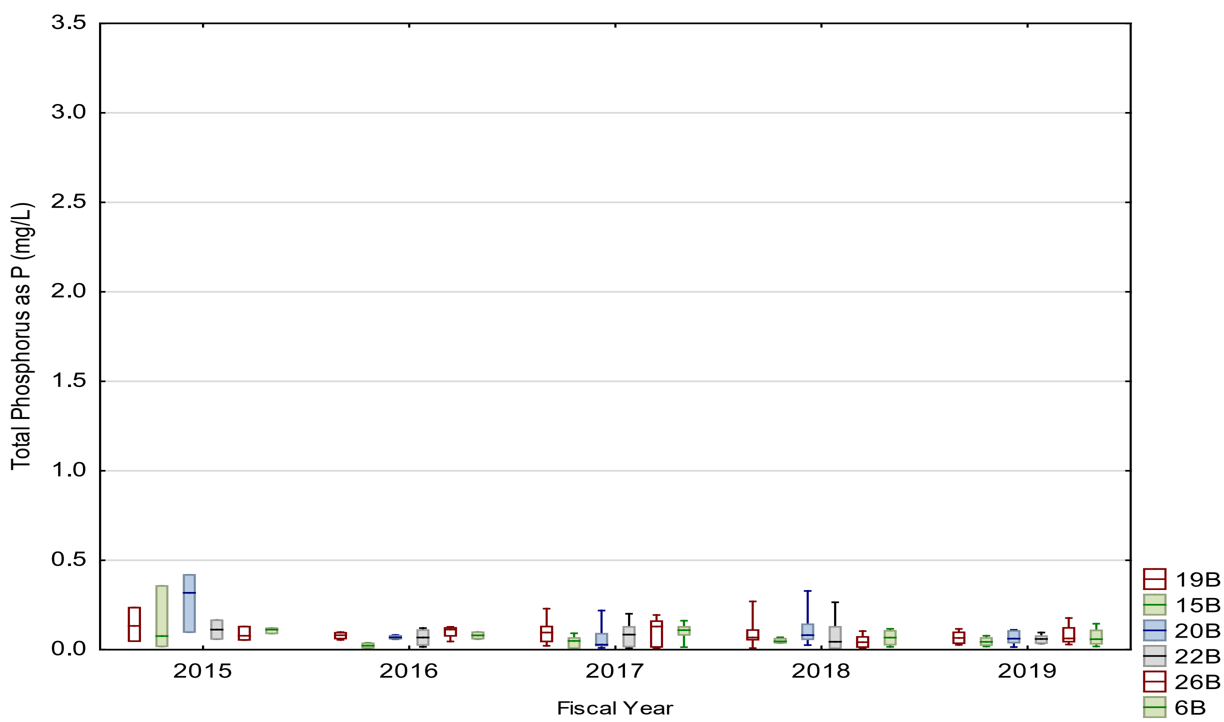


Figure A-32. Box plot of total phosphorus from FY 2015 to FY 2019 at lakes draining to Gordon River.

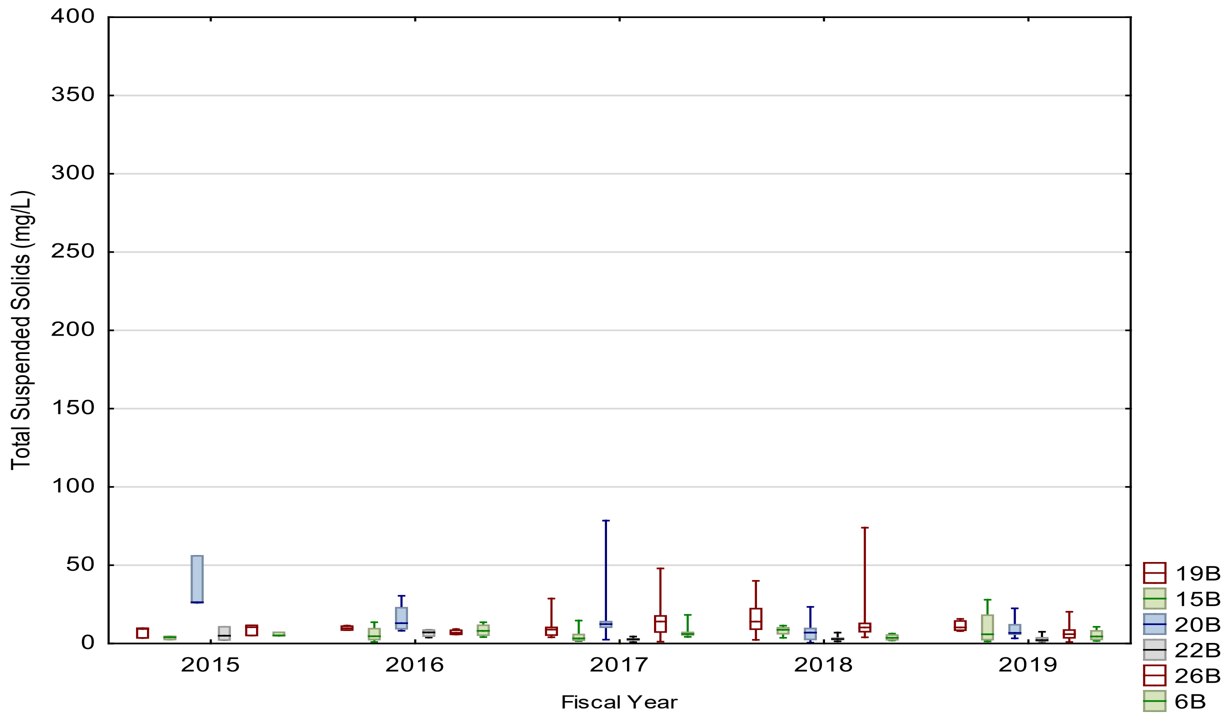


Figure A-33. Box plot of total suspended solids from FY 2015 to FY 2019 at lakes draining to Gordon River.

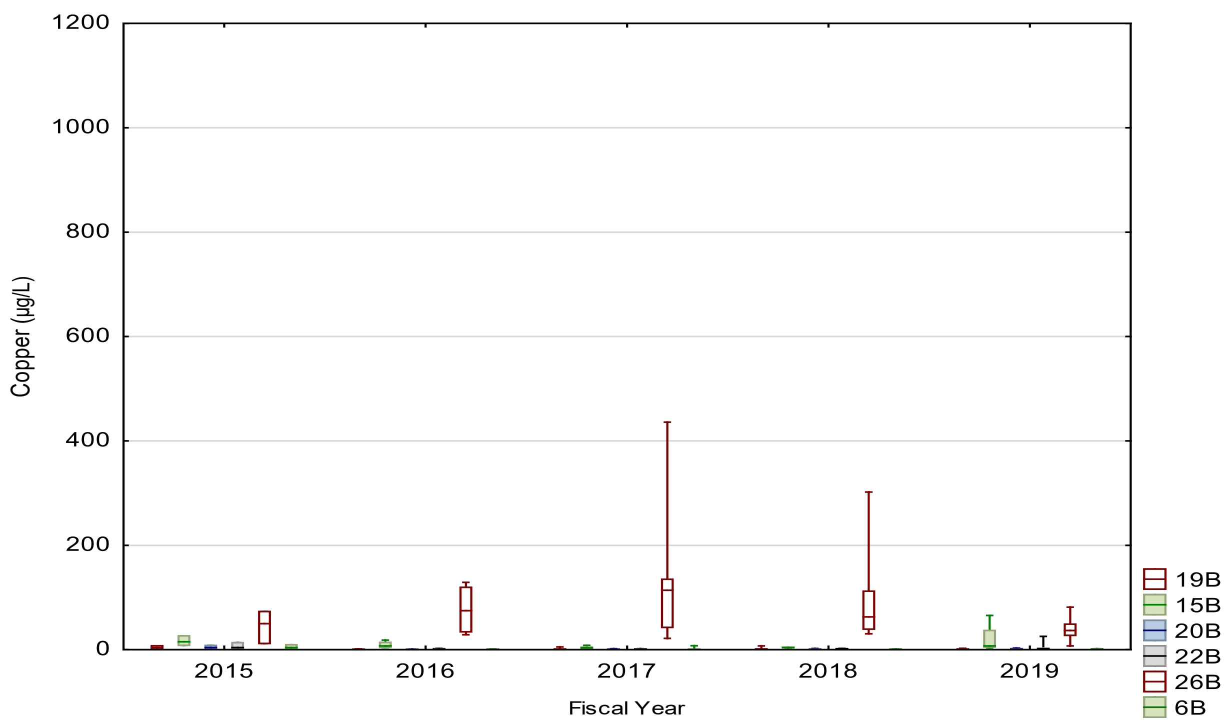


Figure A-34. Box plot of copper from FY 2015 to FY 2019 at lakes draining to Gordon River.

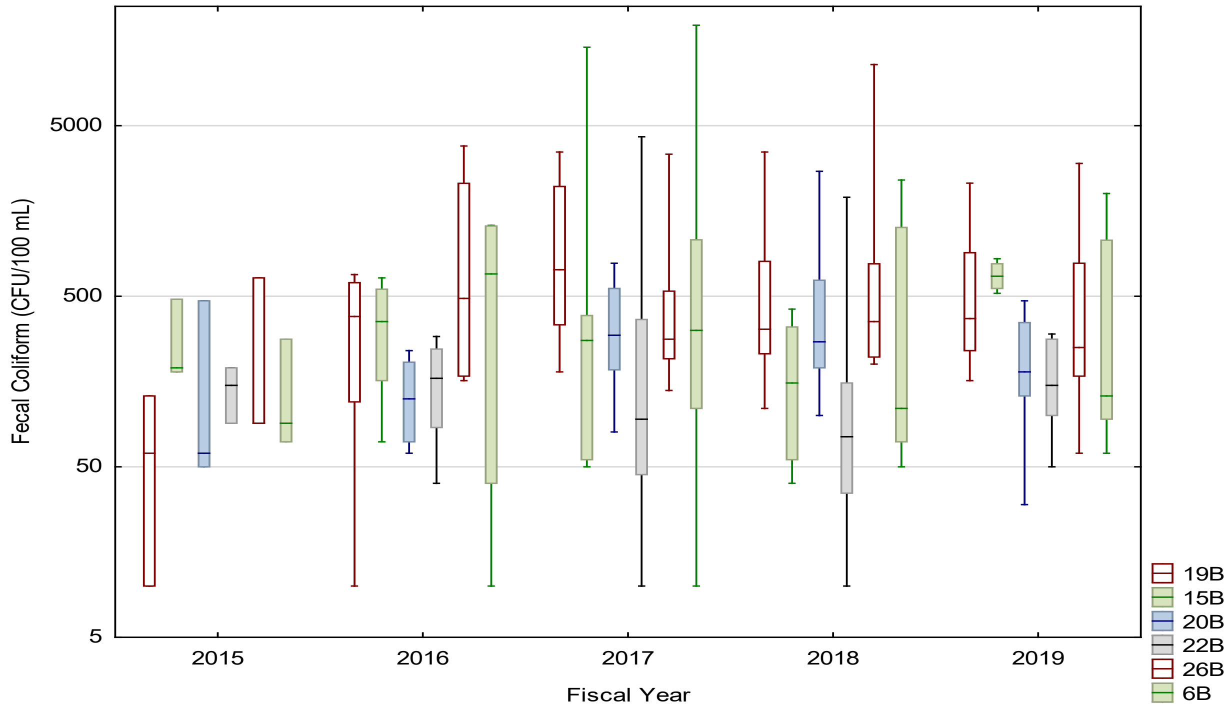


Figure A-35. Box plot of fecal coliform from FY 2015 to FY 2019 at lakes draining to Gordon River.

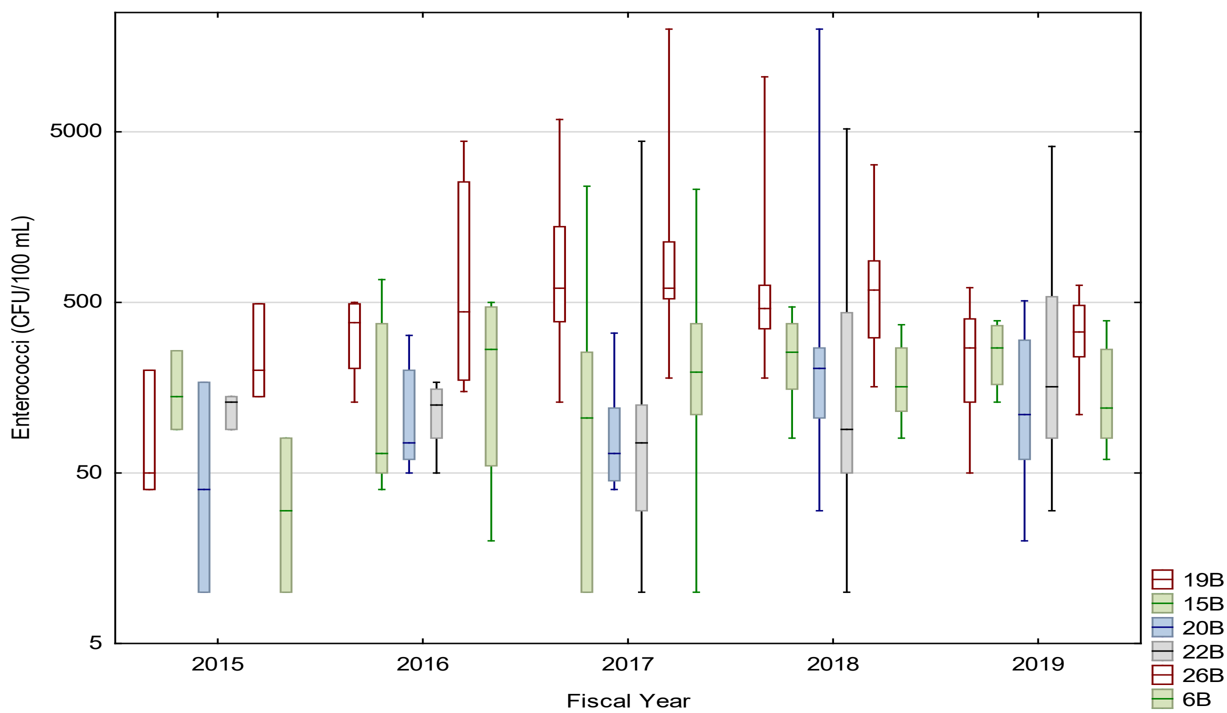


Figure A-36. Box plot of enterococci from FY 2015 to FY 2019 at lakes draining to Gordon River.

A.1.3 Lakes Draining to Gulf of Mexico or Naples Bay

Field Parameters

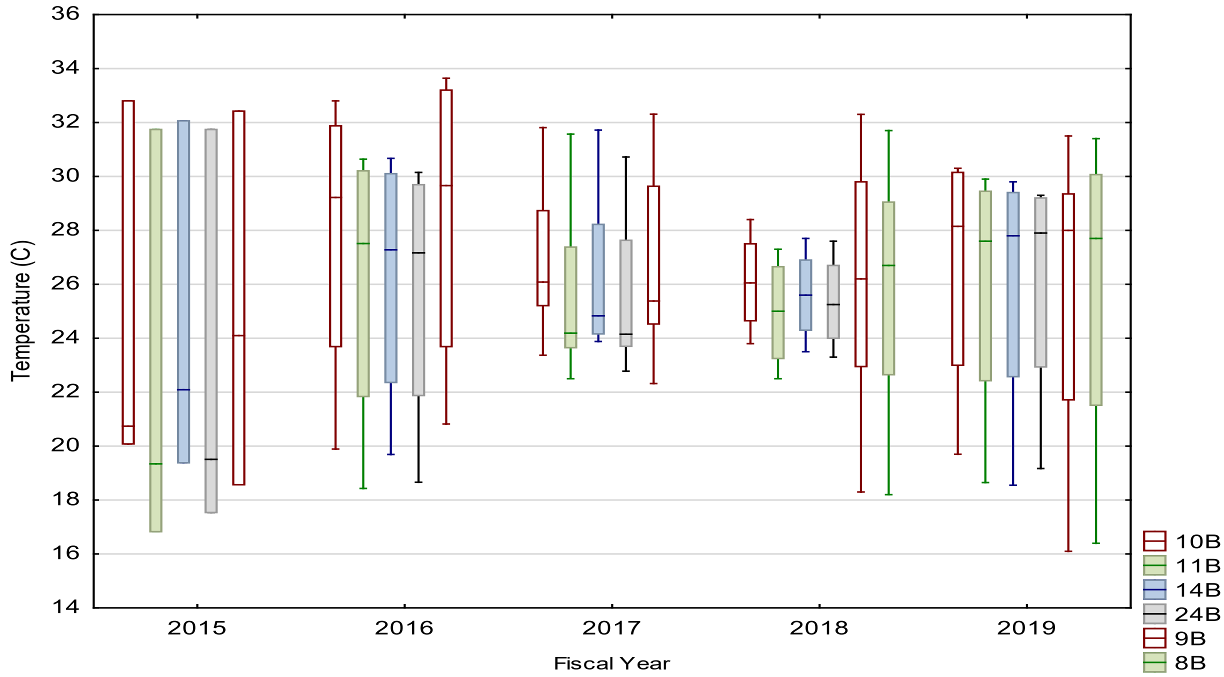


Figure A-37. Box plot of water temperature from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

