Subbasin Chapter Appendix

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Table 1: Jordan Lake Nutrient Strategy Point Source Total Nitrogen and Total Phosphorus Annual Loads for 2009-2022 and the Annual Jordan Lake Management Strategy Arm Load and Cap Totals. (Provided by NPDES, based on data reported in eDMRs.)

Jordan Lake Nutrient Strategy
TN & TP Point Source Loads, 2009-2022

UNH = Upper New Hope Arm
LNH = Lower New Hope Arm
Haw = Haw River Arm

Total Nitrogen

	Permit	Owner Name	Facility Name	TF	Outfall	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
UNH	NC0047597	City of Durham	South Durham WRF		001	278,697	279,865	268,218	263,678	230,106	208,199	217,331	173,454	173,792	205,465	184,629	200,085	188,774	162,974
UNH	NC0025241	Orange Water And Sewer	Mason Farm WWTP		001	304,520	232,323	151,090	152,615	145,981	145,072	122,894	122,928	124,847	131,175	108,131	96,235	101,203	109,214
UNH	NC0026051	Durham County	Triangle WWTP		001	57,605	52,093	67,196	48,199	62,619	92,013	67,472	73,655	84,562	85,063	52,899	37,421	44,531	74,871
UNH	NC0056413	Aqua North Carolina Inc	Chatham WRF		001	2,919	5,013	6,142	2,903	783	940	2,189	3,902	6,754	3,453	2,894	1,704	1,842	2,642
LNH	NC0043559	Fearrington Utilities Inc	Fearrington Village WWTP		001	11,835	15,491	17,350	15,339	12,662	12,946	14,956	13,670	14,702	8,469	6,959	13,117	14,265	12,190
HAW	NC0047384	City of Greensboro	T.Z. Osborne WWTP	0.5	001	683,172	788,641	879,806	644,482	783,901	1,083,787	1,357,850	1,099,537	1,323,868	1,481,861	1,537,981	1,236,827	586,838	518,041
HAW	NC0024325	City of Greensboro	North Buffalo Creek WWTP	0.4	001	300,691	260,320	321,884	344,921	343,694	365,712	353,170	358,093	242,944	0	0	0	0	0
HAW	NC0023868	City of Burlington	Eastside WWTP	0.8	001	201,868	198,749	203,741	182,288	176,151	121,627	105,573	170,375	146,322	175,143	172,785	156,417	163,403	159,251
HAW	NC0023876	City of Burlington	Southside WWTP	0.8	001	151,802	130,032	61,470	53,264	86,354	83,317	84,901	104,540	98,537	116,446	118,746	120,268	101,500	84,407
HAW	NC0024881	City of Reidsville	Reidsville WWTP	0.7	001	31,087	48,535	27,580	24,319	28,608	22,620	26,670	63,256	109,198	74,792	60,997	90,993	79,419	85,598
HAW	NC0021211	City of Graham	Graham WWTP	0.8	001	40,028	34,916	29,223	20,498	27,317	26,748	42,167	109,198	56,462	100,683	40,303	36,435	34,733	30,390
HAW	NC0021474	City of Mebane	Mebane WWTP	0.6	001	31,922	29,743	29,272	21,598	24,966	14,187	15,811	13,705	14,636	27,347	19,682	32,981	21,590	21,802
HAW	NC0020354	Town of Pittsboro	Pittsboro WWTP	0.8	001	20,861	27,148	22,499	24,339	22,110	22,991	26,912	29,324	21,748	17,288	11,011	12,701	11,115	9,923
HAW	NC0066966	Quarterstone Farm HOA	Quarterstone Farm WWTP	0.5	001	434	332	383	1,132	1,461	1,852	2,488	2,564	3,130	3,348	1,276	2,332	1,554	1,340
			Yearly Totals			2,117,442	2,103,201	2,085,853	1,799,575	1,946,713	2,202,014	2,440,385	2,338,200	2,421,500	2,430,531	2,318,293	2,037,518	1,350,767	1,272,643

Total Nitrogen

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
UNH Cap	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170	434,170
LNH Cap	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138	8,138
Haw Cap	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822	1,543,822
UNH Load	643,741	569,294	492,645	467,395	439,489	446,225	409,887	373,938	389,954	425,156	348,553	335,445	336,350	349,701
LNH Load	11,835	15,491	17,350	15,339	12,662	12,946	14,956	13,670	14,702	8,469	6,959	13,117	14,265	12,190
Haw Load	1,461,865	1,518,416	1,575,858	1,316,841	1,494,562	1,742,843	2,015,542	1,950,591	2,016,844	1,996,906	1,962,781	1,688,956	1,000,152	910,752

Total Phosphorus

	Permit	Owner Name	Facility Name		Outfall	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
UNH	NC0047597	City of Durham	South Durham WRF		001	17,740	8,521	7,302	10,752	7,104	10,075	10,362	8,755	7,058	10,221	11,710	8,008	11,198	12,208
UNH	NC0025241	Orange Water And Sewer	Mason Farm WWTP		001	8,227	7,371	6,234	5,652	4,240	7,520	7,640	12,705	7,471	4,179	2,262	1,143	1,224	1,958
UNH	NC0026051	Durham County	Triangle WWTP		001	6,644	4,374	4,609	5,259	3,307	6,039	4,185	3,739	3,884	3,759	6,315	8,019	3,574	7,973
UNH	NC0056413	Aqua North Carolina Inc	Chatham WRF		001	155	131	197	161	177	189	624	316	93	85	137	161	101	106
LNH	NC0043559	Fearrington Utilities Inc	Fearrington Village WWTP		001	805	208	218	177	253	345	461	445	741	663	592	1,566	521	281
HAW	NC0047384	City of Greensboro	T.Z. Osborne WWTP	0.4	001	55,840	49,619	68,197	44,465	35,697	64,963	87,633	78,292	72,807	99,141	67,211	75,546	106,549	52,737
HAW	NC0024325	City of Greensboro	North Buffalo Creek WWTP	0.4	001	14,584	10,055	9,081	8,483	5,912	17,425	17,036	15,590	7,778	0	0	0	0	0
HAW	NC0023868	City of Burlington	Eastside WWTP	0.7	001	10,101	9,064	6,265	6,620	5,822	7,546	5,690	5,605	4,372	5,994	5,913	3,121	3,438	3,007
HAW	NC0023876	City of Burlington	Southside WWTP	0.7	001	19,981	11,714	8,772	11,335	15,030	7,587	7,249	8,719	3,913	6,496	7,594	9,657	7,108	6,553
HAW	NC0024881	City of Reidsville	Reidsville WWTP	0.6	001	2,143	2,843	2,307	1,553	1,789	1,385	2,061	4,496	6,951	10,438	5,139	7,427	5,199	9,084
HAW	NC0021211	City of Graham	Graham WWTP	0.7	001	6,035	4,046	5,269	5,386	4,524	6,495	6,949	6,951	5,051	4,319	2,946	2,694	2,354	6,803
HAW	NC0021474	City of Mebane	Mebane WWTP	0.6	001	5,342	4,023	3,572	3,682	3,971	4,811	4,424	4,054	3,226	3,665	4,280	3,031	4,765	4,362
HAW	NC0020354	Town of Pittsboro	Pittsboro WWTP	0.8	001	1,168	1,319	1,217	1,197	840	890	964	588	539	530	344	323	791	548
HAW	NC0066966	Quarterstone Farm HOA	Quarterstone Farm WWTP	0.4	001	44	28	47	234	123	232	232	201	295	557	329	180	217	220
			Yearly Totals			148,809	113,316	123,287	104,956	88,791	135,503	155,510	150,455	124,178	150,048	114,771	120,875	147,038	105,839

Total Phosphorus

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
UNH Cap	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919	32,919
LNH Cap	566	566	566	566	566	566	566	566	566	566	566	566	566	566
Haw Cap	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056	194,056
UNH Load	32,766	20,398	18,341	21,824	14,829	23,823	22,811	25,515	18,505	18,244	20,424	17,331	16,096	22,245
LNH Load	805	208	218	177	253	345	461	445	741	663	592	1,566	521	281
Haw Load	115,238	92,710	104,728	82,955	73,709	111,334	132,239	124,496	104,932	131,141	93,755	101,978	130,422	83,314

Chapter 7 Deep River

2016 Rocky River D.O. Assessment Study FINAL – See report attached at the end of this Appendix.

NC Division of Water Resources

Water Sciences Section

February 20, 2017

MEMORANDUM

To: Nora Deamer

From: Joseph Smith
Katharine DeVilbiss

Subject: Rocky River Monitoring Study 2016
Chatham County
HUC 030300030503

Summary

The following report contains the results of a recent study conducted by the Intensive Survey Branch (ISB) assess the impact of Charles Turner Reservoir and Hackney Dam on dissolved Oxygen (D.O.) levels along a 6.7-mile stretch in the Rocky River system May to July, 2016. This stretch is currently impaired due to low D.O. readings at a gauging station located on US 64, downstream of the Hackney dam. Physical and chemical parameters were collected from eight sites in the area of study. During the study period (July 8th, 2016), a pulse of 20 cubic feet per second (cfs) was released by the town of Siler City and ISB staff were able to capture in situ physical parameters downstream of Charles Turner Reservoir (CPFRR01) and in the headwaters of the reservoir upstream of Hackney Dam (CPFRR03).