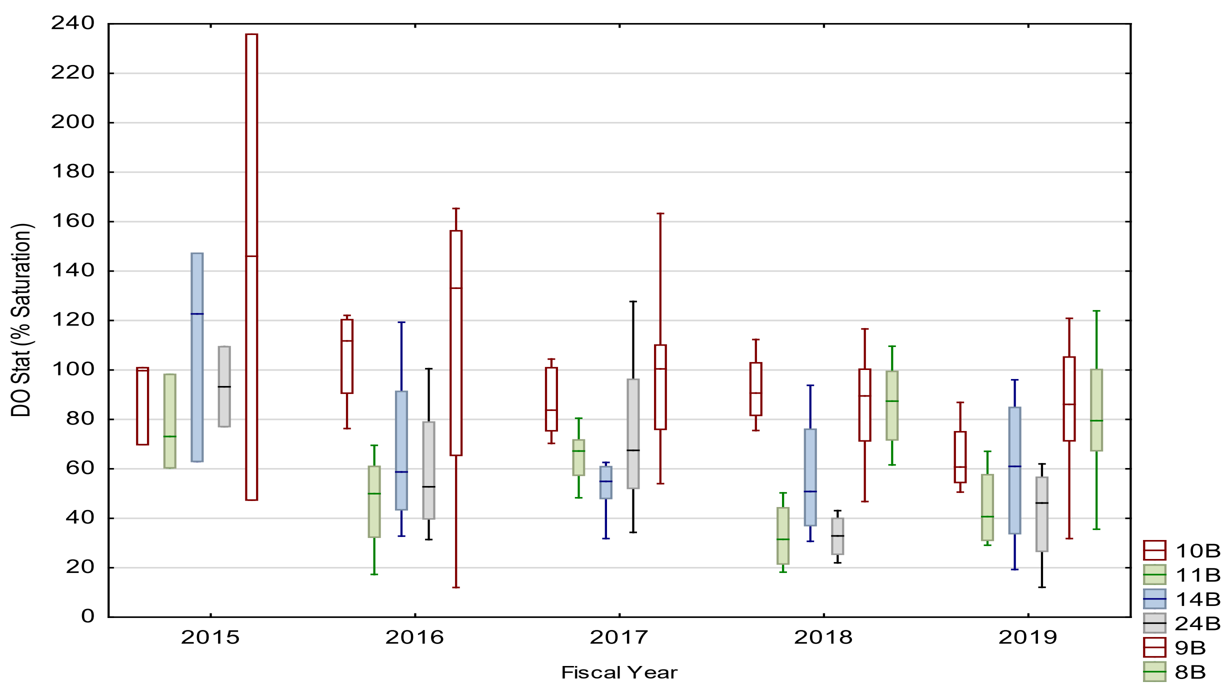


Figure A-38. Box plot of dissolved oxygen saturation from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

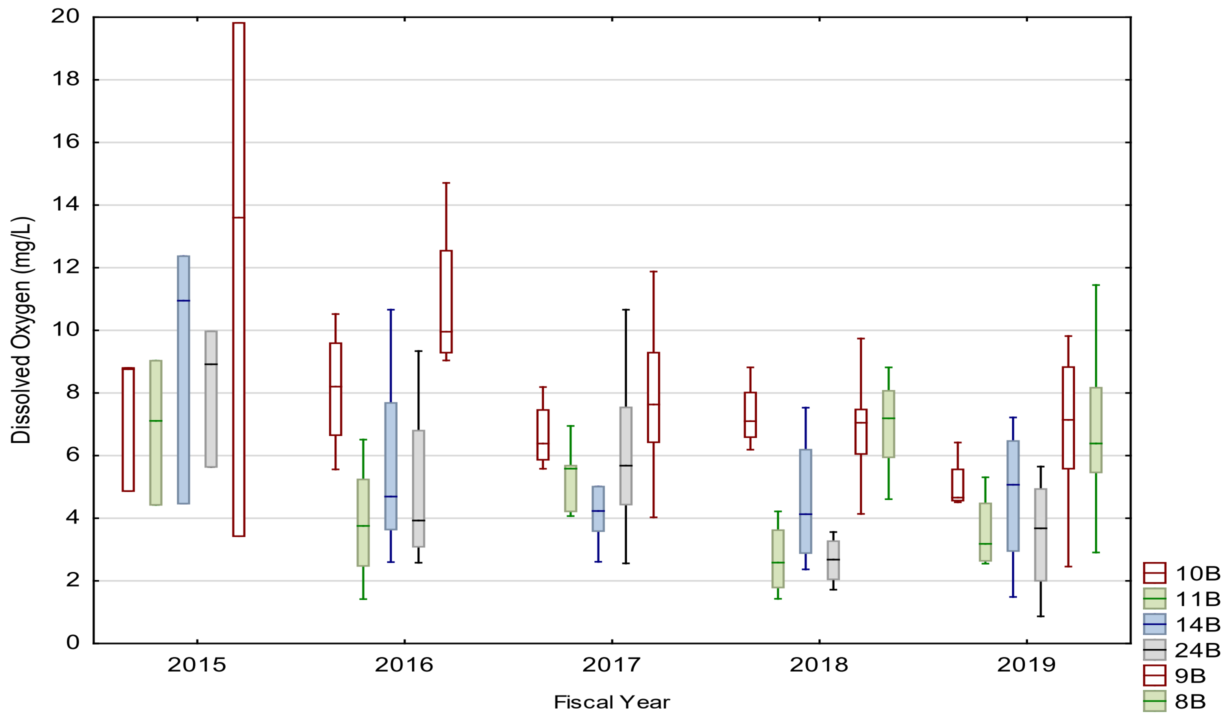


Figure A-39. Box plot of dissolved oxygen (mg/L) from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

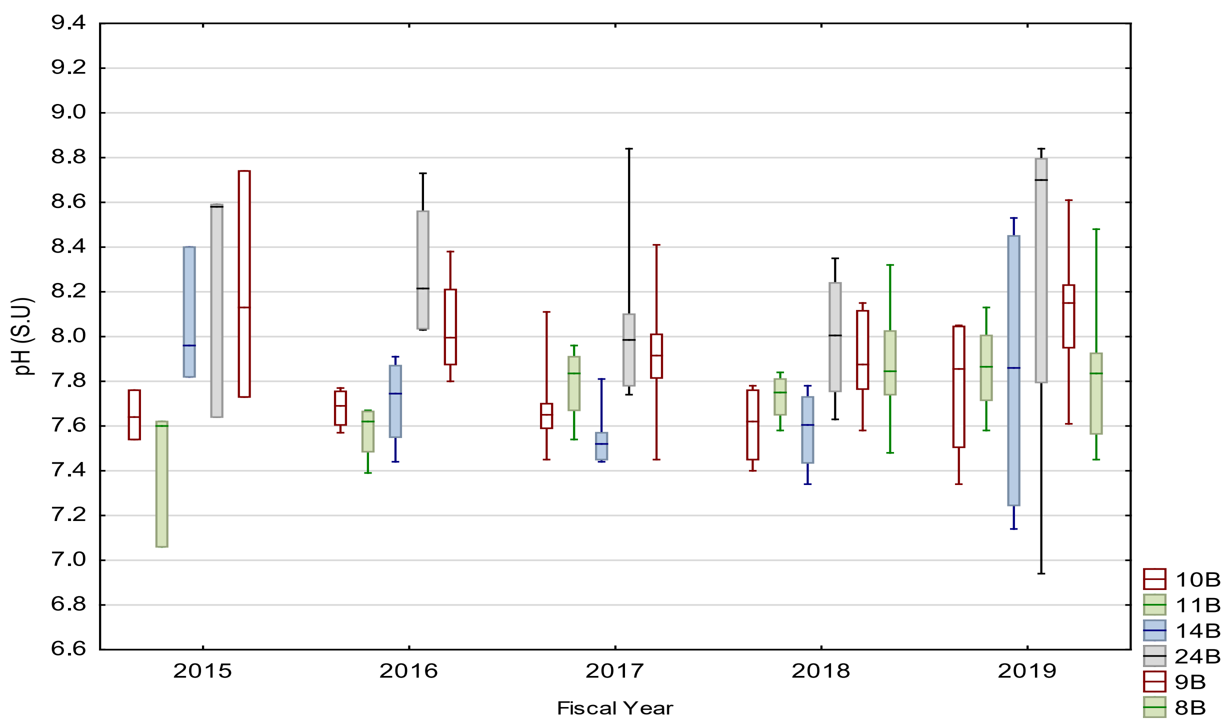


Figure A-40. Box plot of pH from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

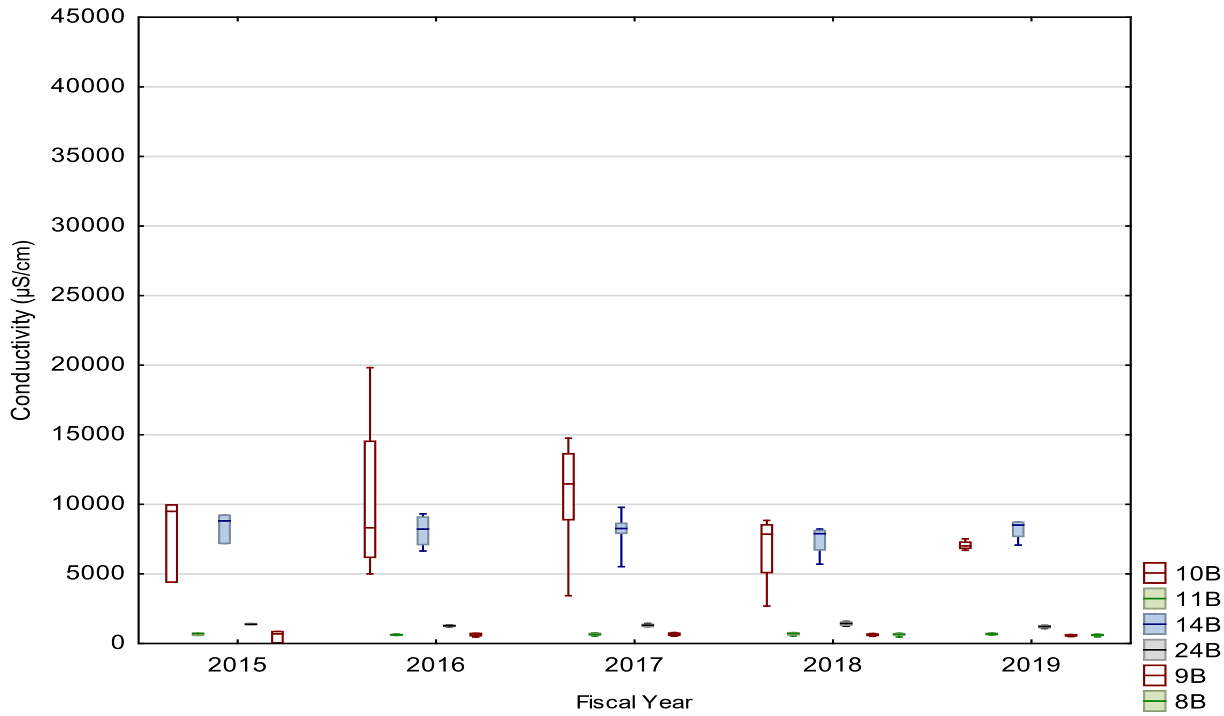


Figure A-41. Box plot of specific conductivity from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

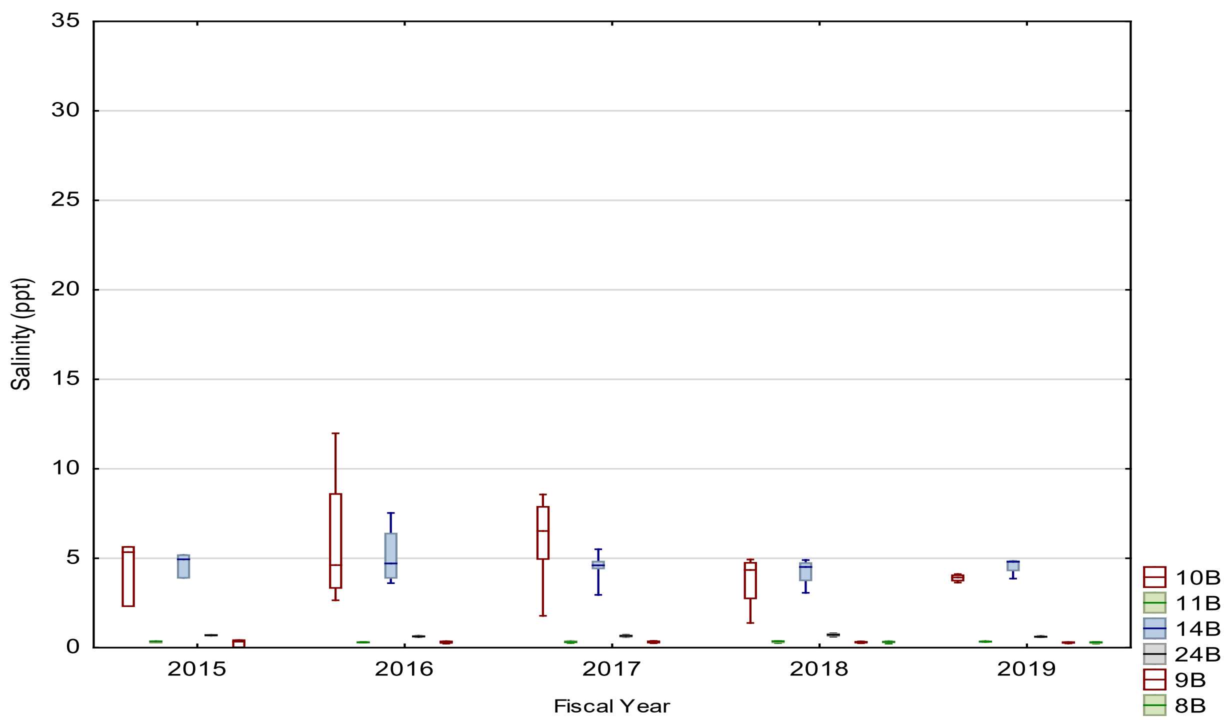


Figure A-42. Box plot of salinity from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

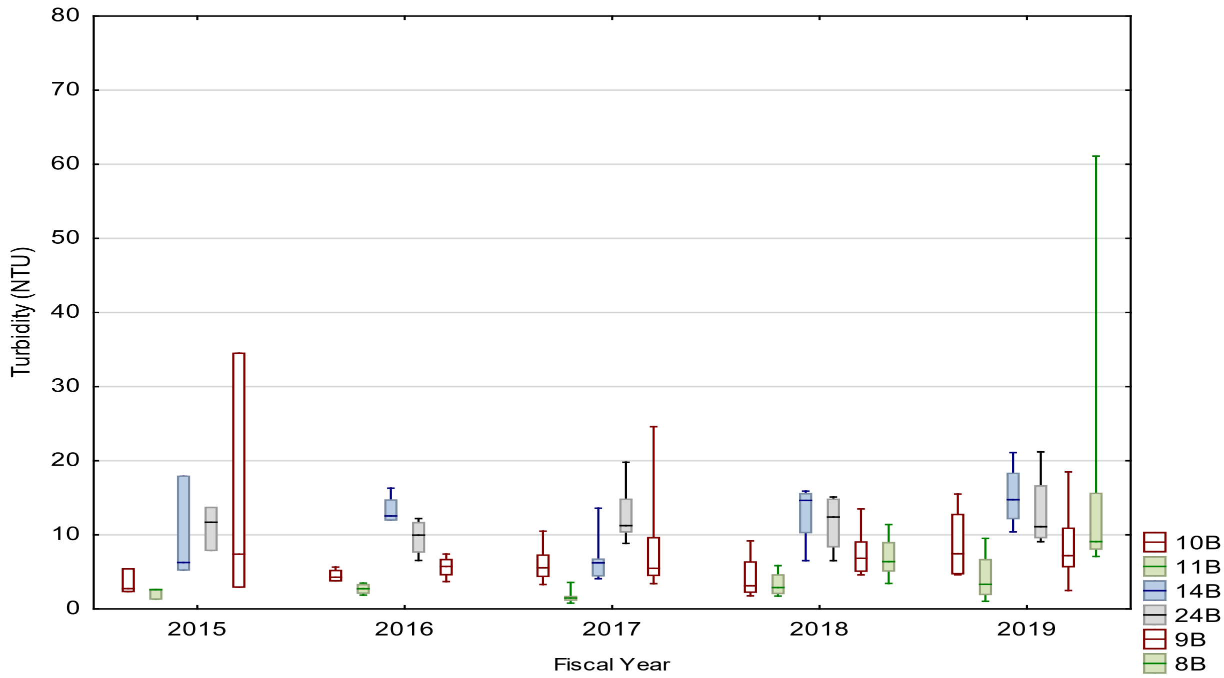


Figure A-43. Box plot of turbidity from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

Lab Parameters

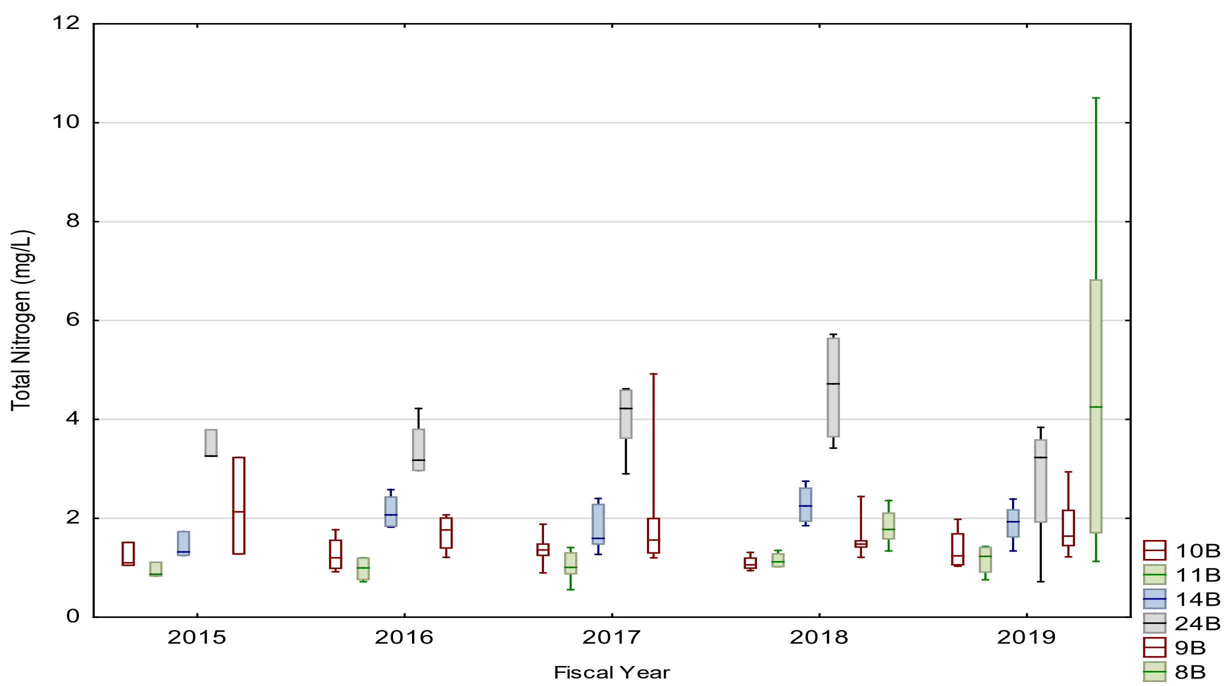


Figure A-44. Box plot of total nitrogen from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

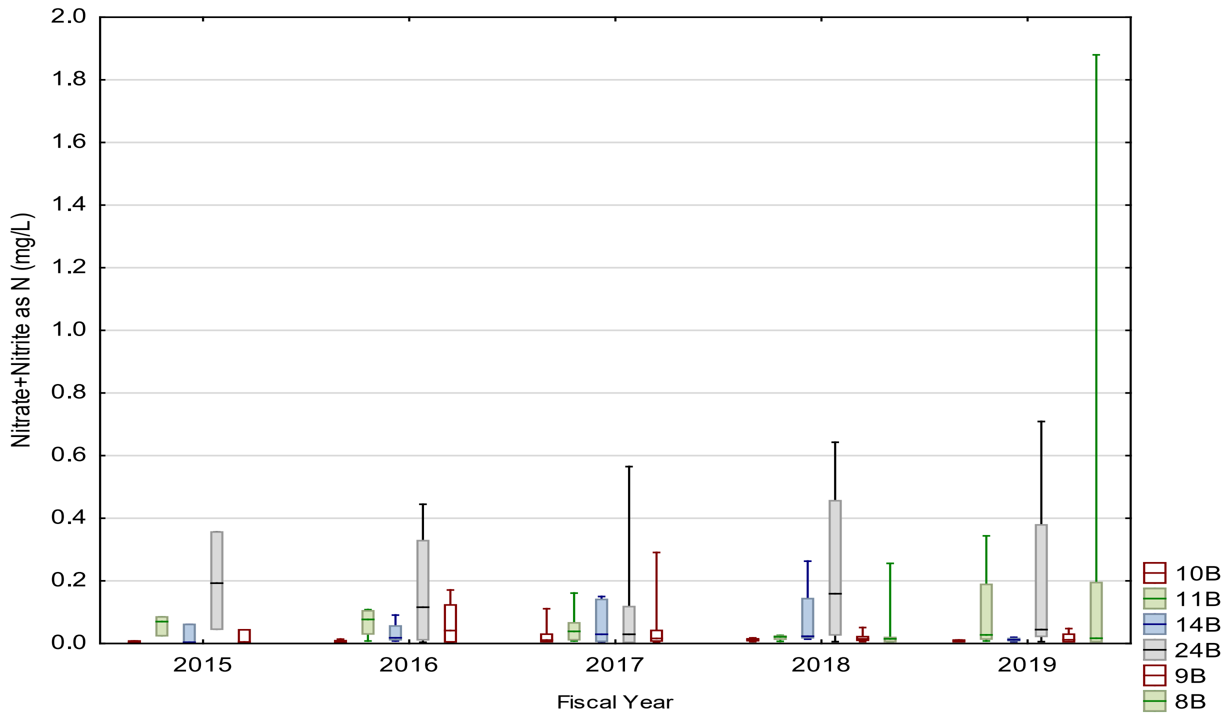


Figure A-45. Box plot of nitrate-nitrite from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

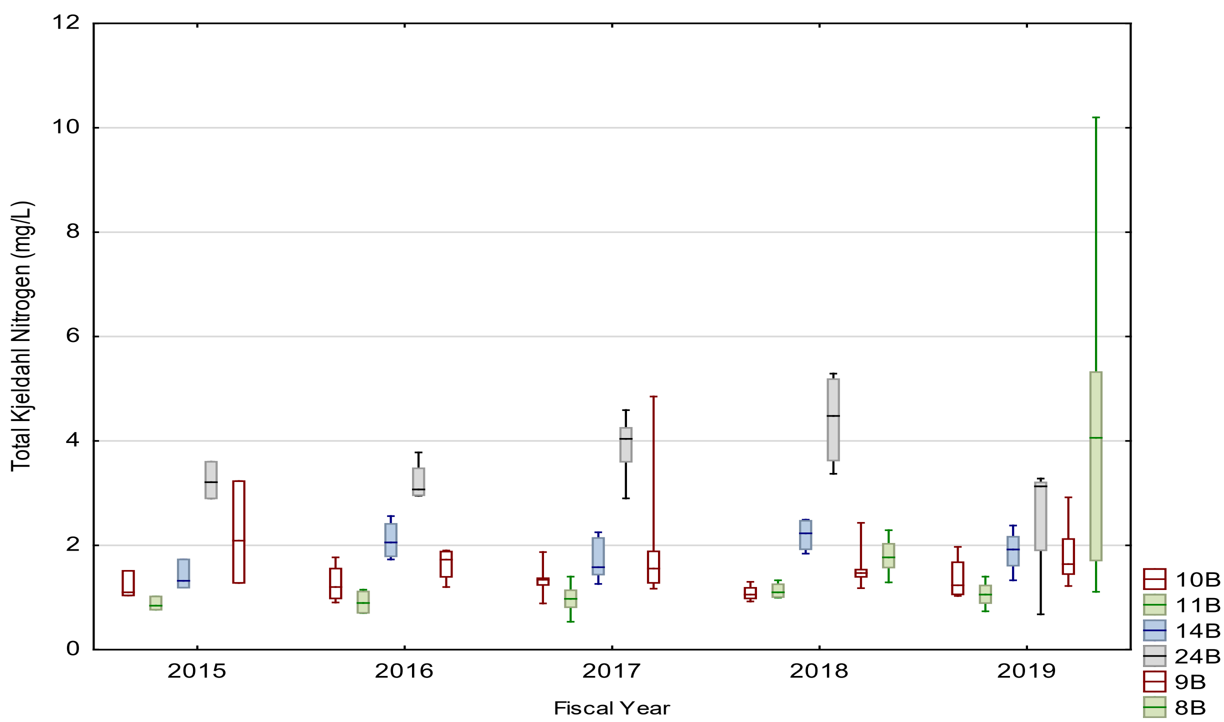


Figure A-46. Box plot of Total Kjeldahl Nitrogen from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

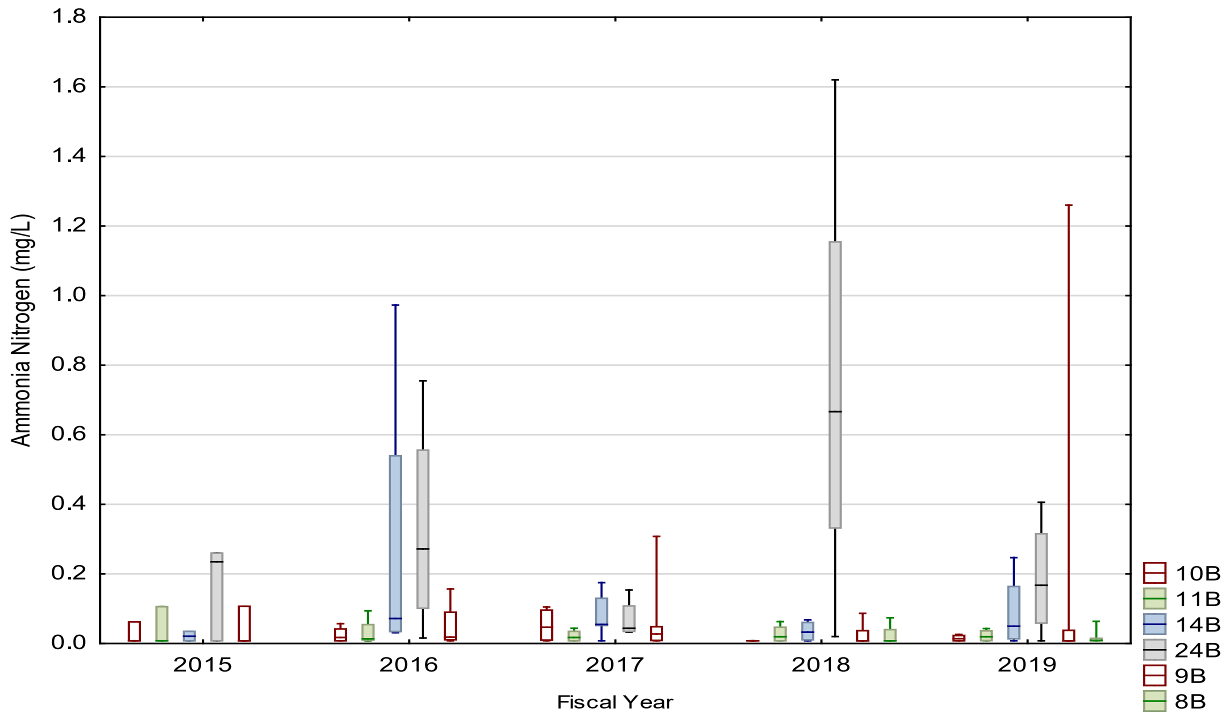


Figure A-47. Box plot of ammonia nitrogen from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

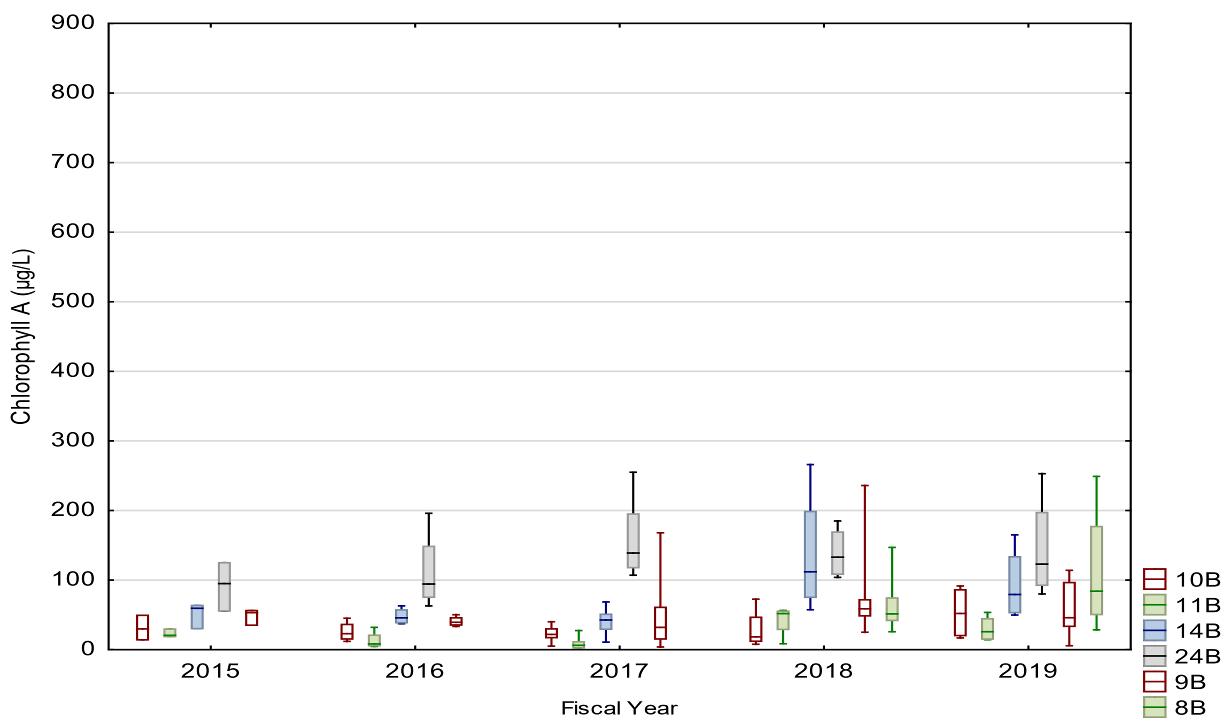


Figure A-48. Box plot of chlorophyll-*a* from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

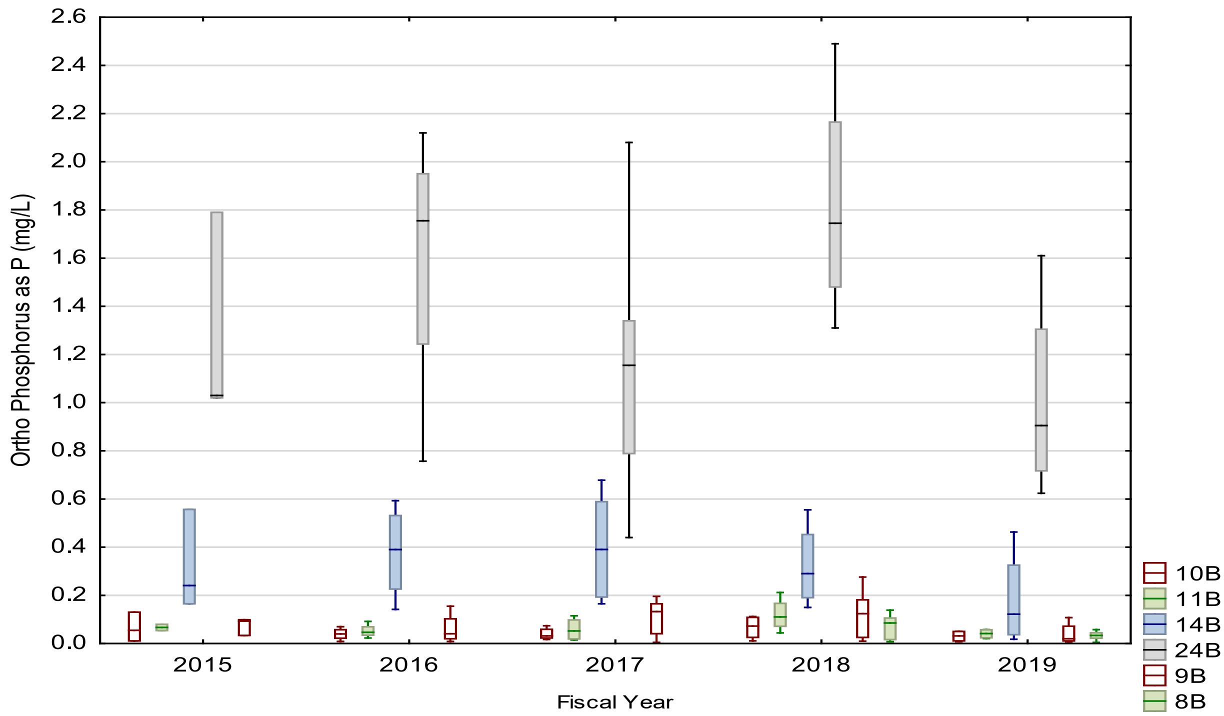


Figure A-49. Box plot of orthophosphate from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