Chapter 8 Upper Cape Fear River

Chapter 9 Lower Cape Fear River

Lower Cape Fear River subbasin (03030005) five-year mean water quality graphs for DWR AMS and MCFBA and LCFRP coalition station physical and chemical parameters.

Figure 1: Harrison Creek and Turnbull Creek Cape Fear River Mainstem Stations.

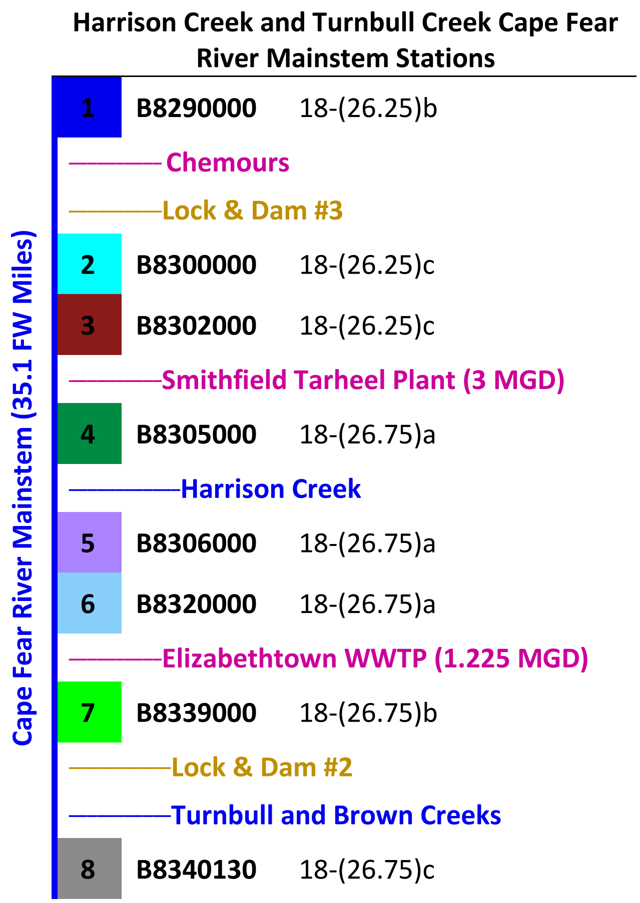

Figure 2: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Turbidity

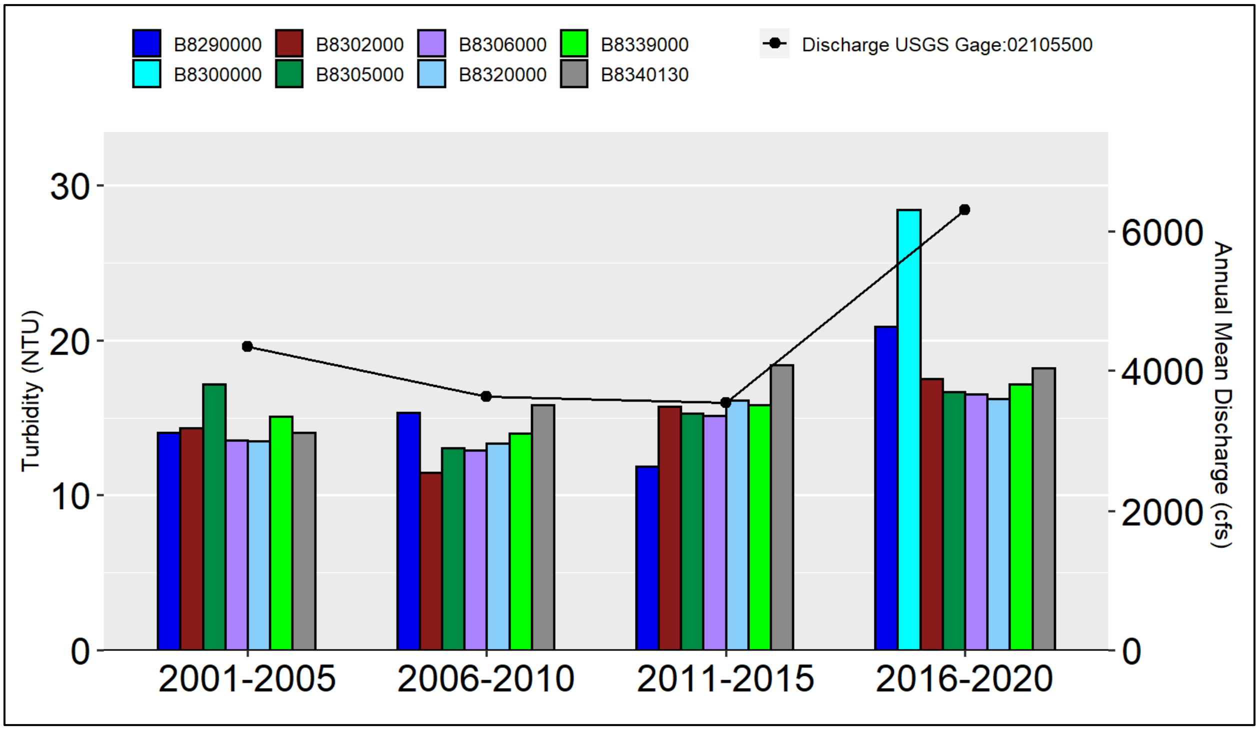

Figure 3: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Specific Conductance