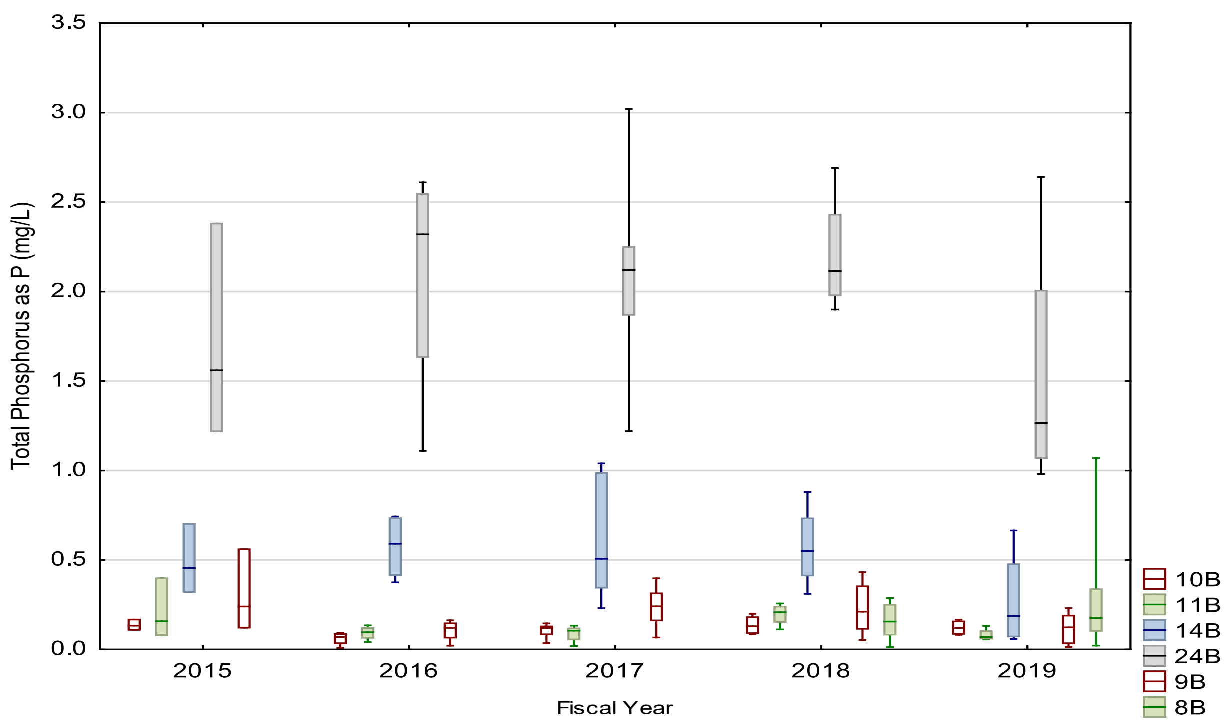


Figure A-50. Box plot of total phosphorus from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

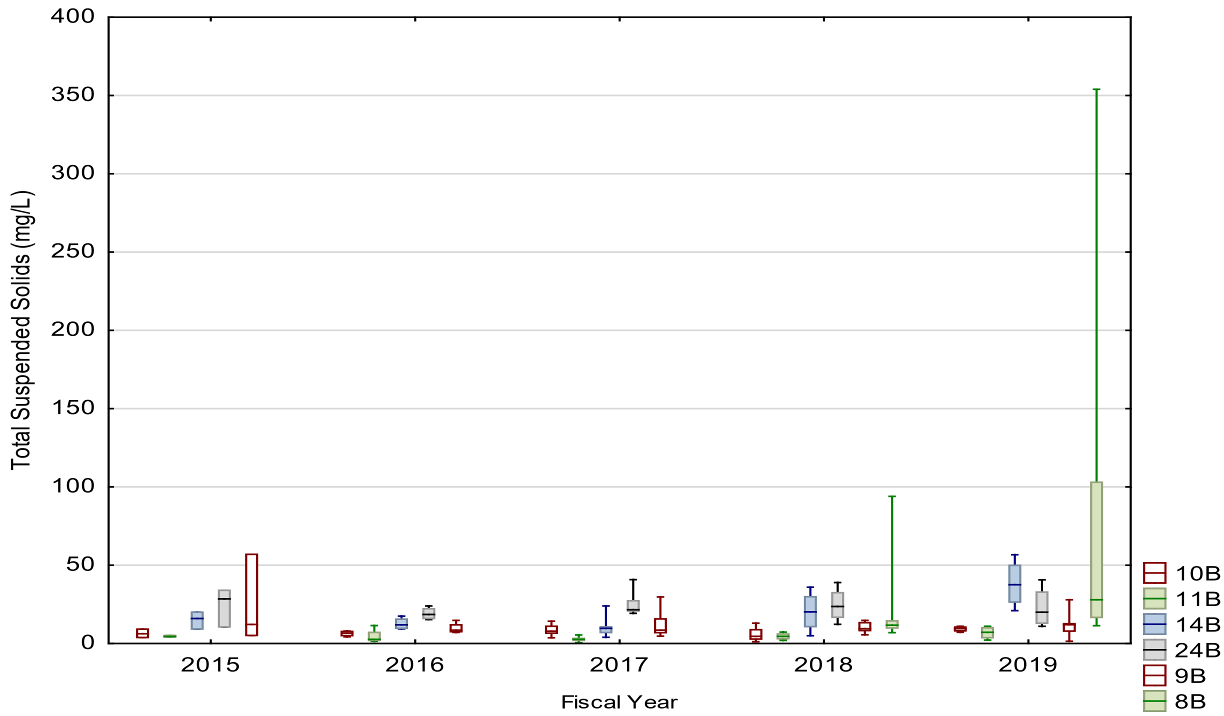


Figure A-51. Box plot of total suspended solids from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

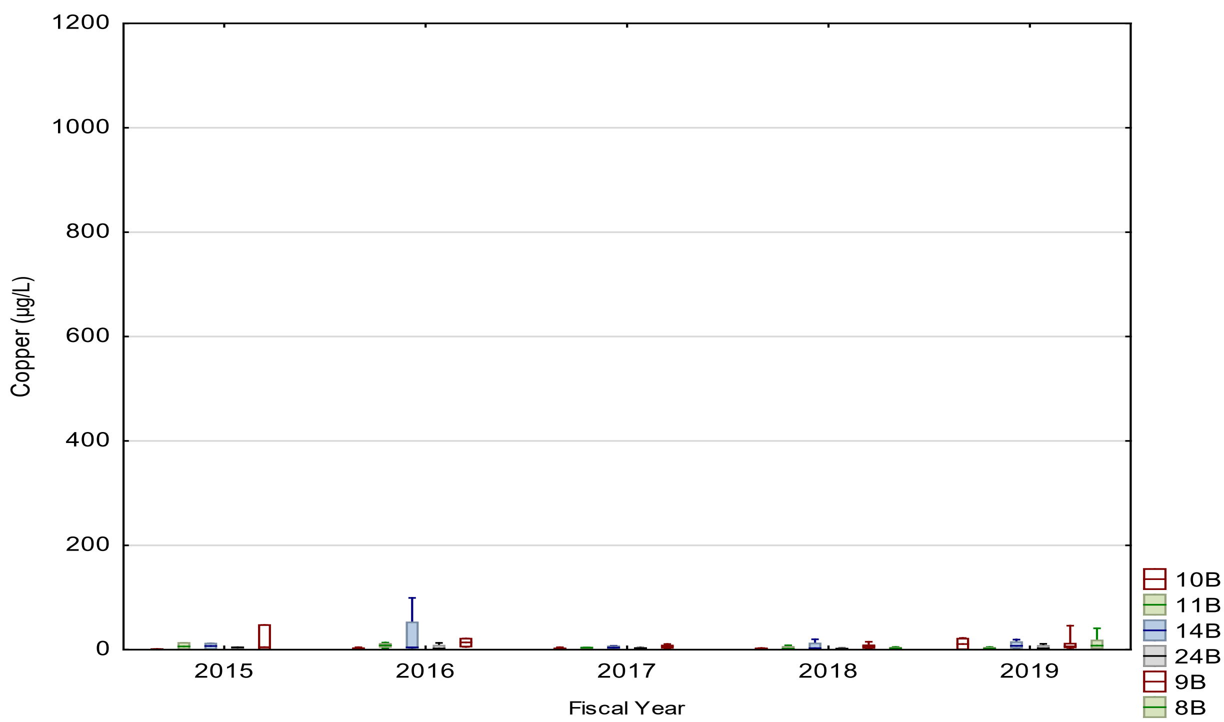


Figure A-52. Box plot of copper from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

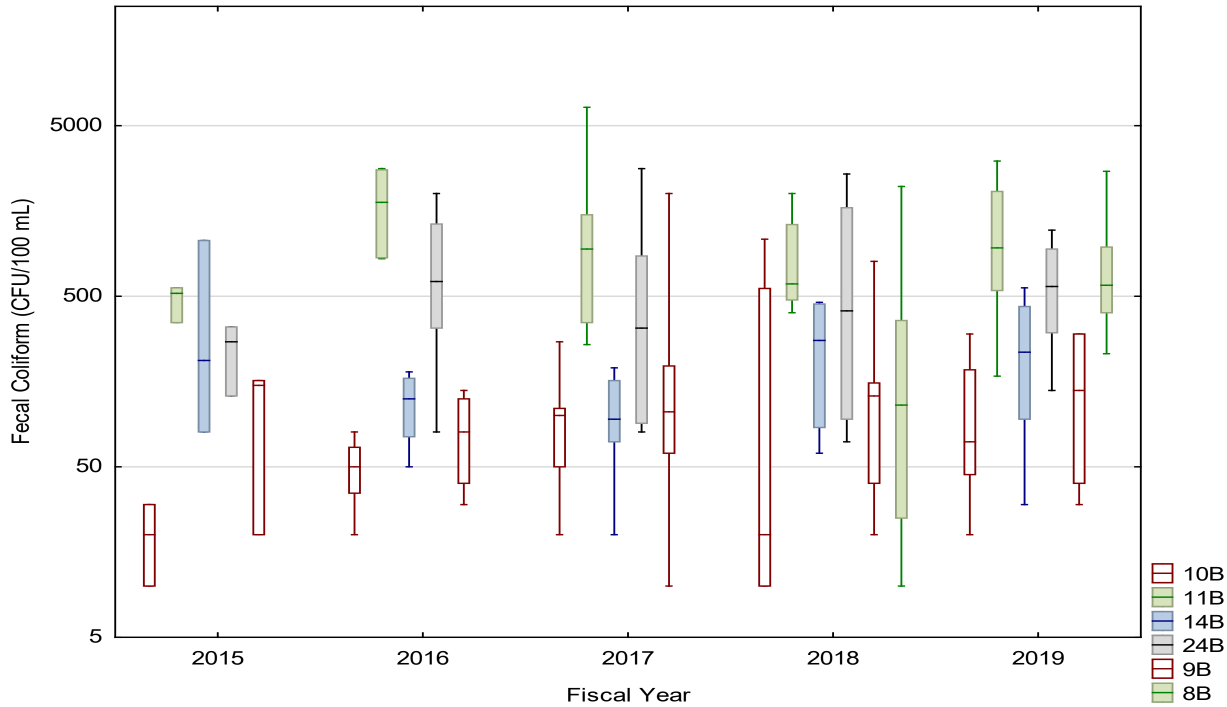


Figure A-53. Box plot of fecal coliform from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

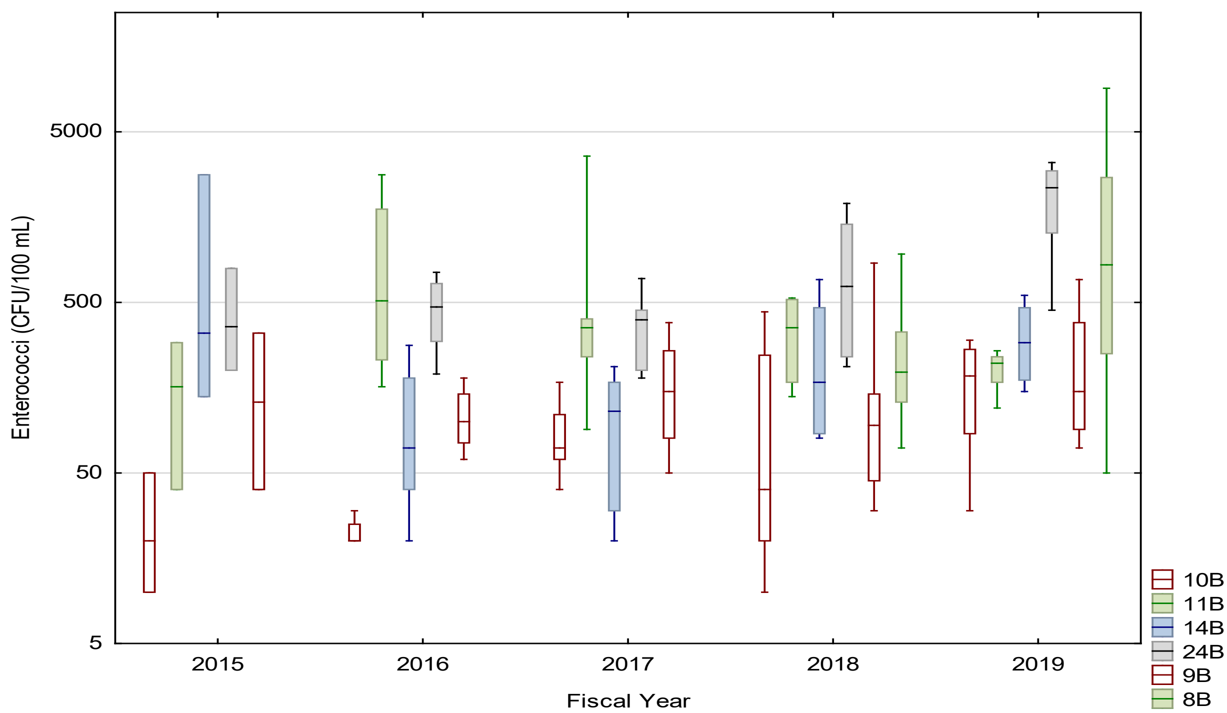


Figure A-54. Box plot of Enterococci from FY 2015 to FY 2019 at lakes draining to Naples Bay/Gulf of Mexico.

A.2 Pump Stations

A.2.1 Field Parameters

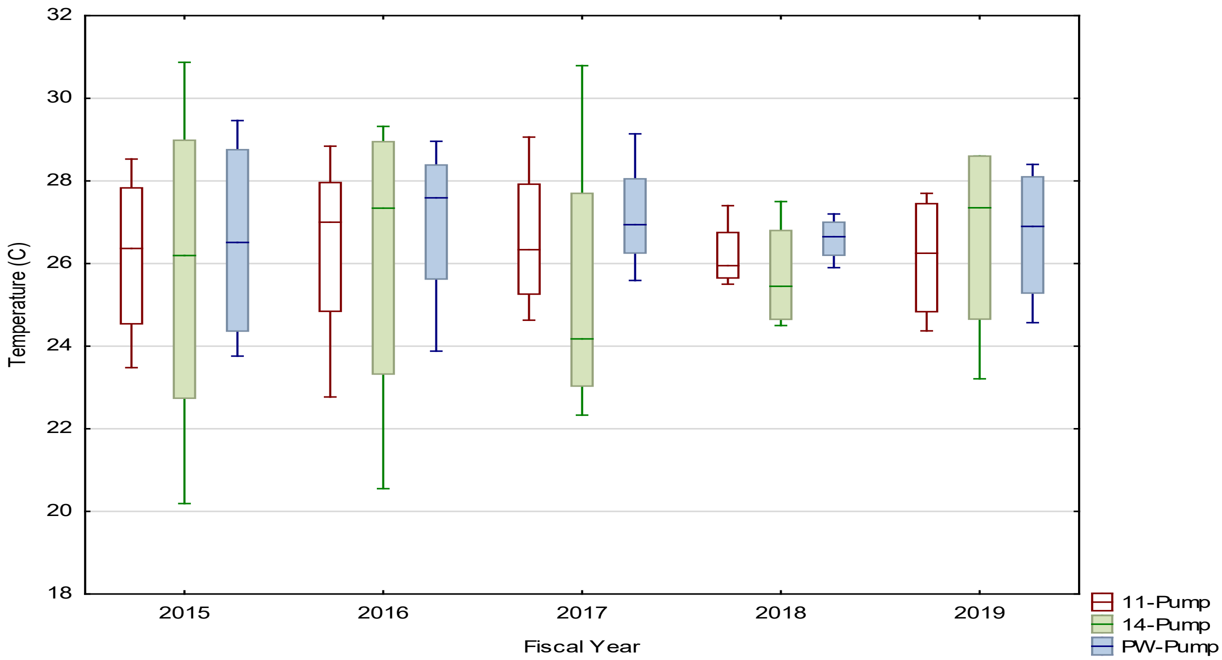


Figure A-55. Box plots of water temperature from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

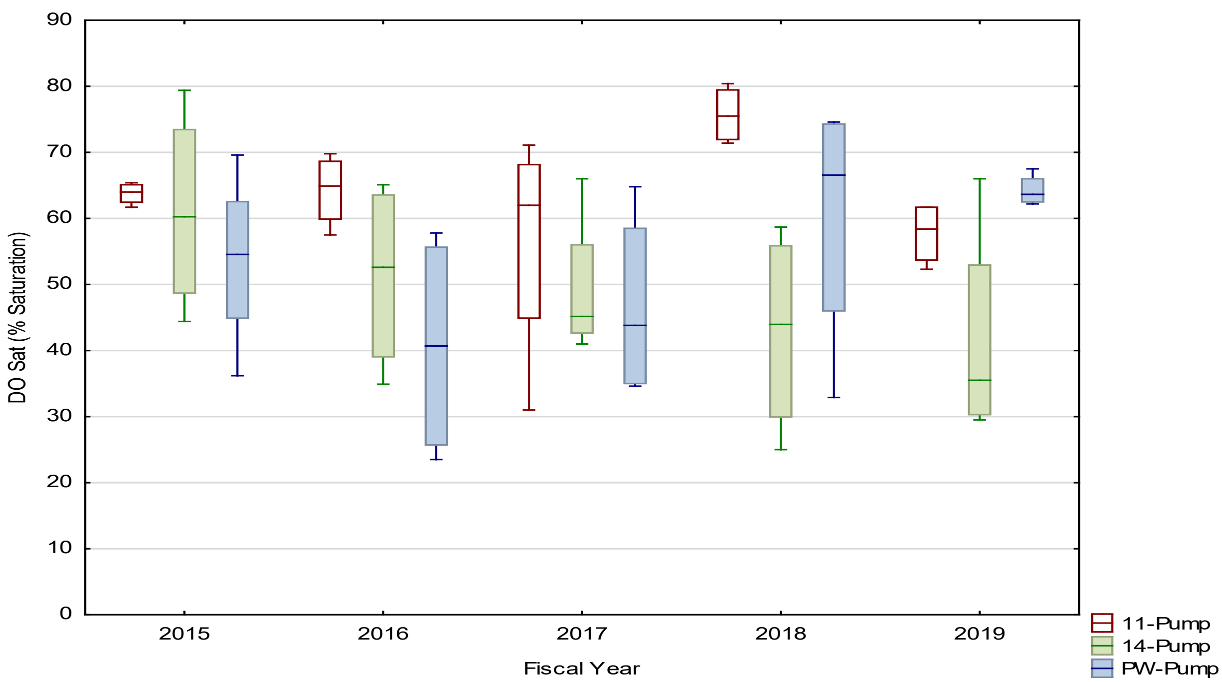


Figure A-56. Box plots of dissolved oxygen saturation from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

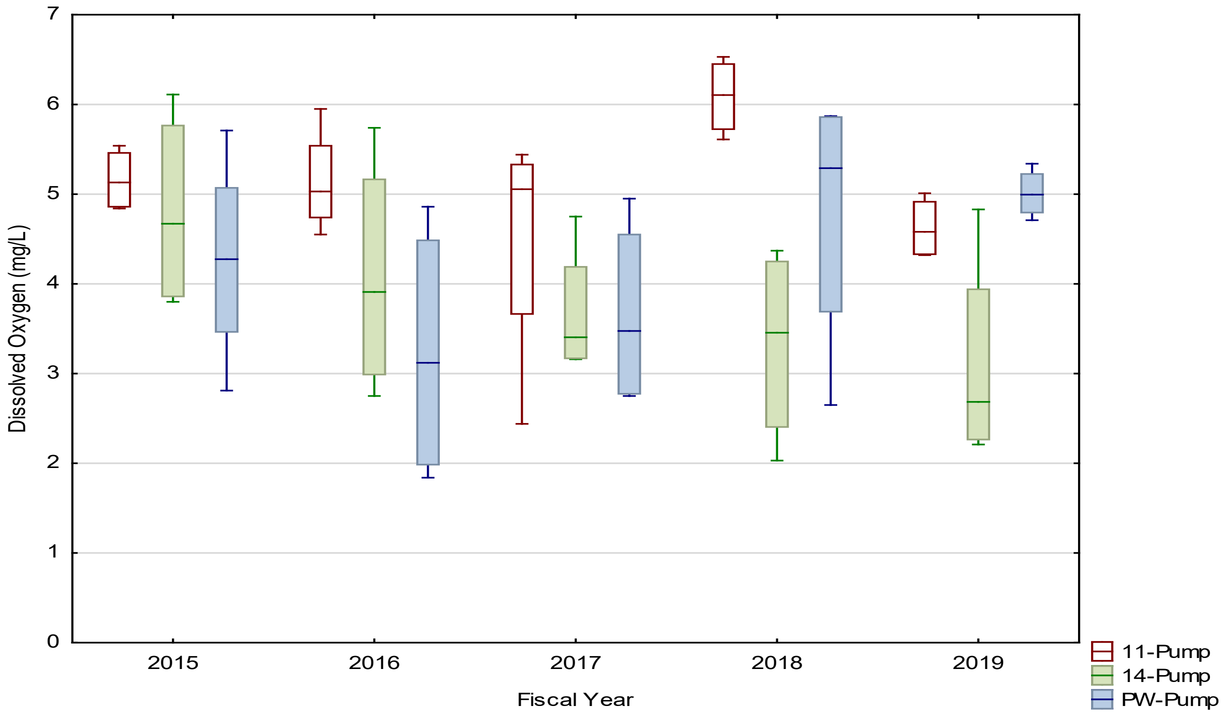


Figure A-57. Box plots of dissolved oxygen (mg/L) from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

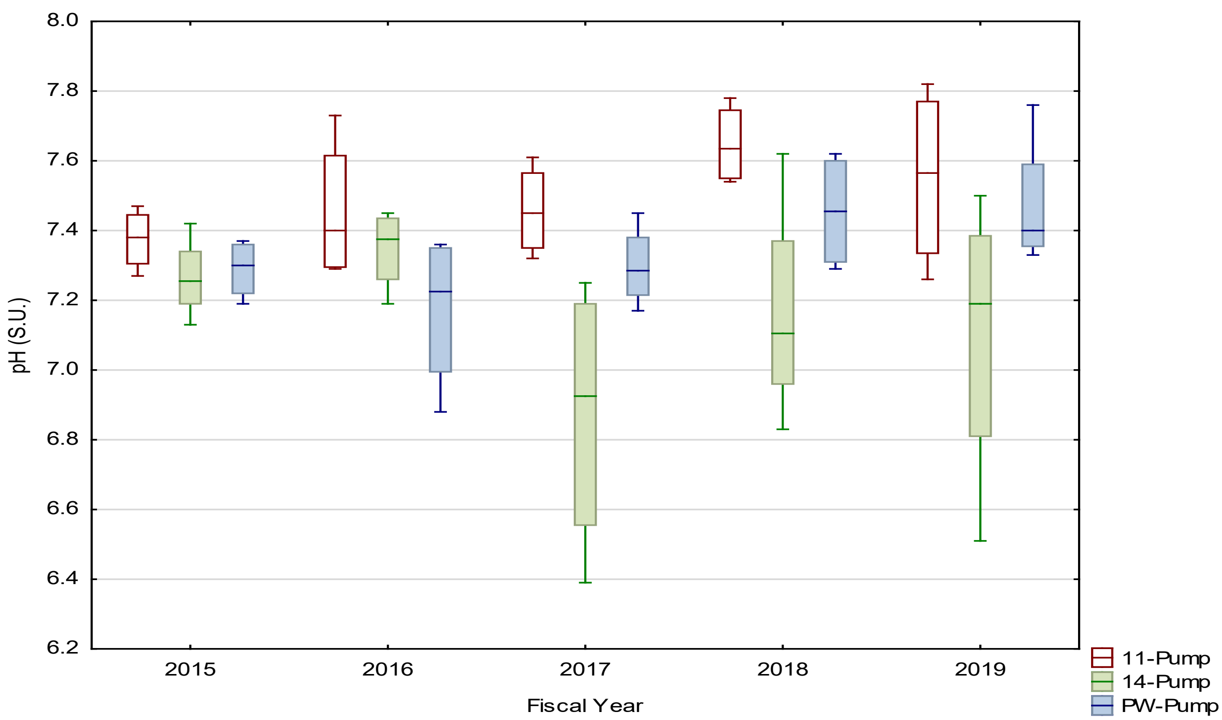


Figure A-58. Box plots of pH from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

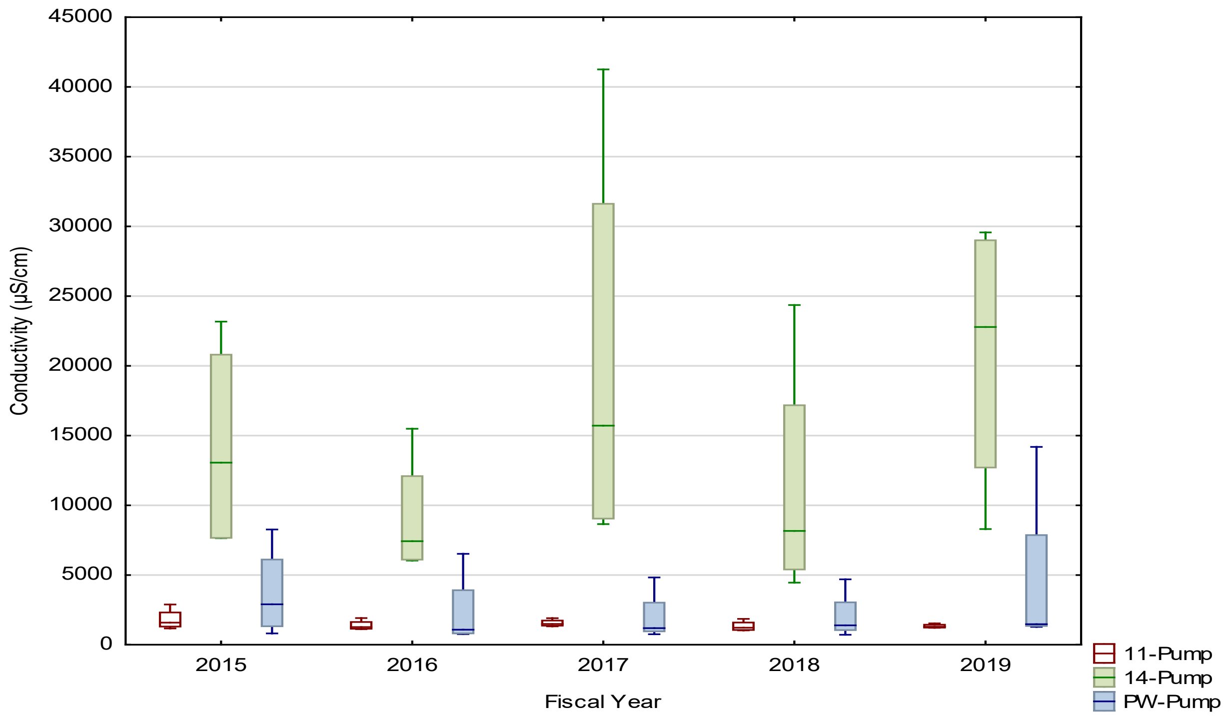


Figure A-59. Box plots of specific conductivity from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

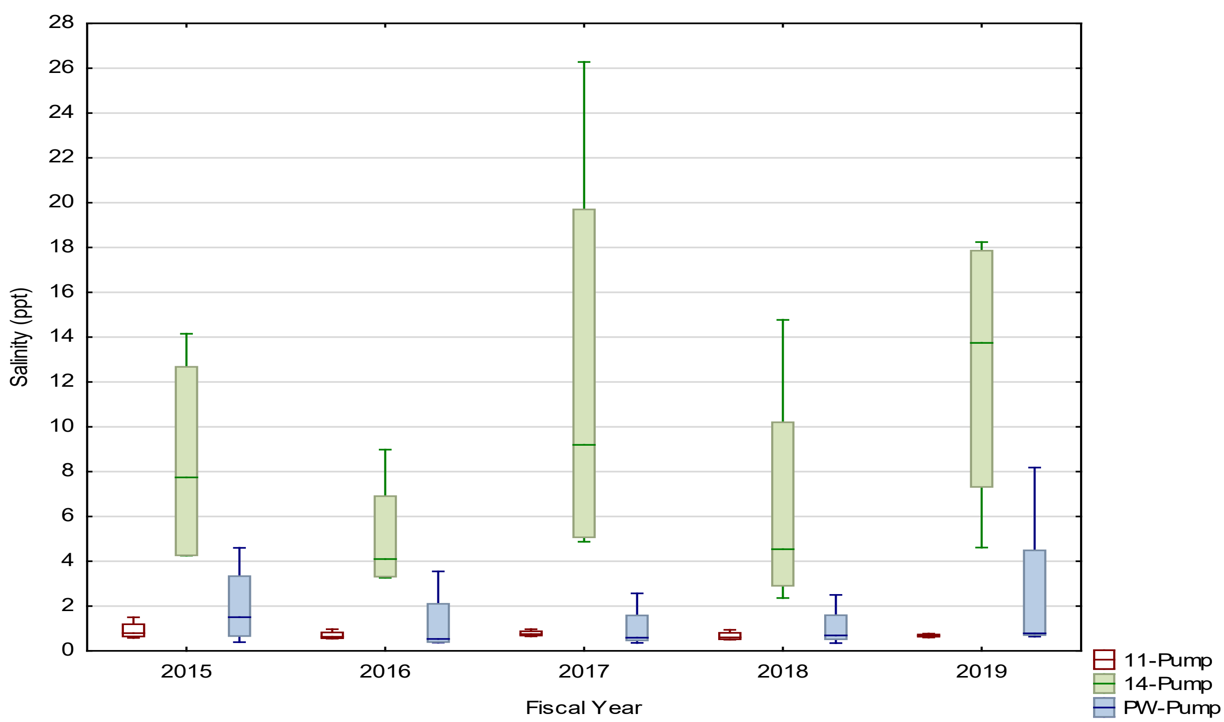


Figure A-60. Box plots of salinity from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

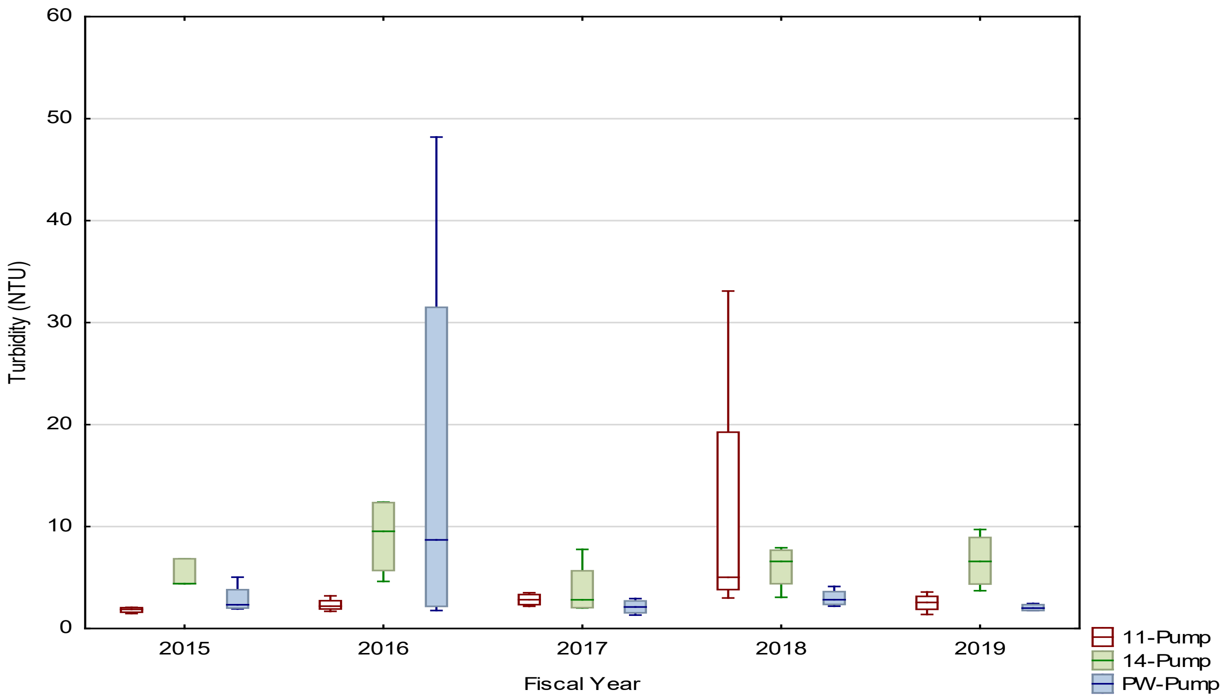


Figure A-61. Box plots of turbidity from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

A.2.2 Lab Parameters

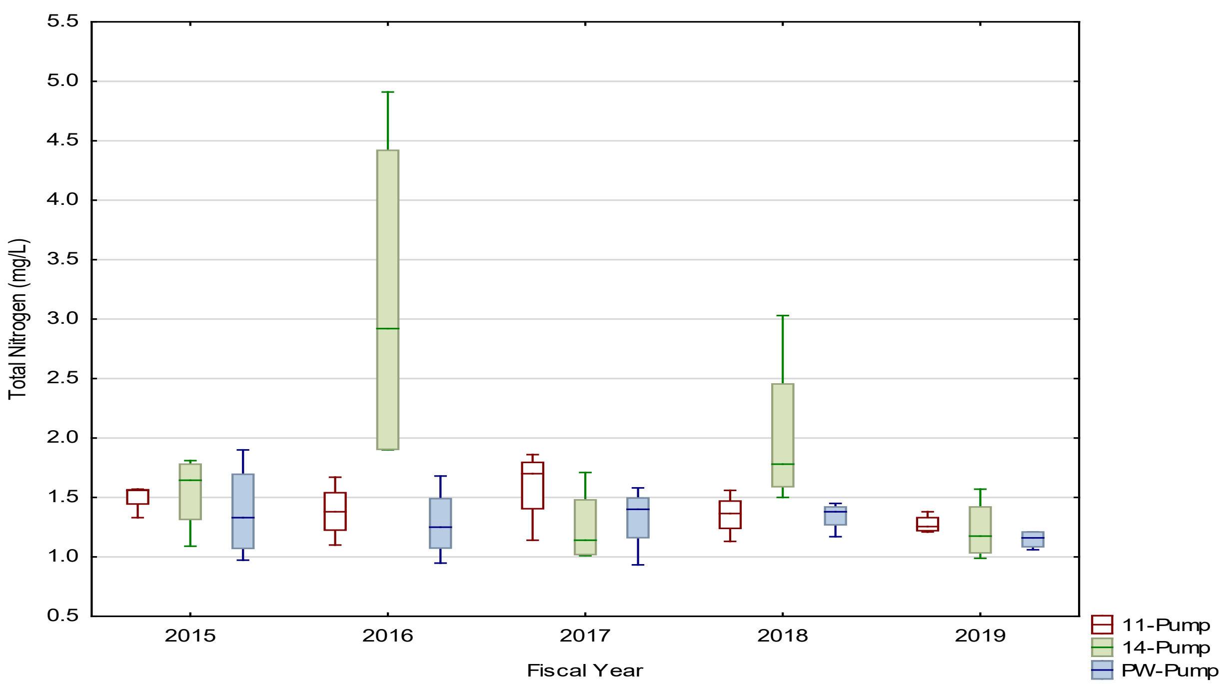


Figure A-62. Box plots of total nitrogen from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