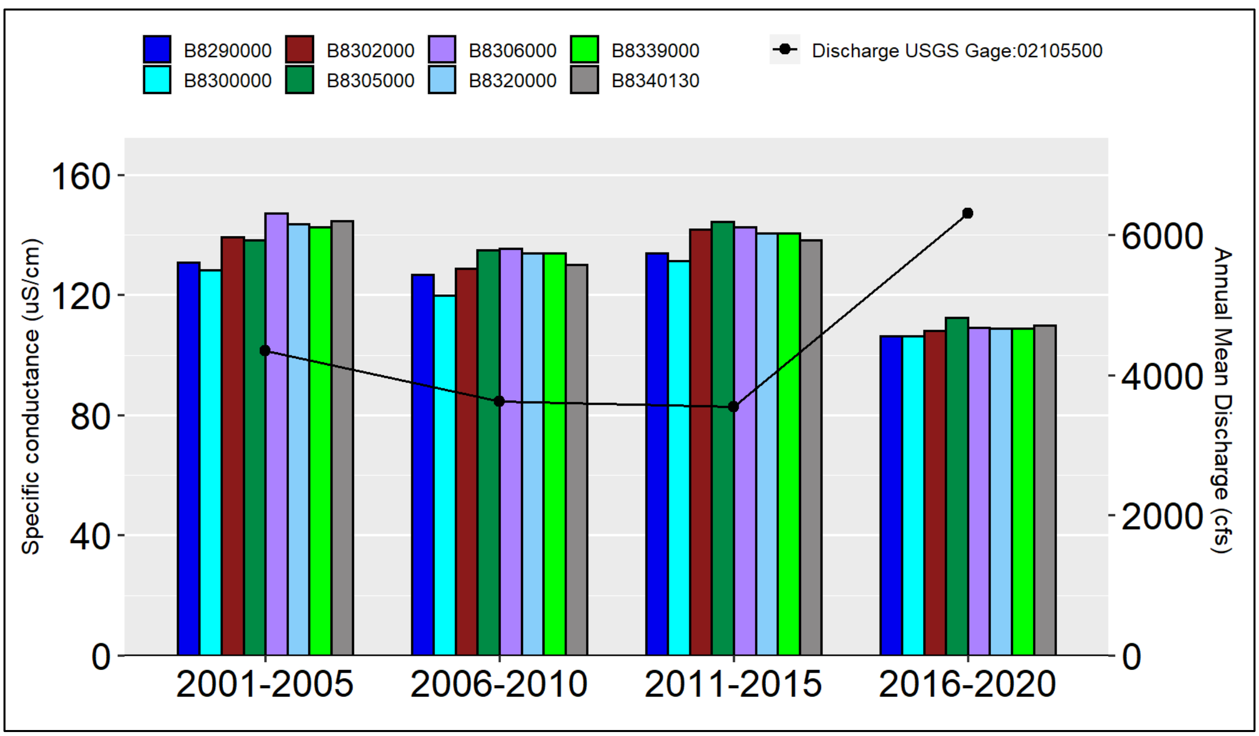

Figure 4: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean pH

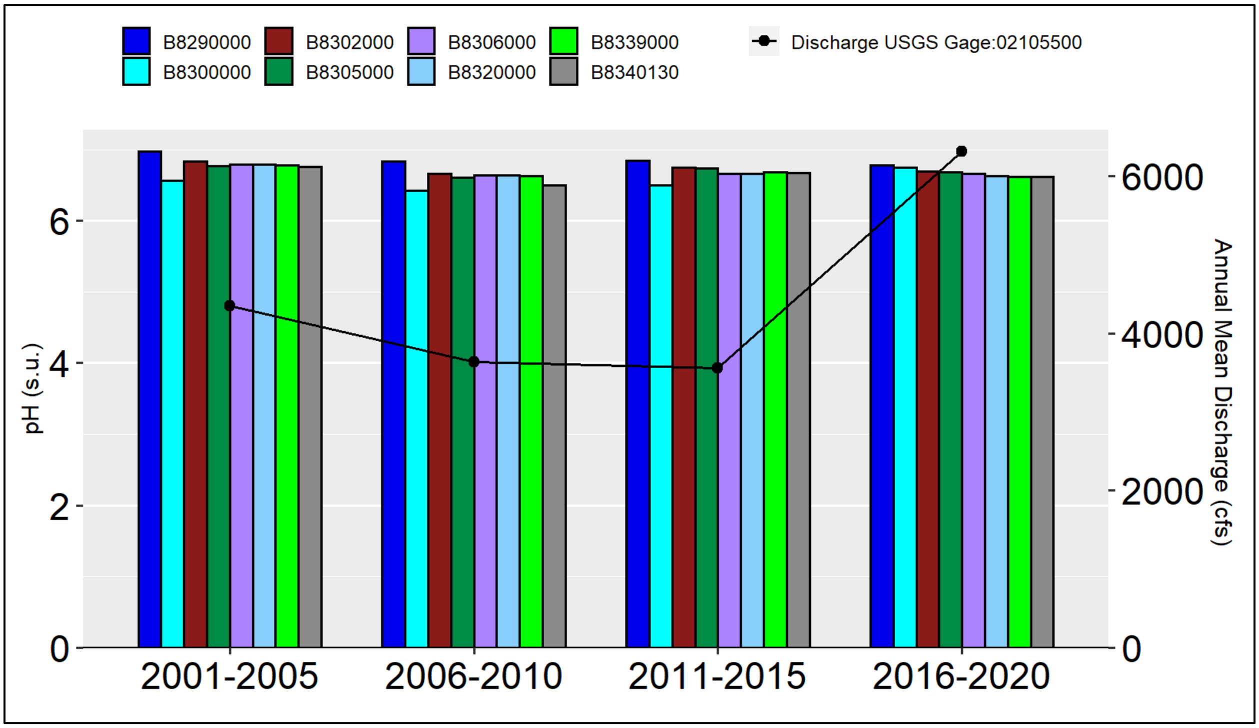

Figure 5: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean DO

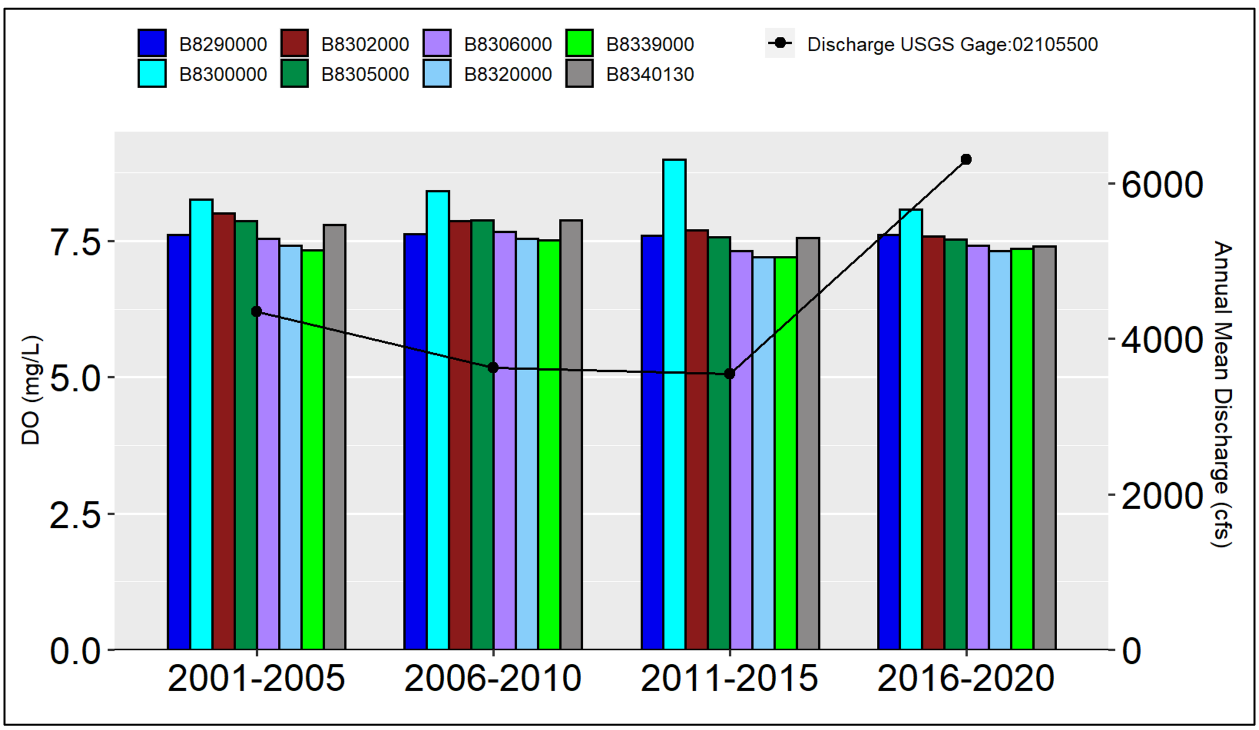

Figure 6: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Fecal Coliform

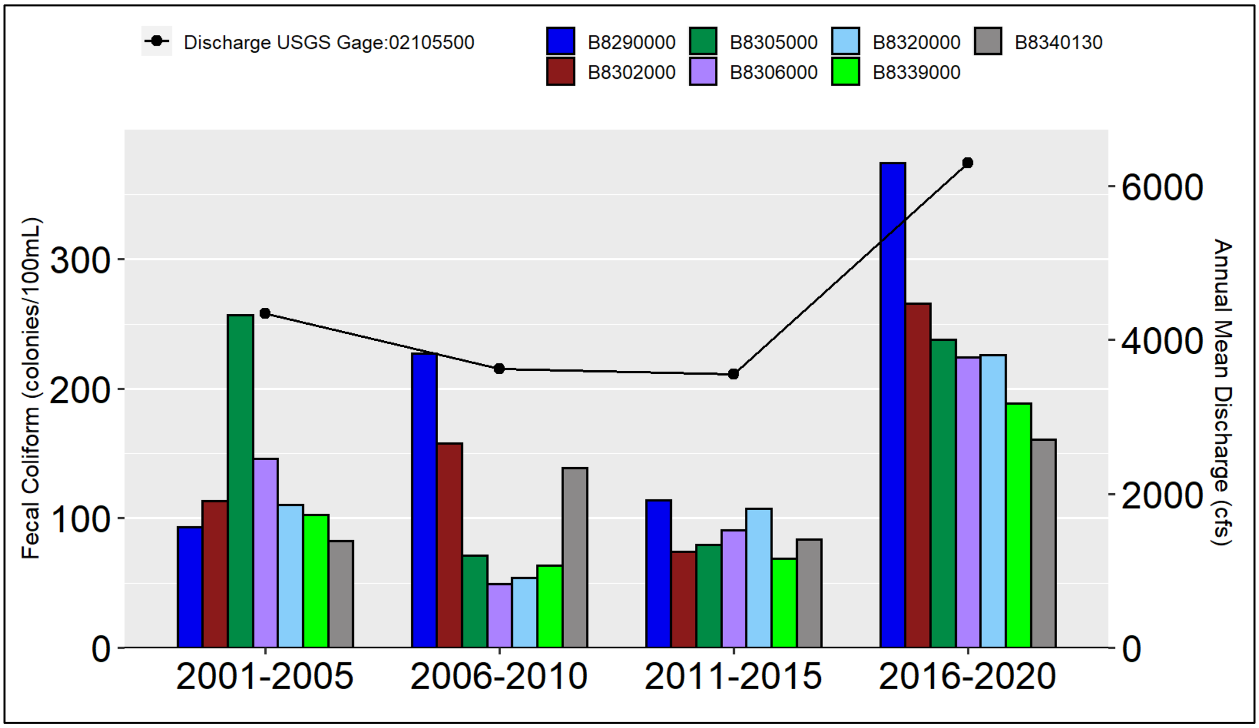

Figure 7: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Total Nitrogen