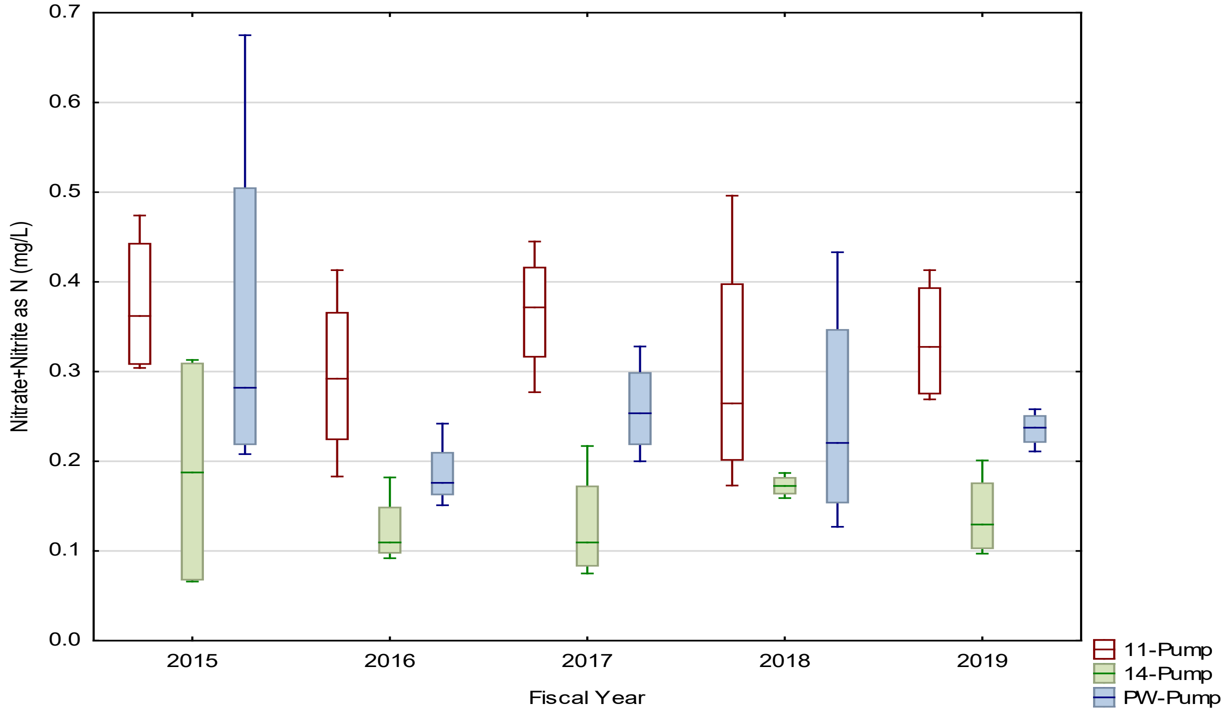


Figure A-63. Box plots of nitrate-nitrite from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

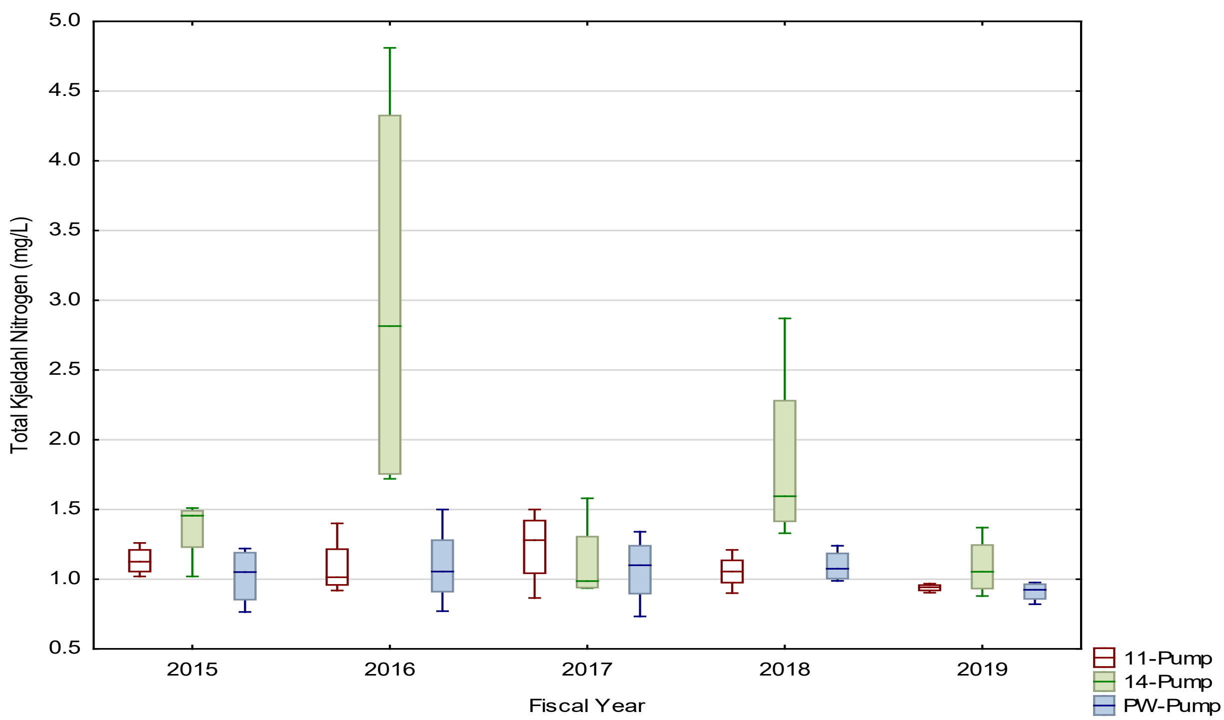


Figure A-64. Box plots of Total Kjeldahl Nitrogen from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

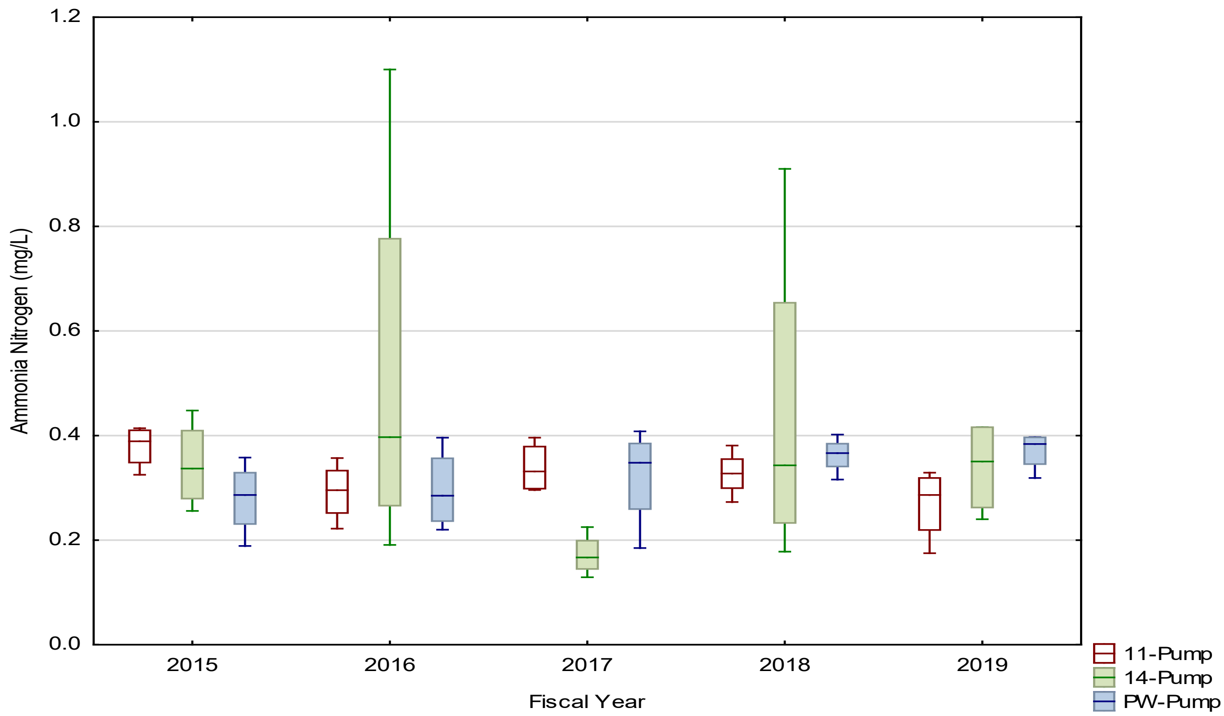


Figure A-65. Box plots of ammonia nitrogen from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

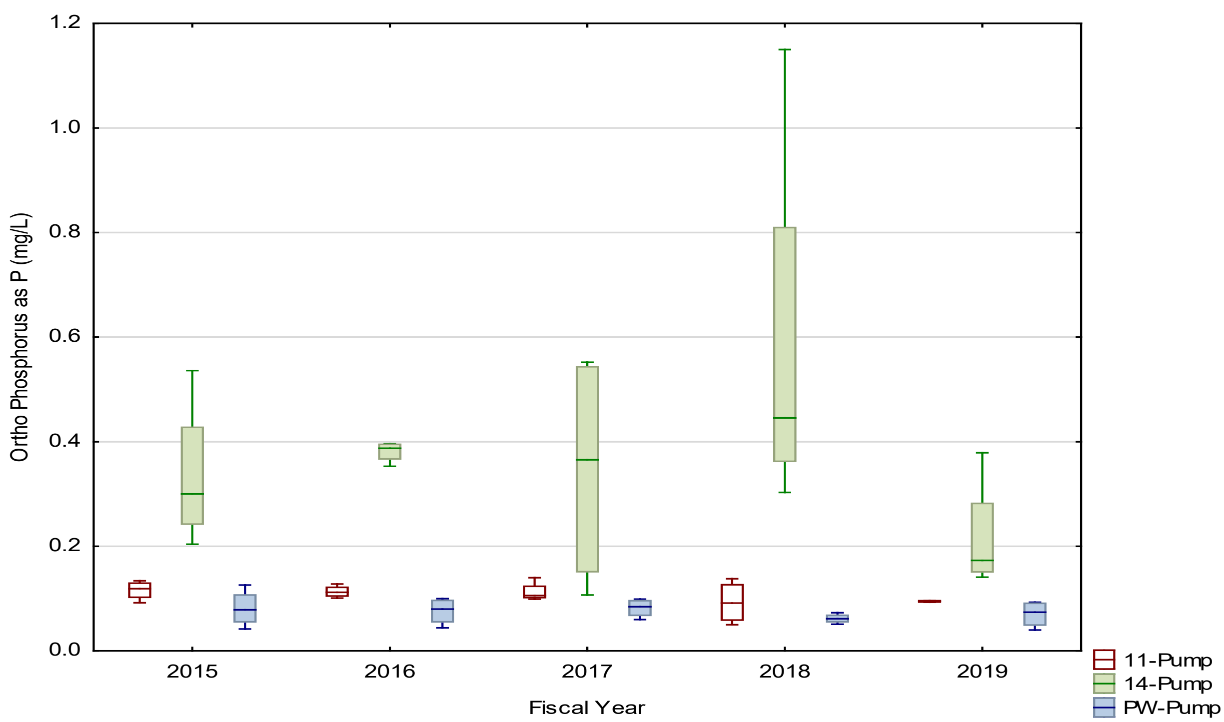


Figure A-66. Box plots of orthophosphate from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

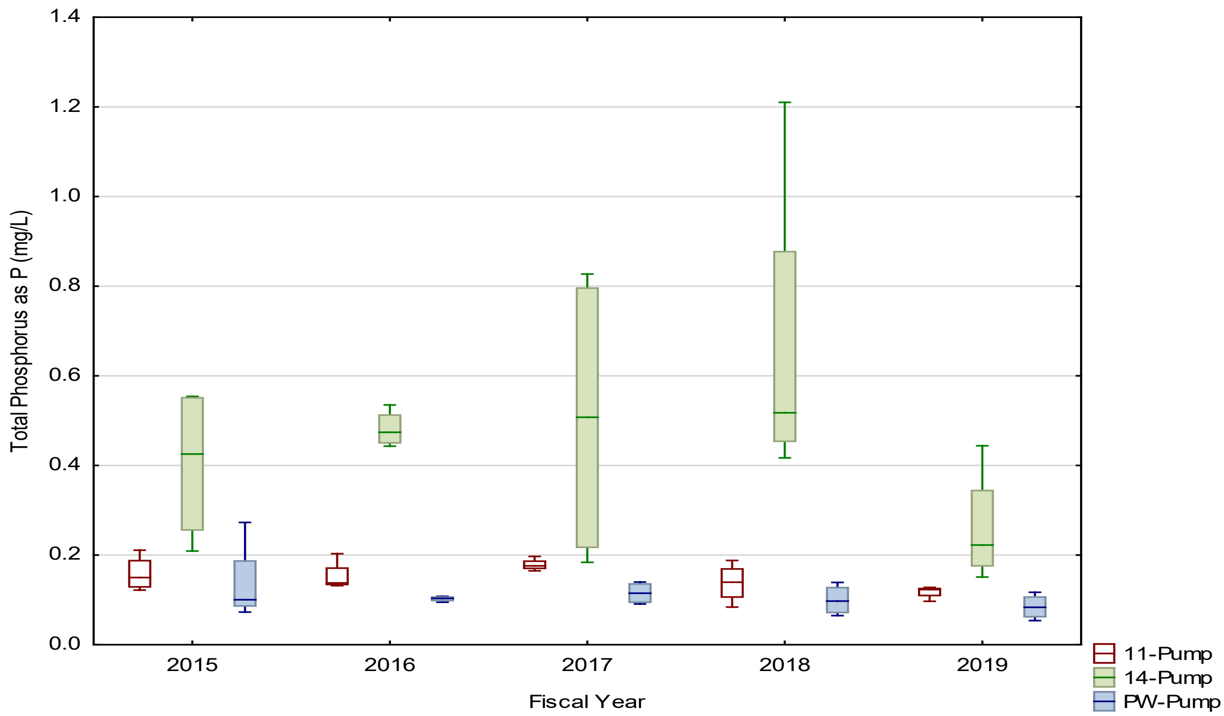


Figure A-67. Box plots of total phosphorus from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

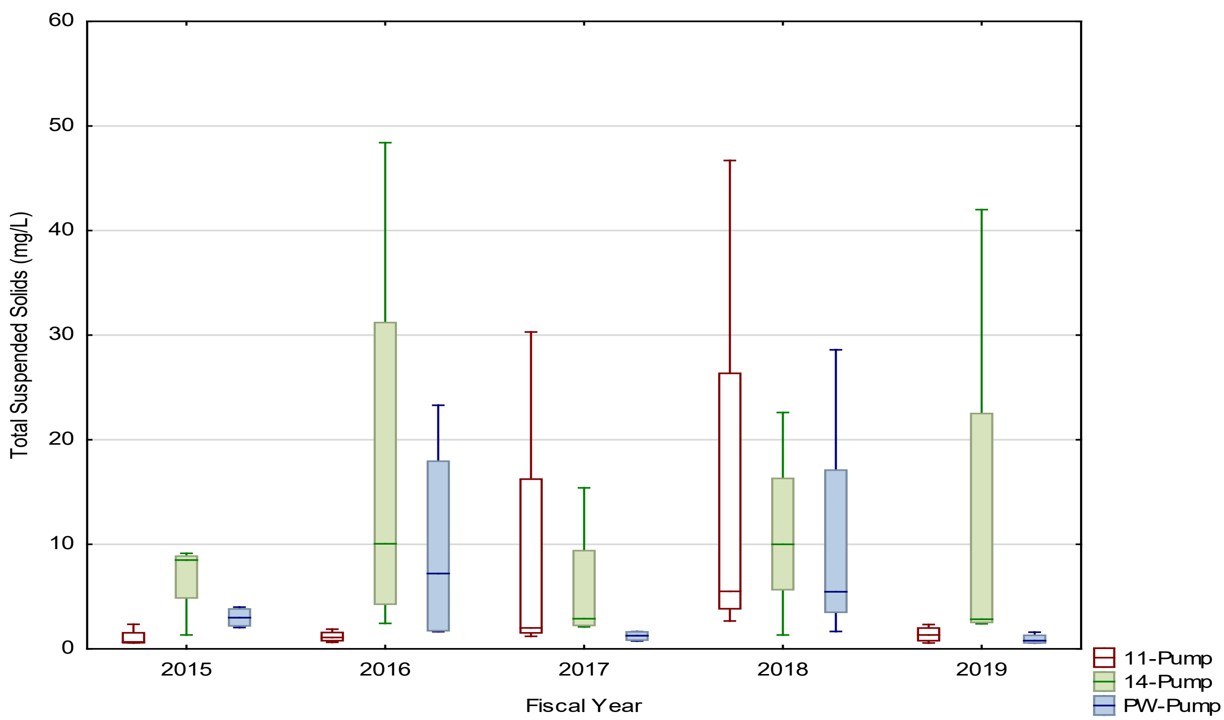


Figure A-68. Box plots of total suspended solids from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