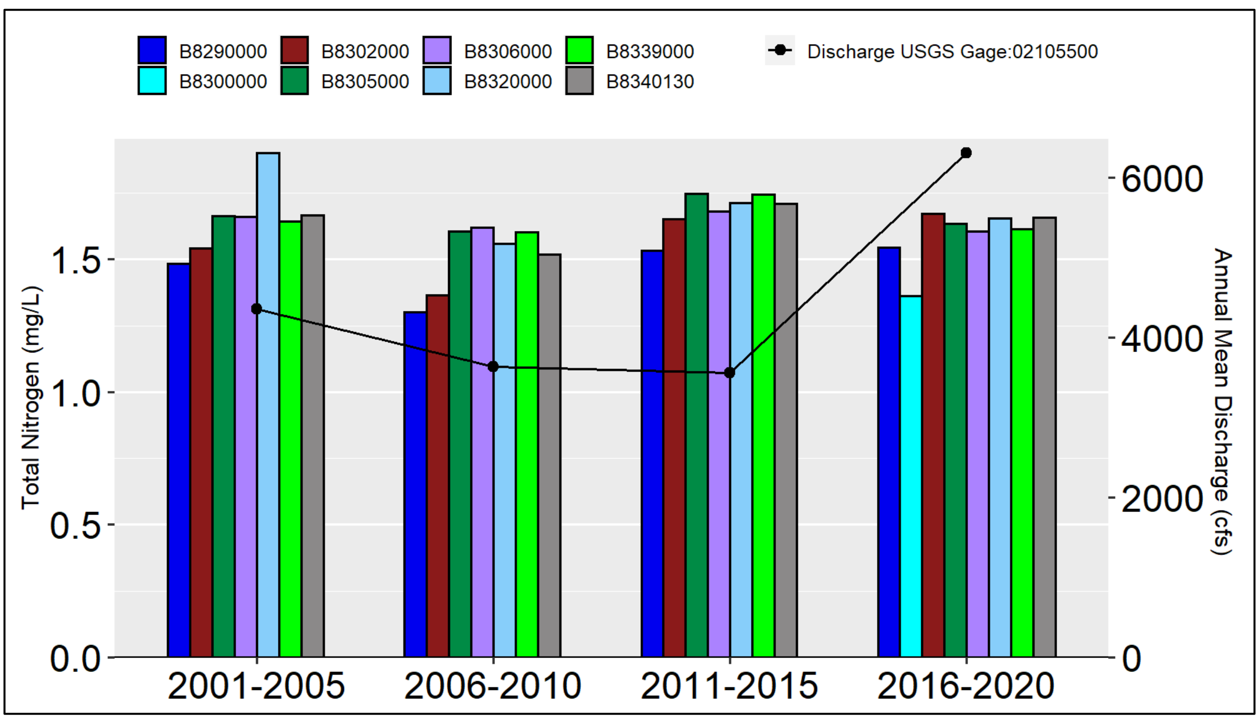

Figure 8: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean TKN

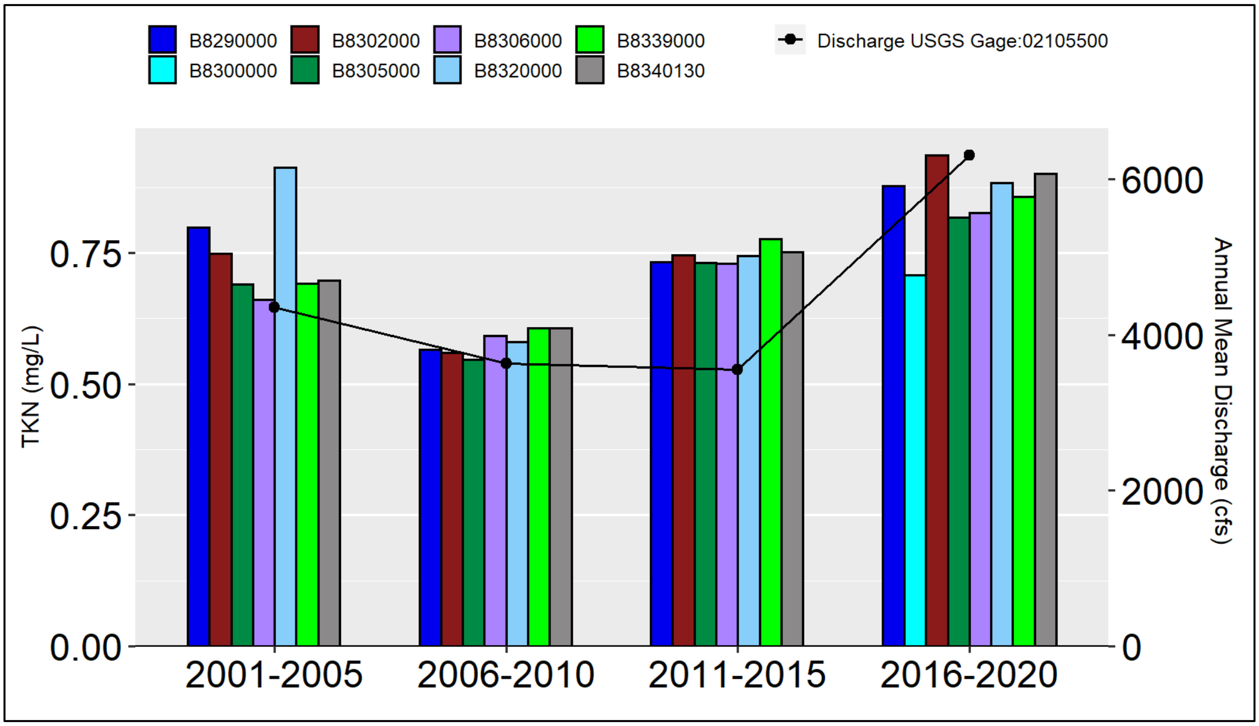

Figure 9: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean NOx

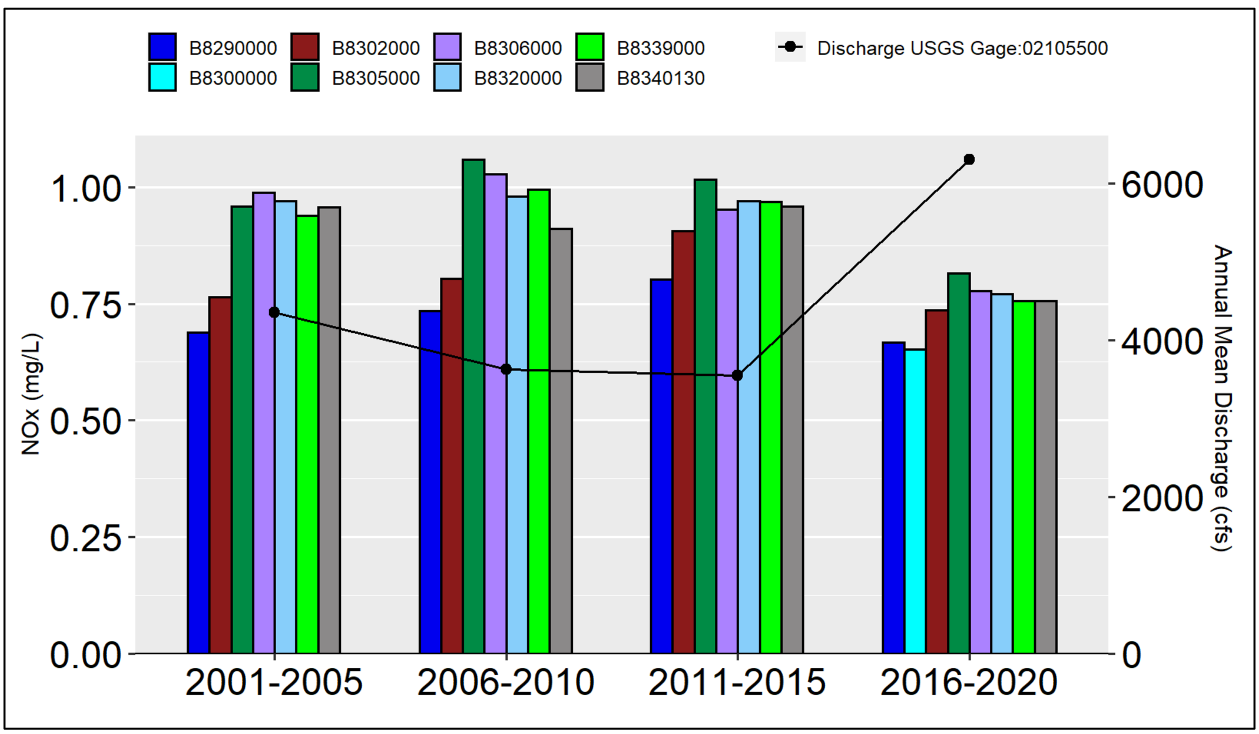

Figure 10: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Ammonia

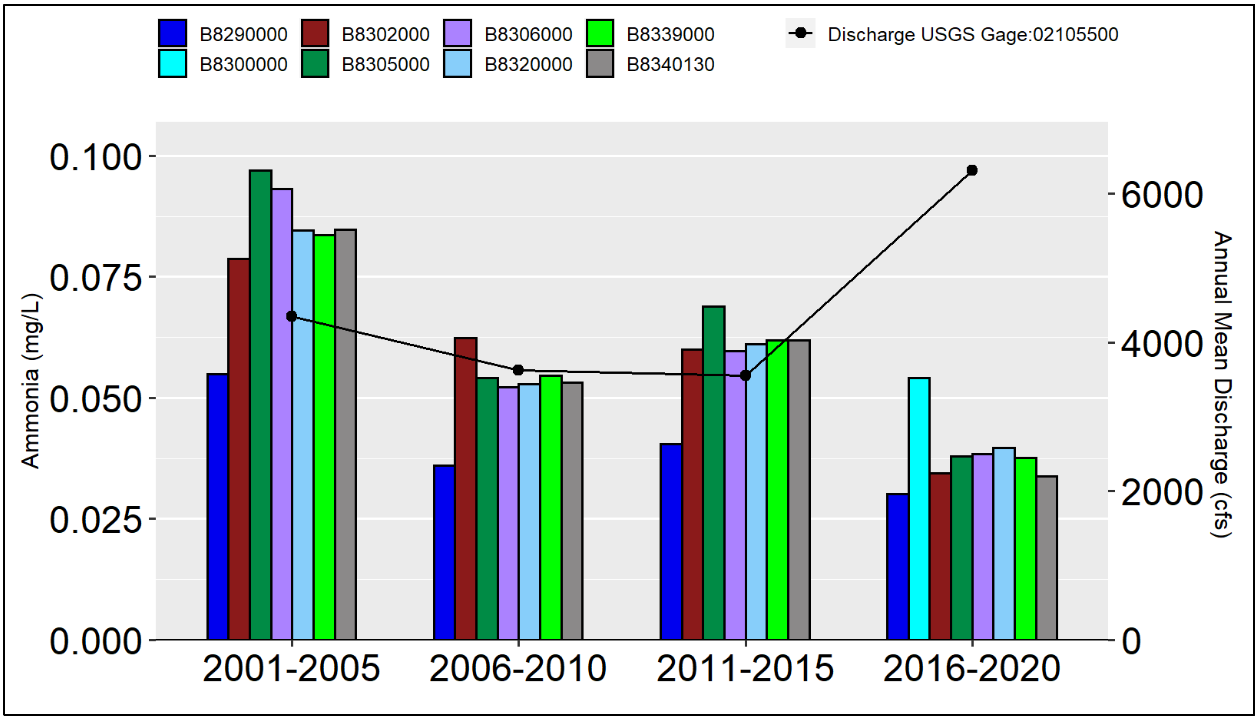

Figure 11: Harrison and Turnbull Creeks Lower Cape Fear Mainstem Stations Five-Year Mean Phosphorus