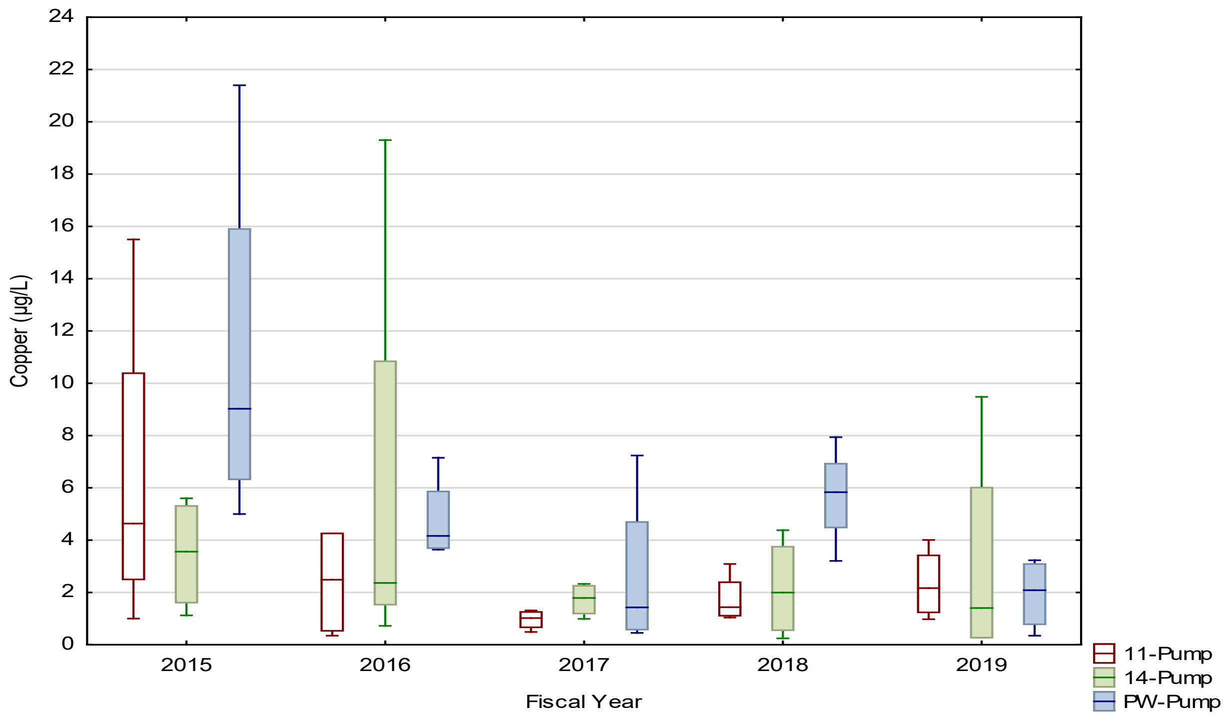


Figure A-69. Box plots of copper from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

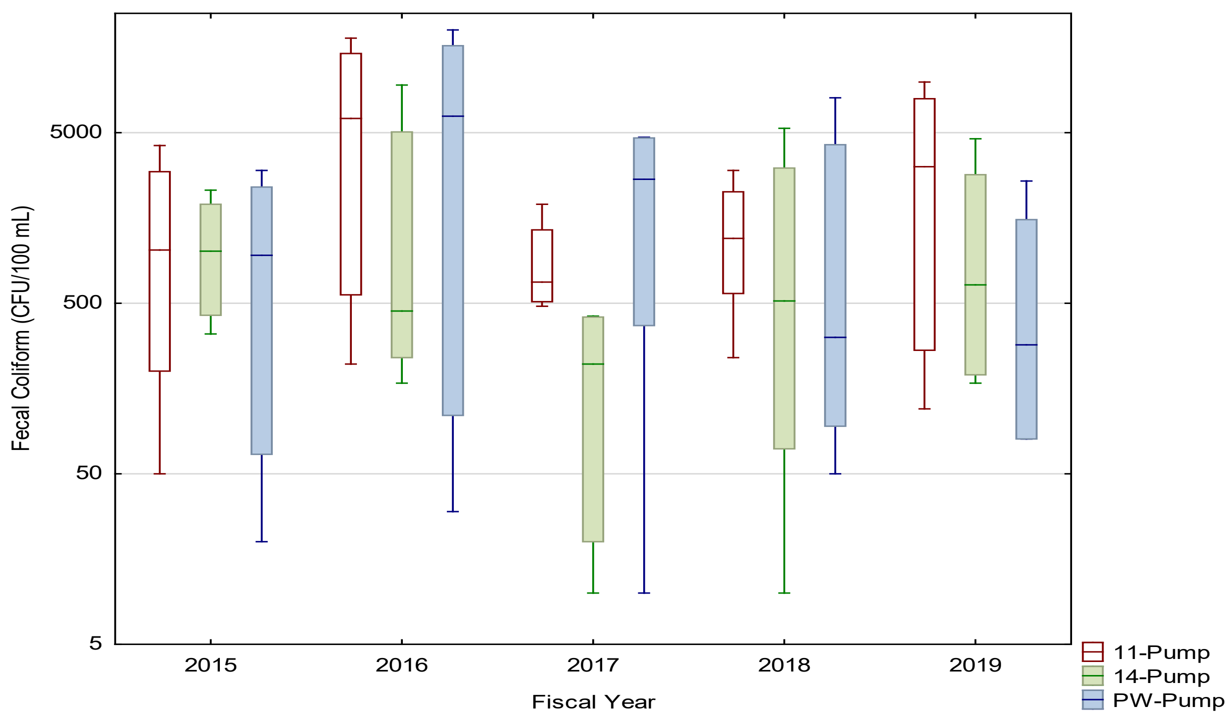


Figure A-70. Box plots of fecal coliform from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

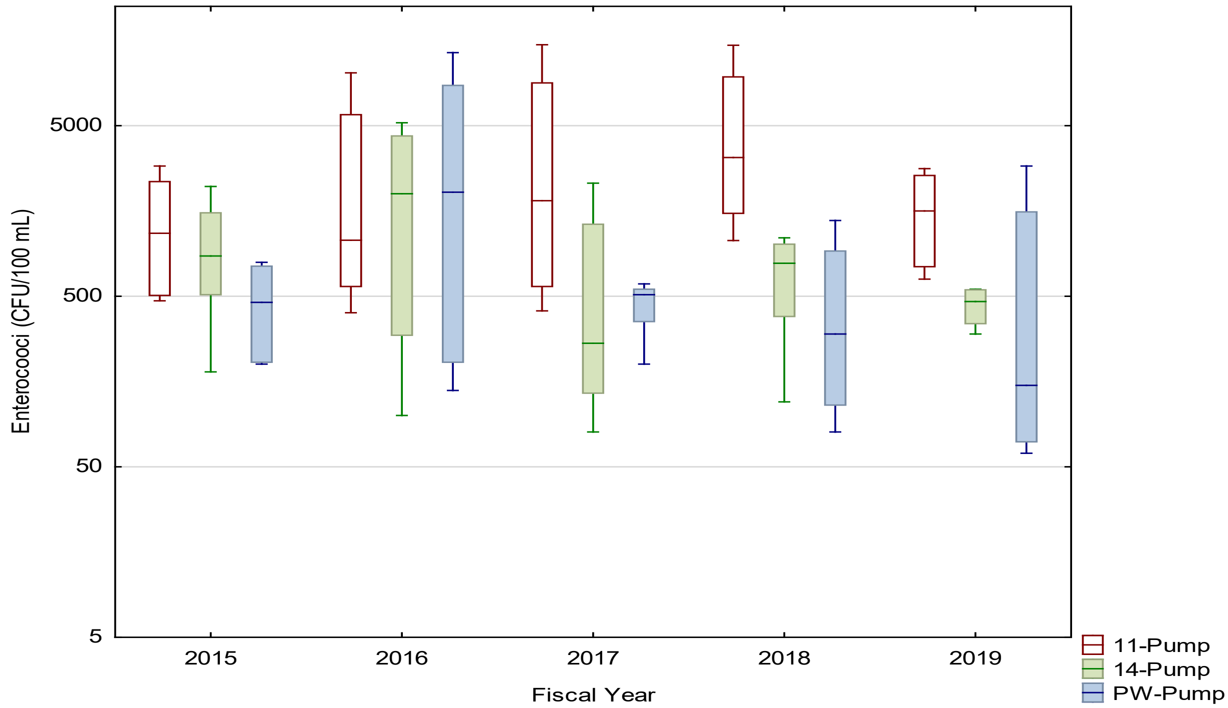


Figure A-71. Box plots of Enterococci from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

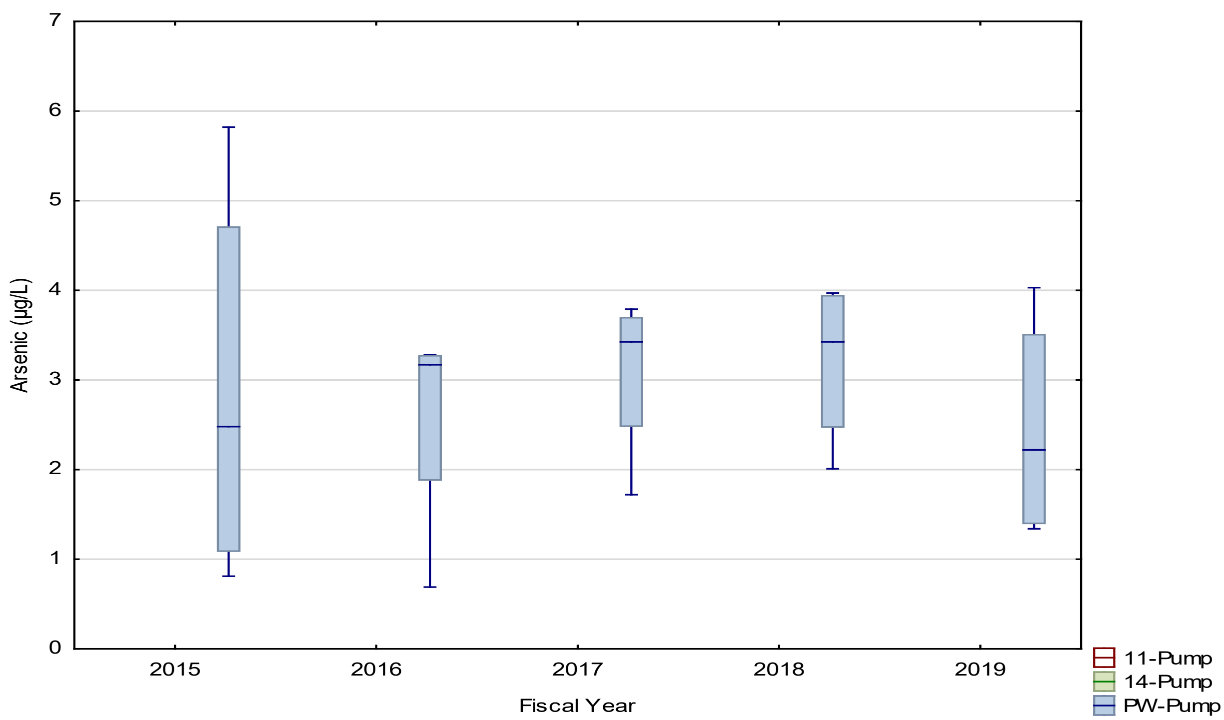


Figure A-72. Box plots of arsenic from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

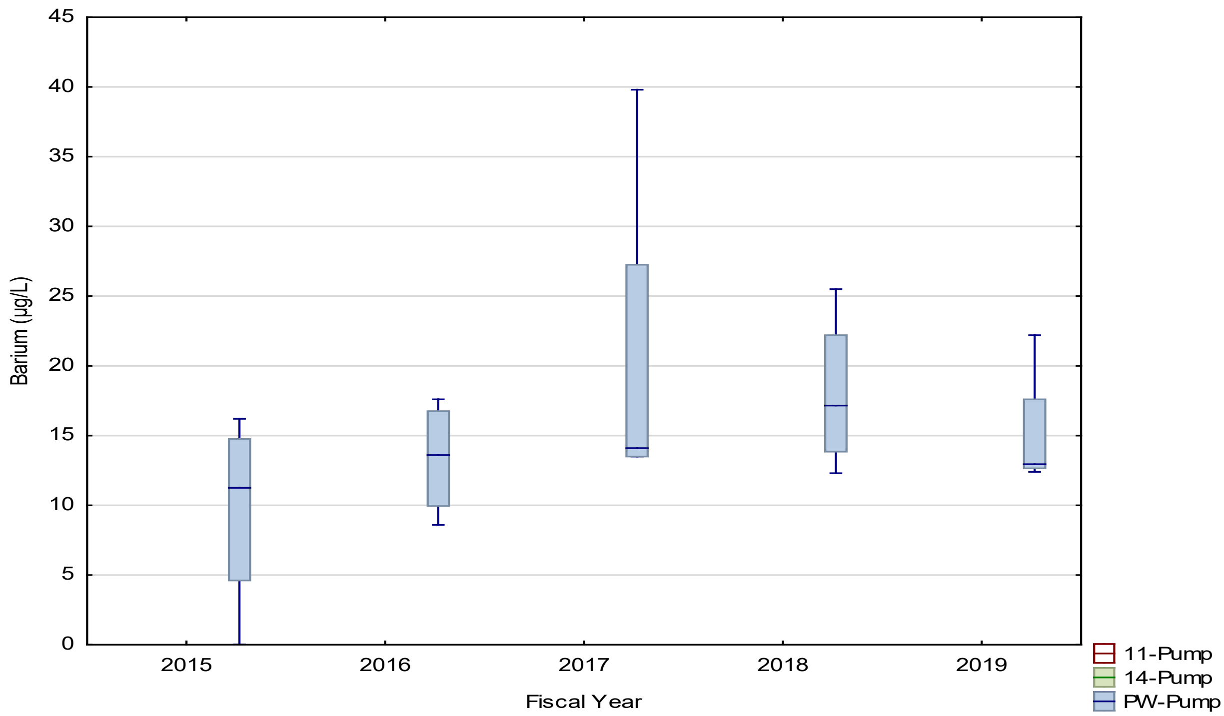


Figure A-73. Box plots of barium from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

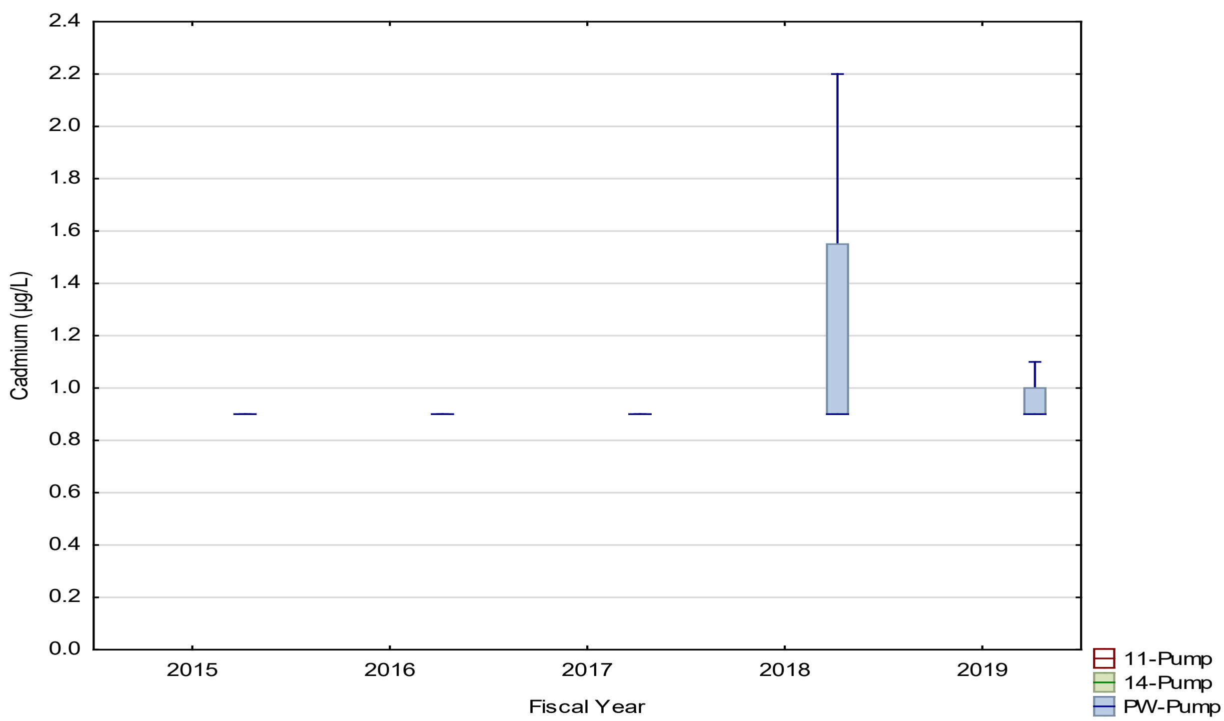


Figure A-74. Box plots of cadmium from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