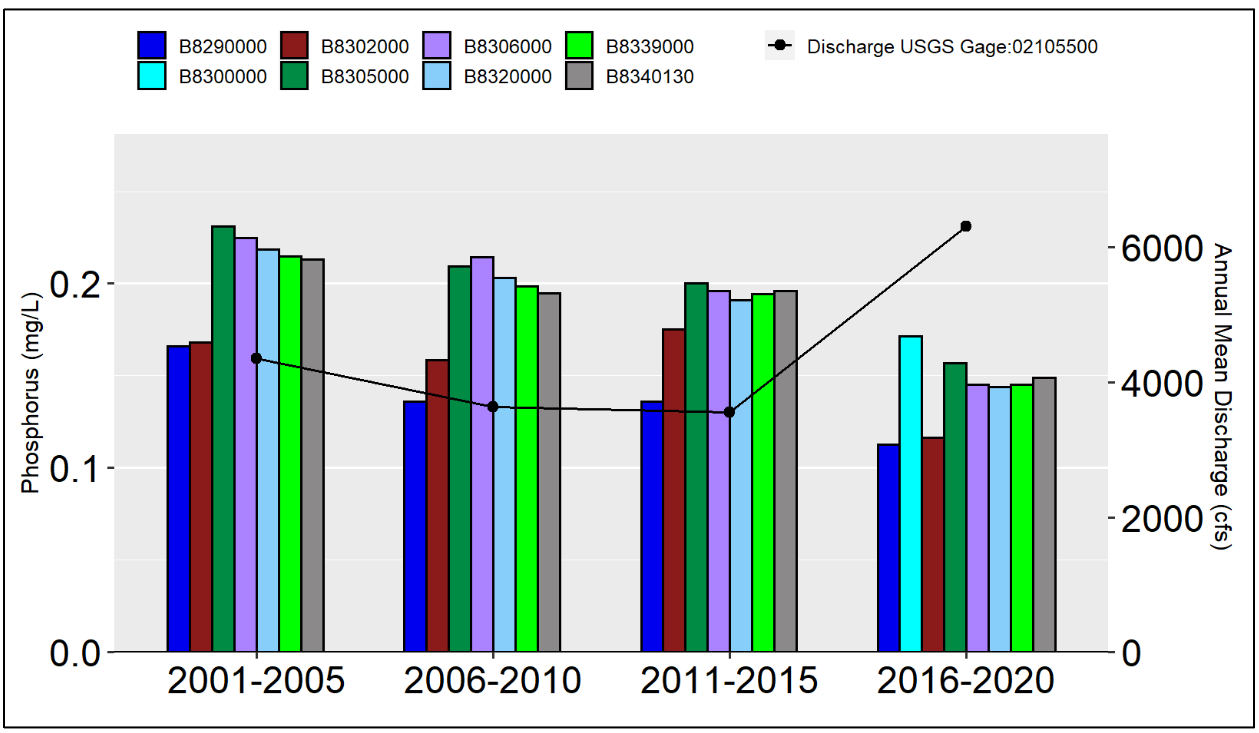

Figure 12: Hood Creek – Cape Fear River Mainstem Stations

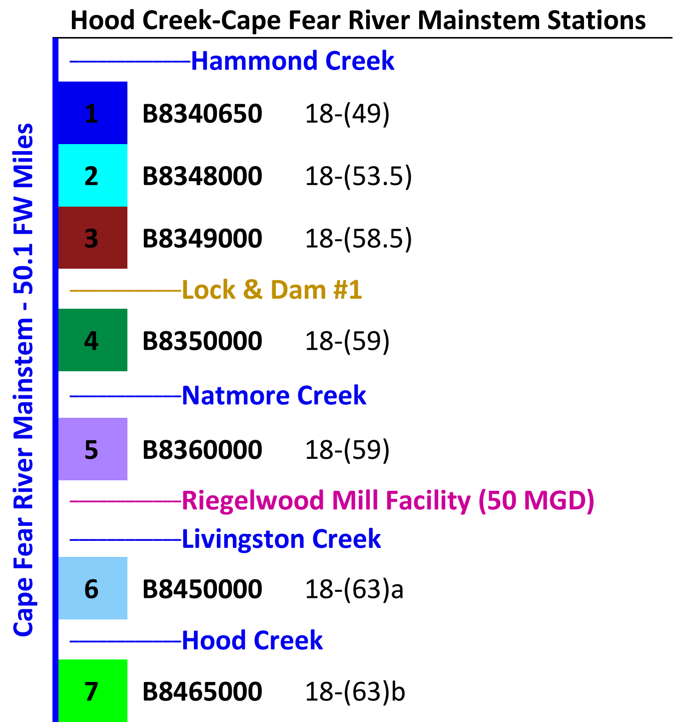

Figure 13: Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Turbidity

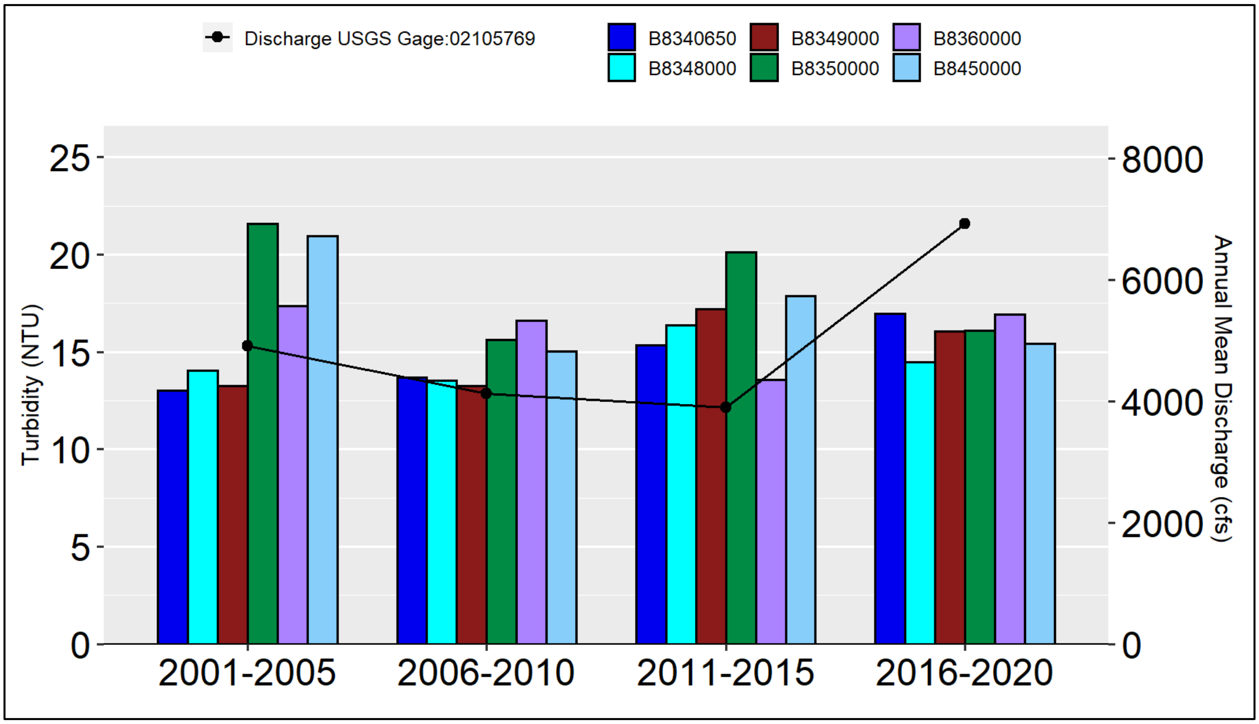

Figure 14: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Specific Conductance

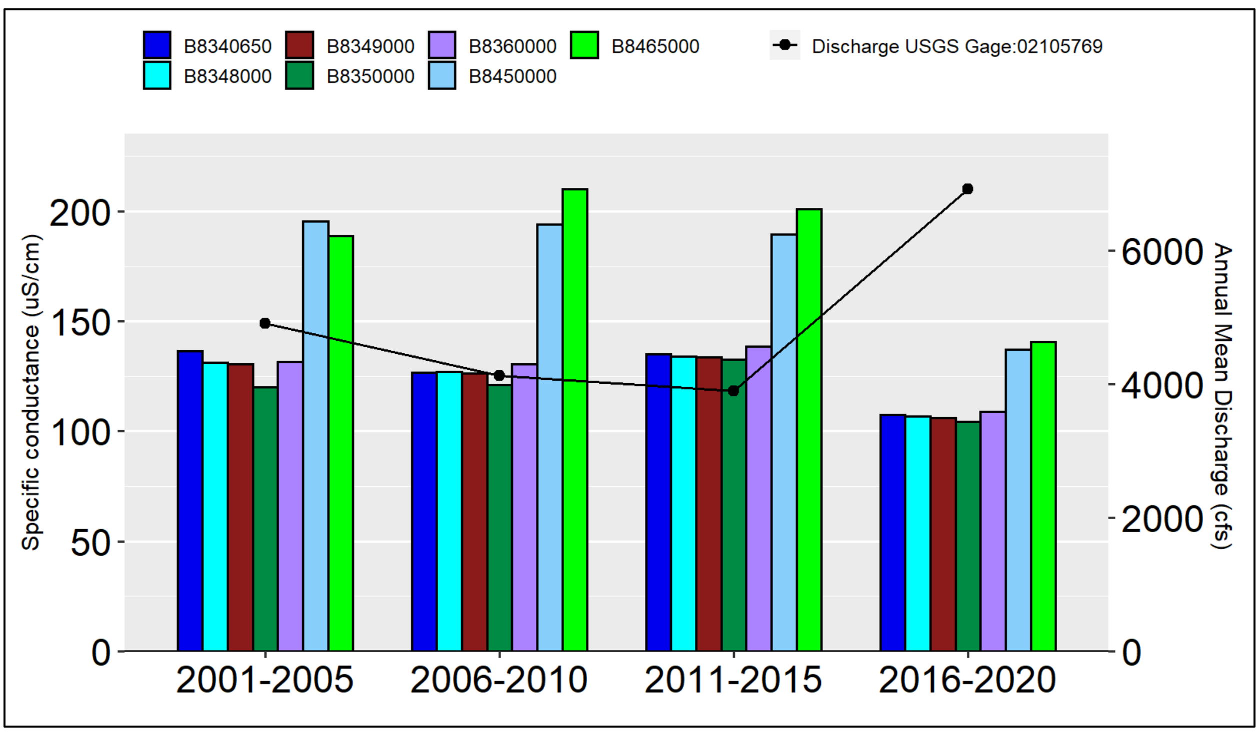

Figure 15: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean pH

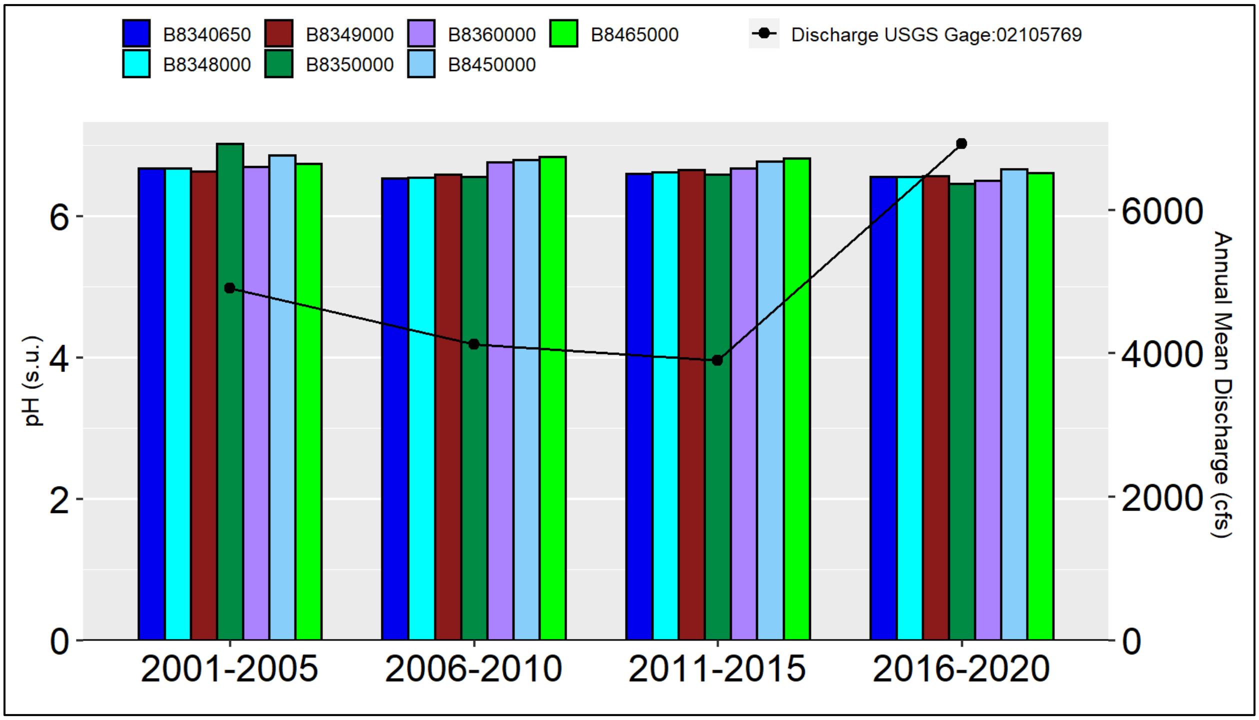

Figure 16: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean DO

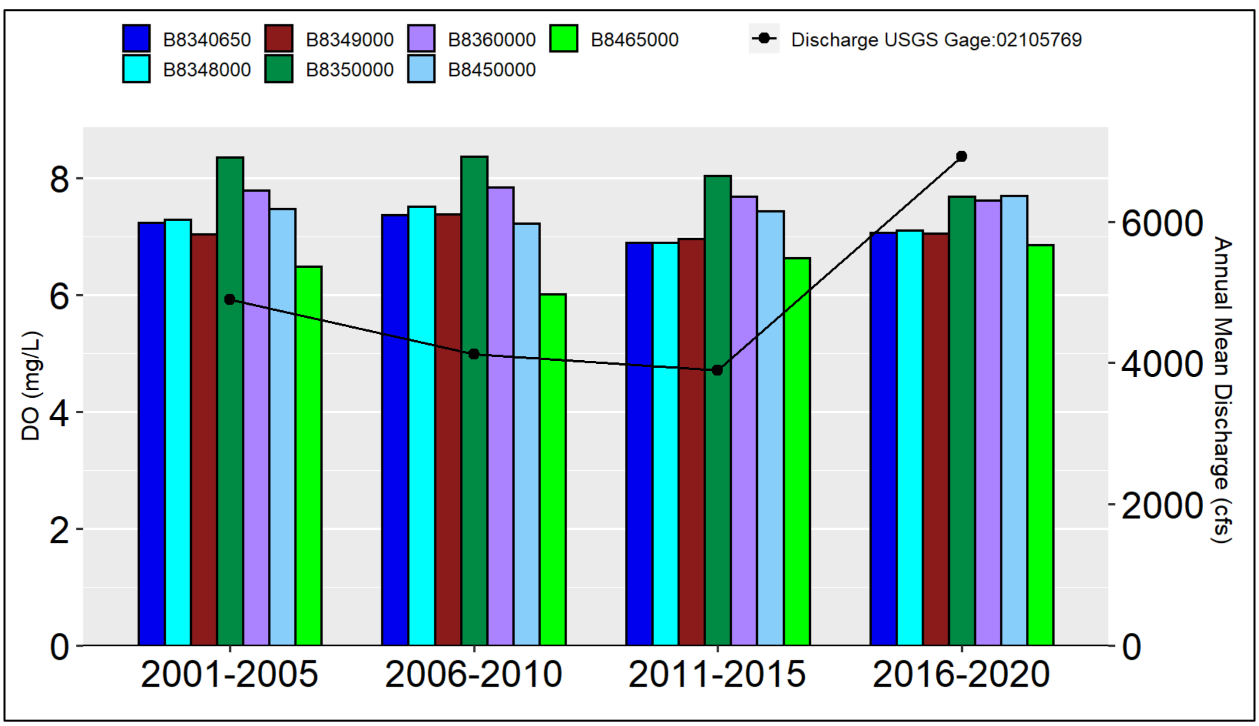

Figure 17: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Fecal Coliform

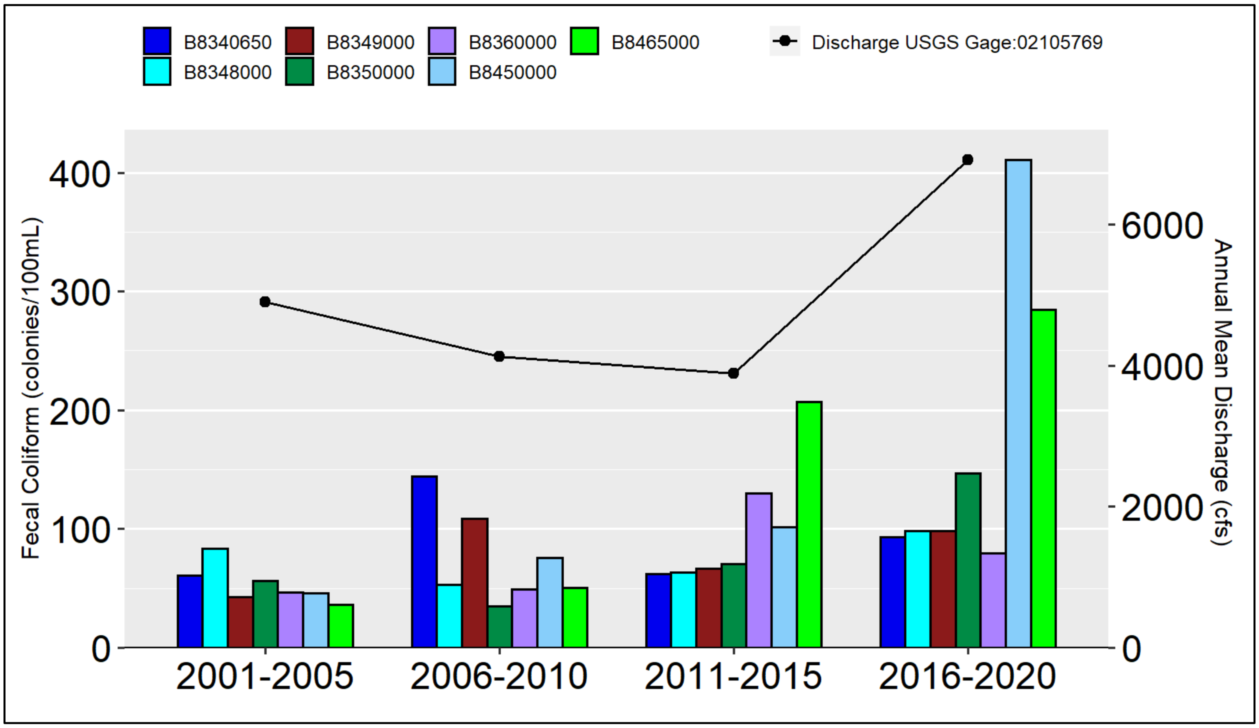