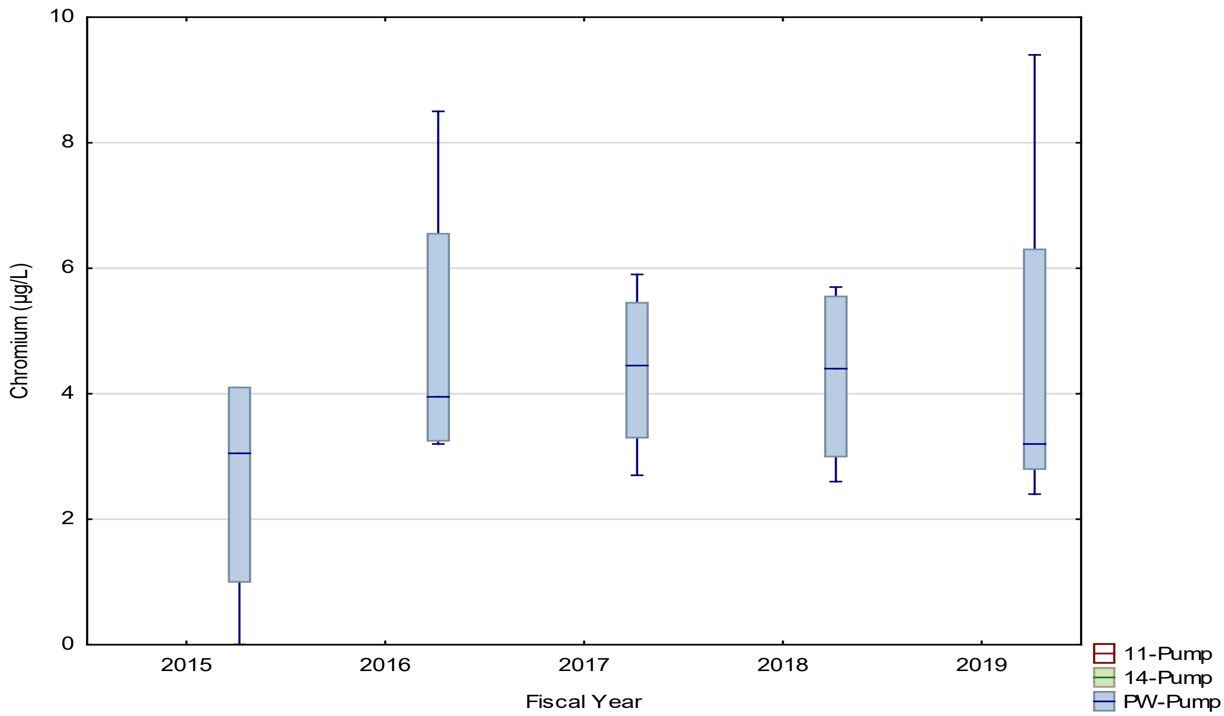


Figure A-75. Box plots of chromium from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

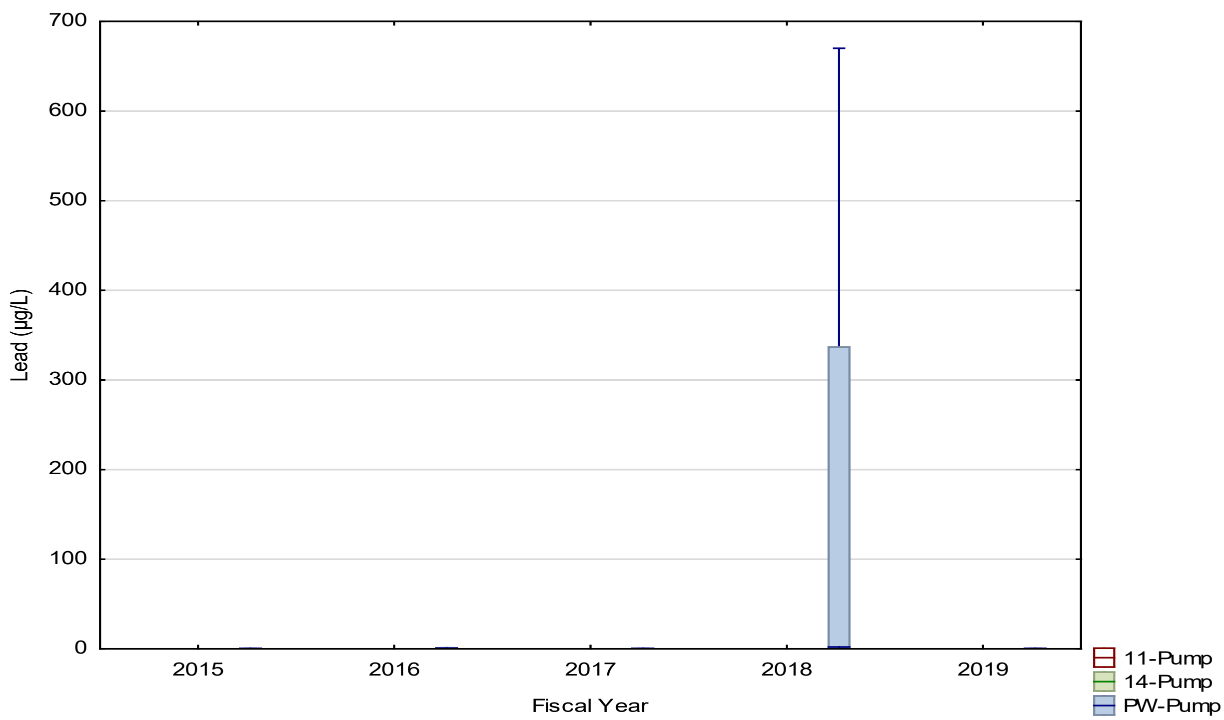


Figure A-76. Box plots of lead from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

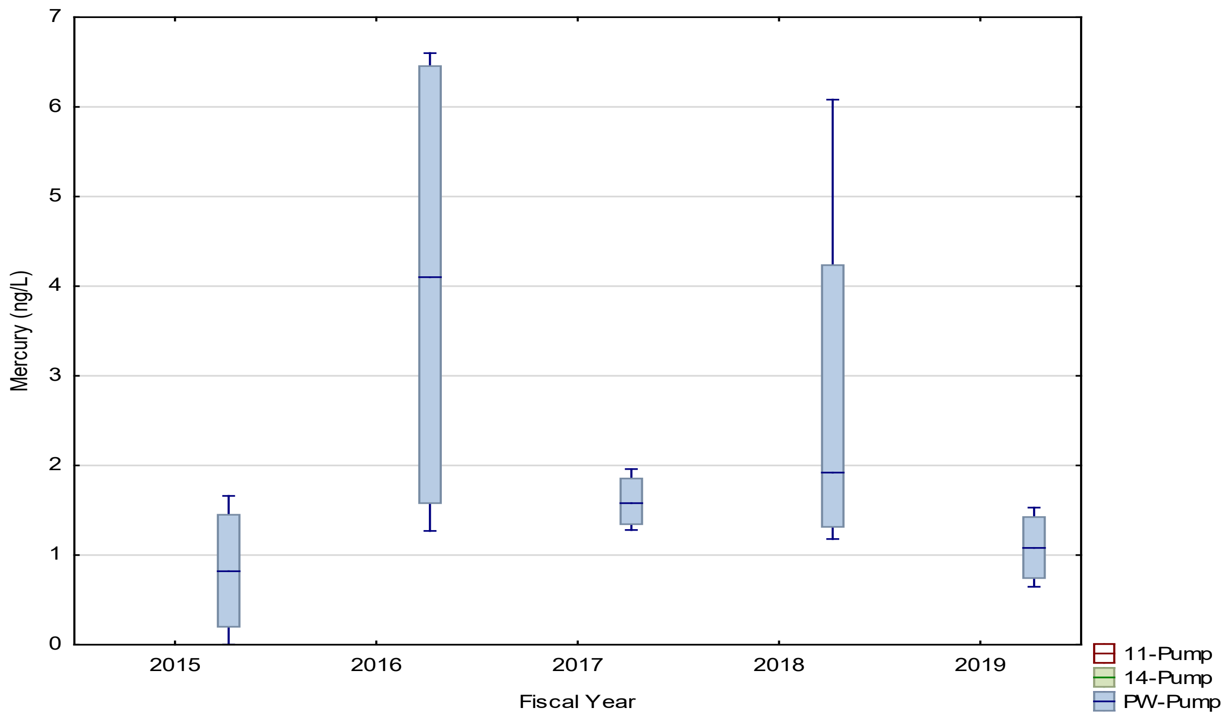


Figure A-77. Box plots of mercury from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

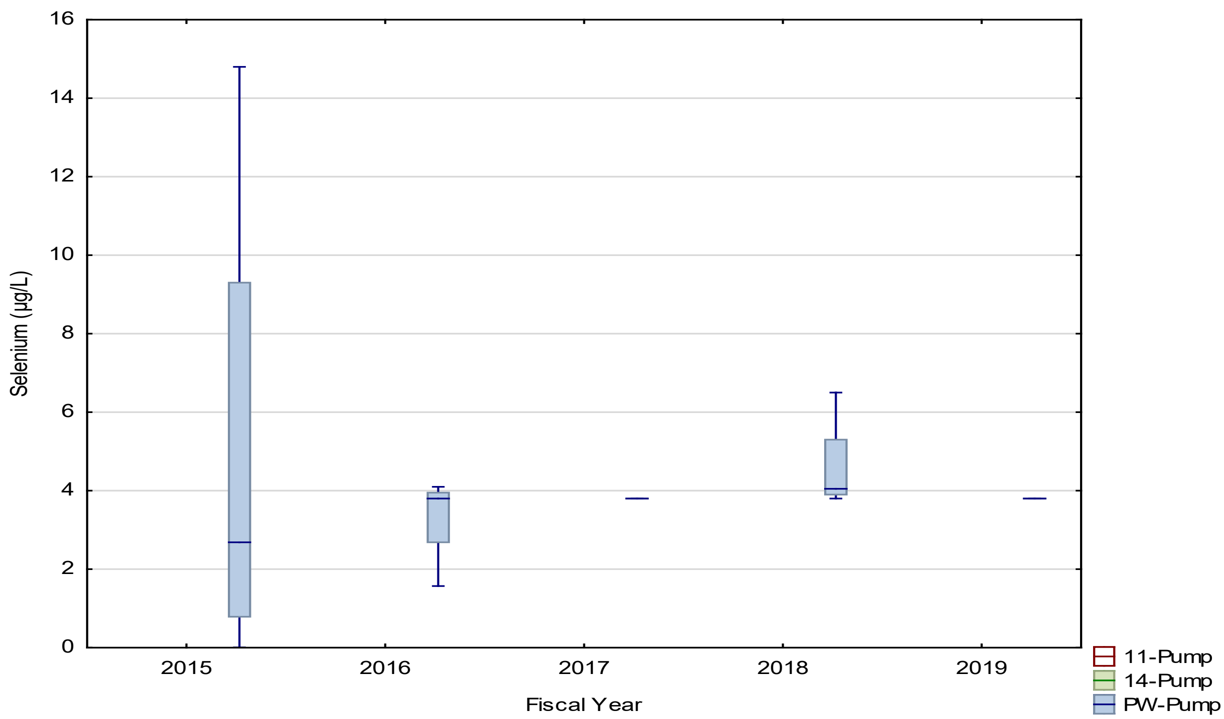


Figure A-78. Box plots of selenium from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

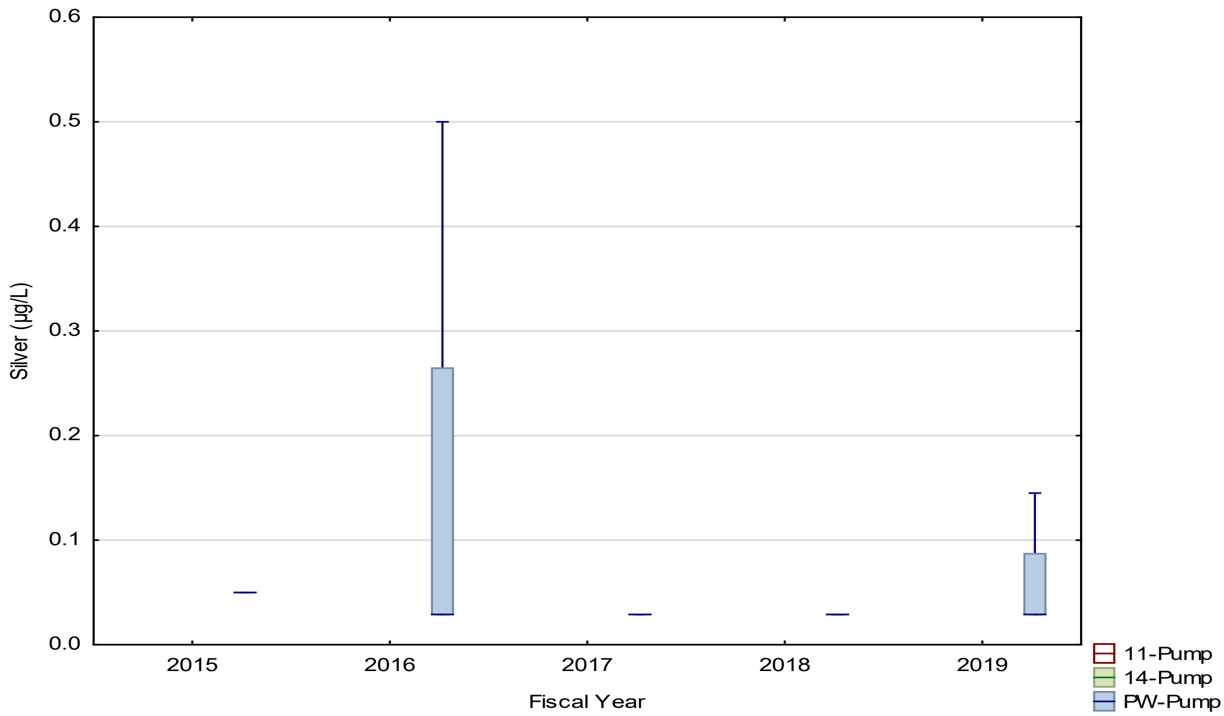


Figure A-79. Box plots of silver from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

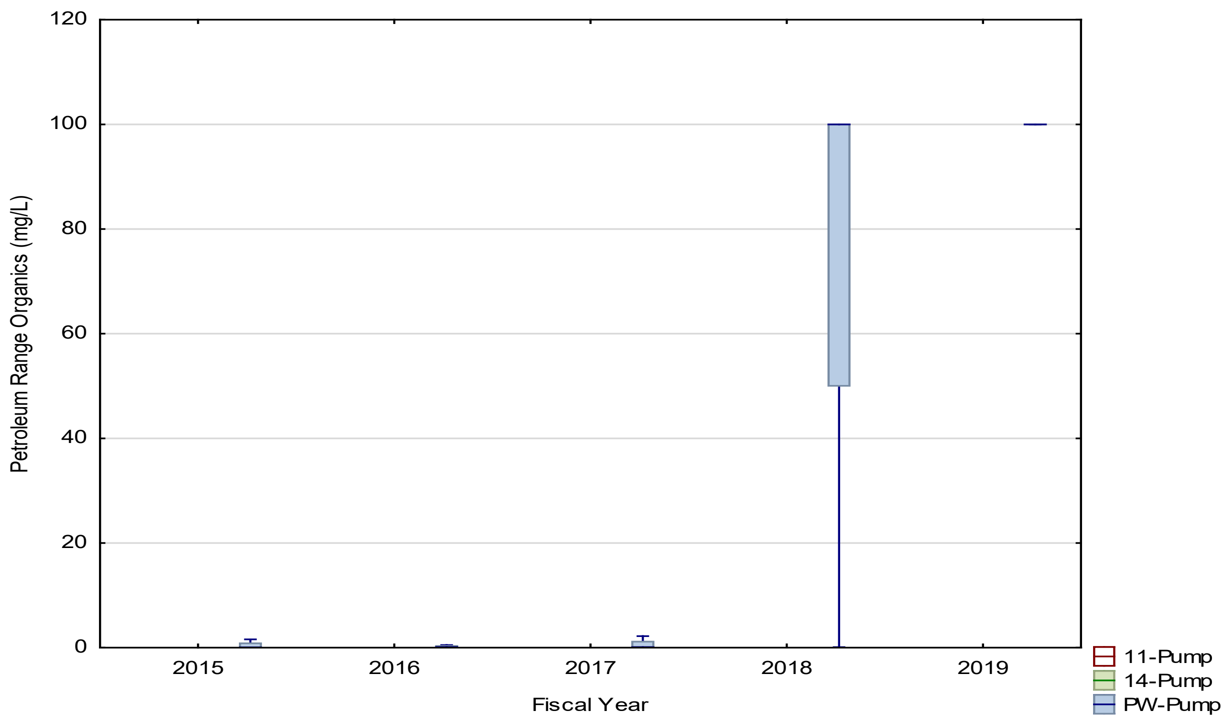


Figure A-80. Box plots of petroleum range organics from FY 2015 to FY 2019 at PW-Pump, 11-Pump, and 14-Pump.

Please Respect the Environment

About Cardno

Cardno is an ASX-200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage, and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

Cardno Zero Harm

Cardno ZERO HARM EVERY JOB. EVERY DAY.

At Cardno, our primary concern is to develop and maintain safe and healthy conditions for anyone involved at our project worksites. We require full compliance with our Health and Safety Policy Manual and established work procedures and expect the same protocol from our subcontractors. We are committed to achieving our Zero Harm goal by continually improving our safety systems, education, and vigilance at the workplace and in the field. Safety is a Cardno core value and through strong leadership and active employee participation, we seek to implement and reinforce these leading actions on every job, every day.