Figure 18: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Total Nitrogen

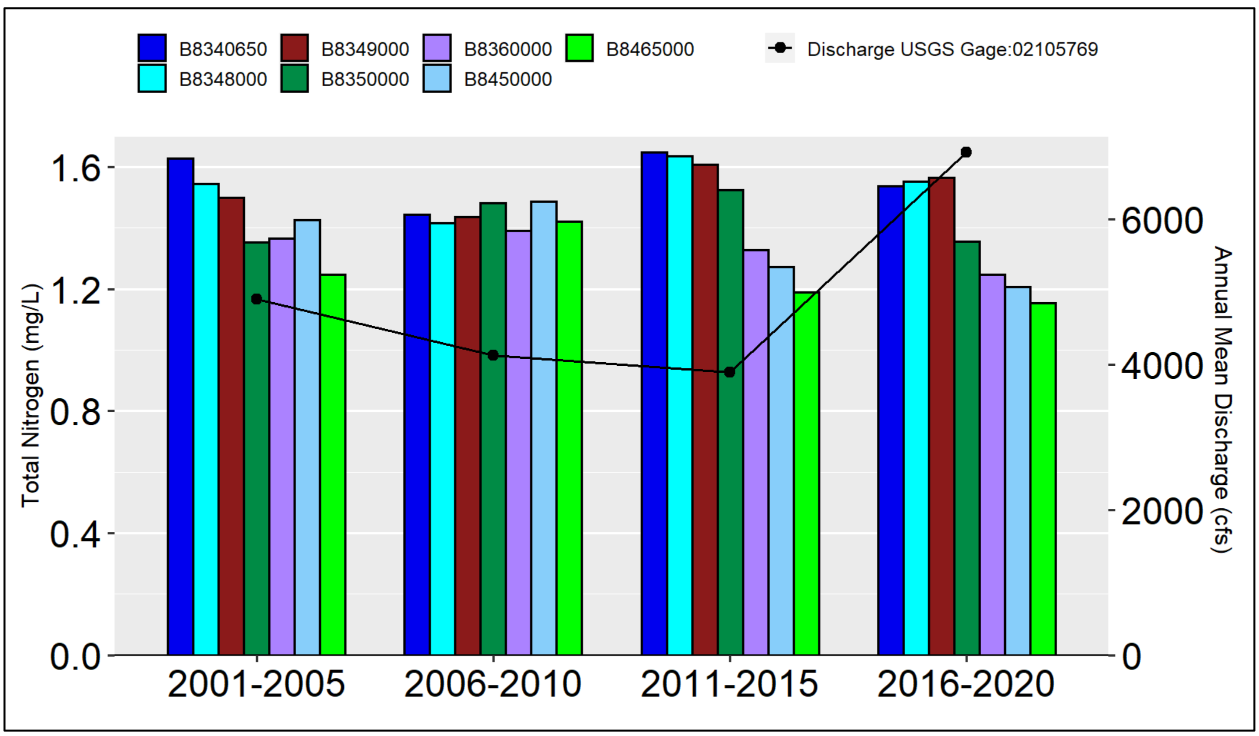

Figure 19: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean TKN

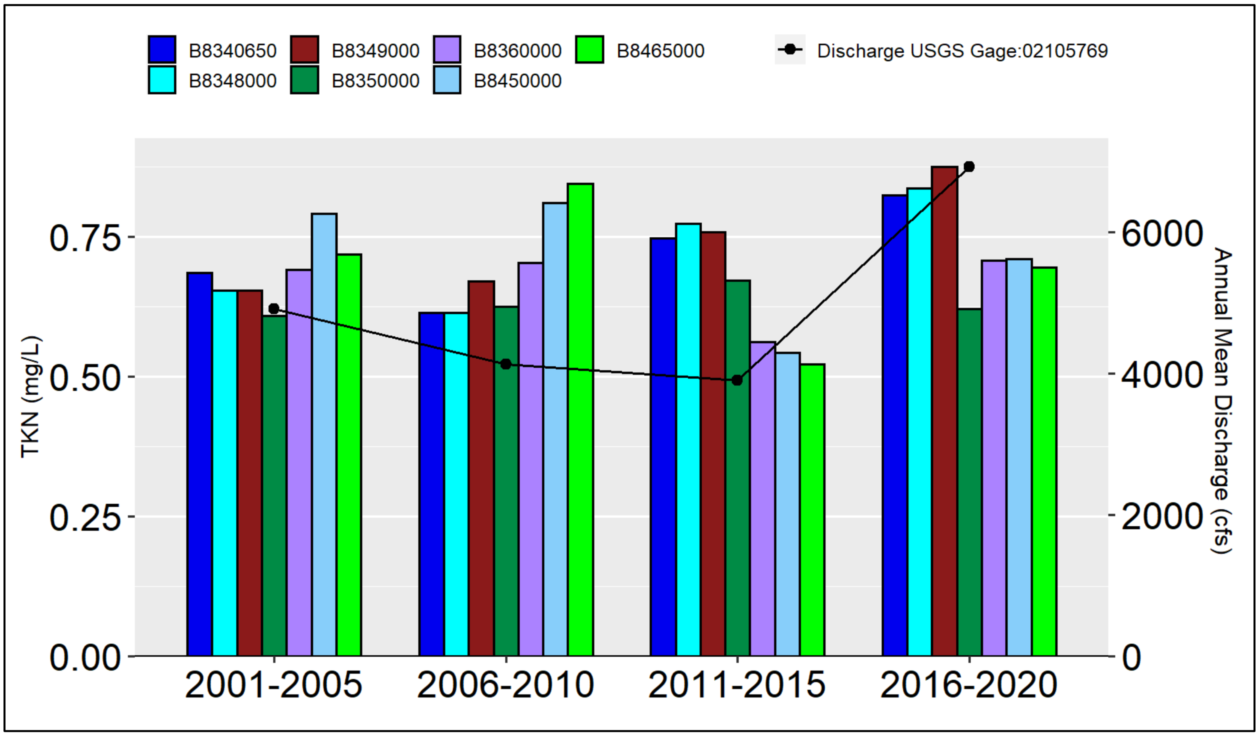

Figure 20: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean NOx

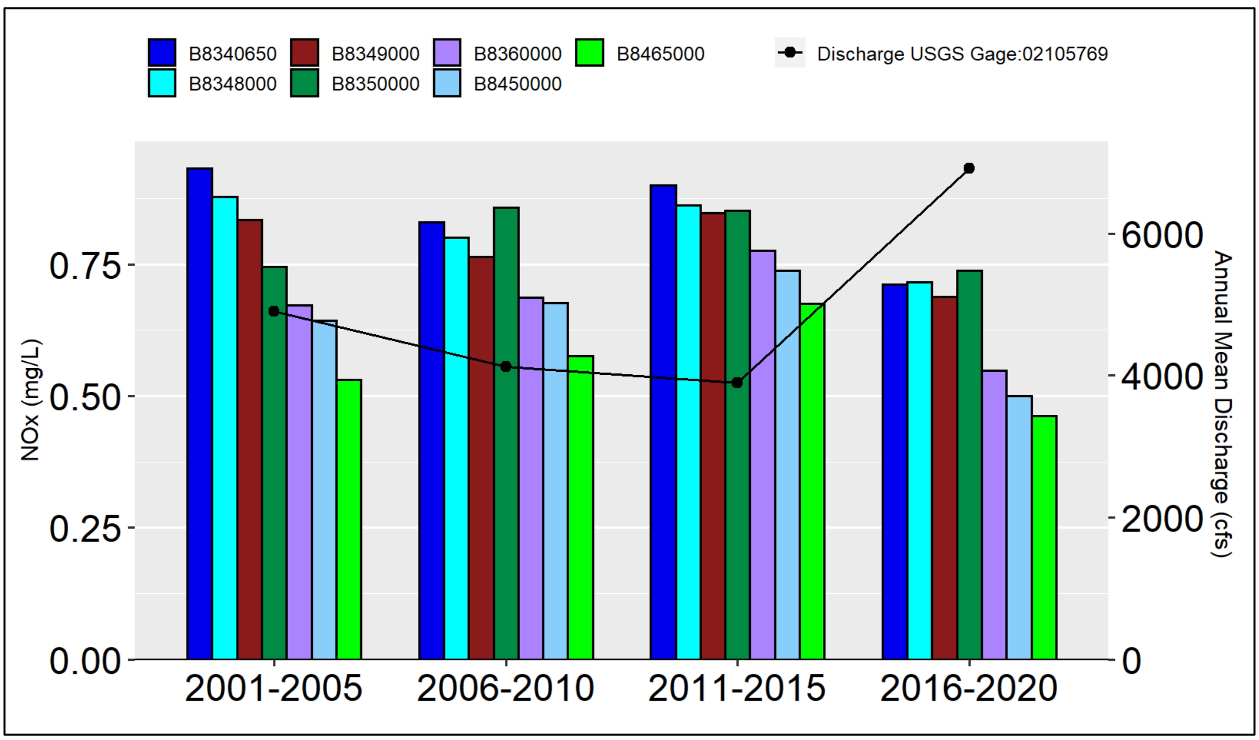

Figure 21: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Ammonia

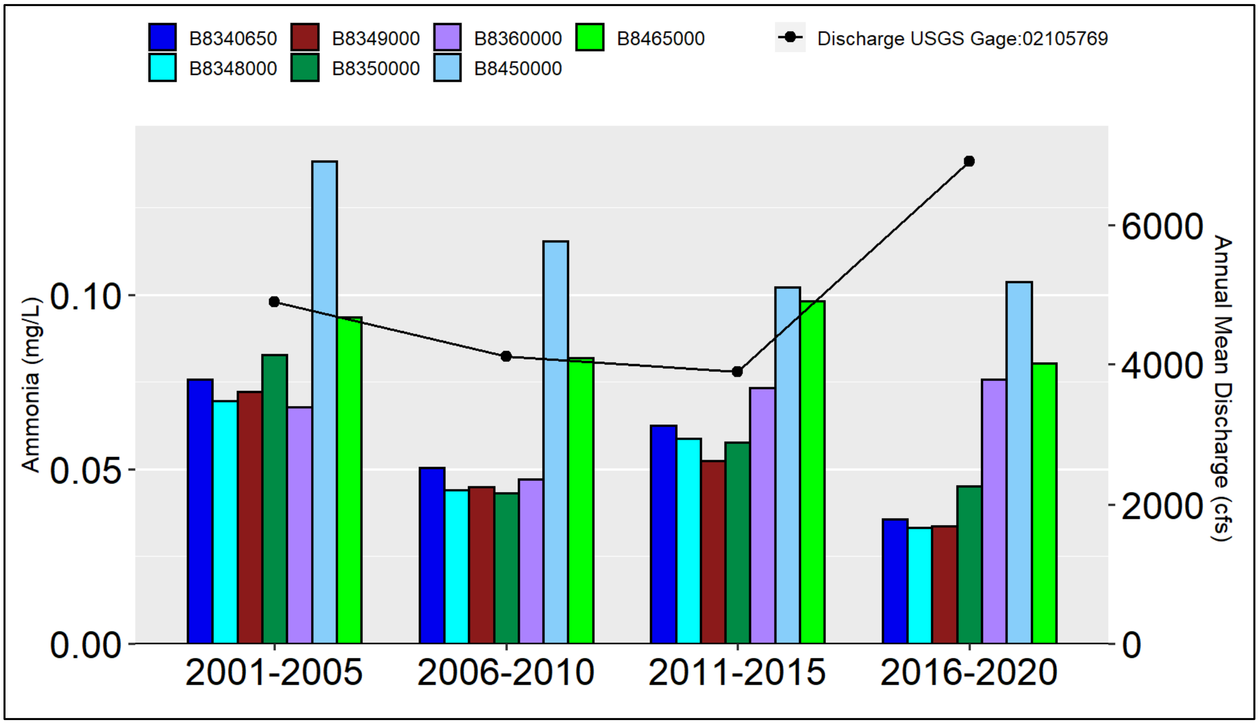

Figure 22: : Hood Creek Lower Cape Fear Mainstem Stations Five-Year Mean Phosphorus

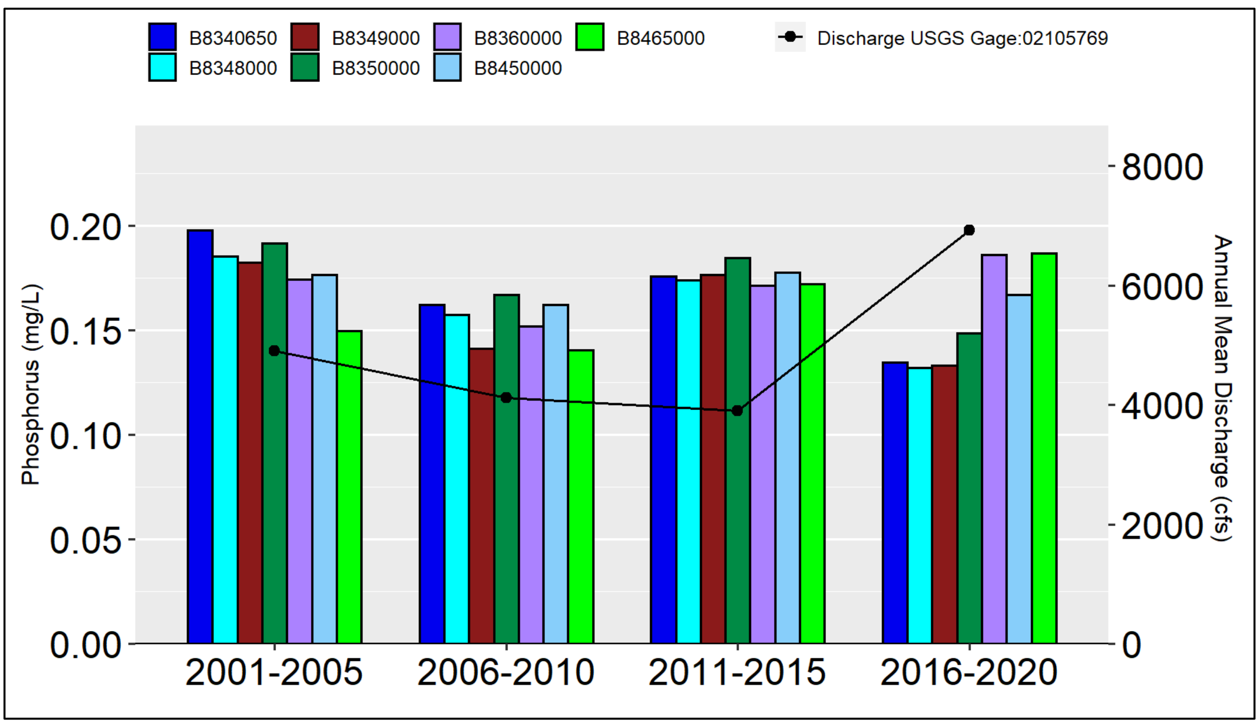

Figure 23: Brunswick River-Cape Fear River Mainstem Stations

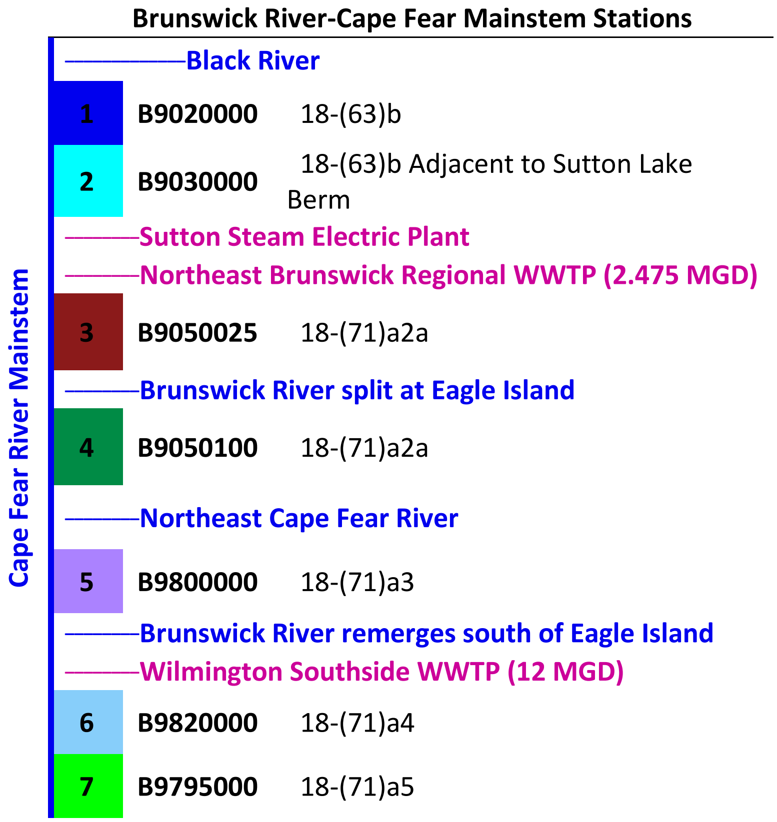

Figure 24: Brunswick River Mainstem Stations Five-Year Mean Turbidity

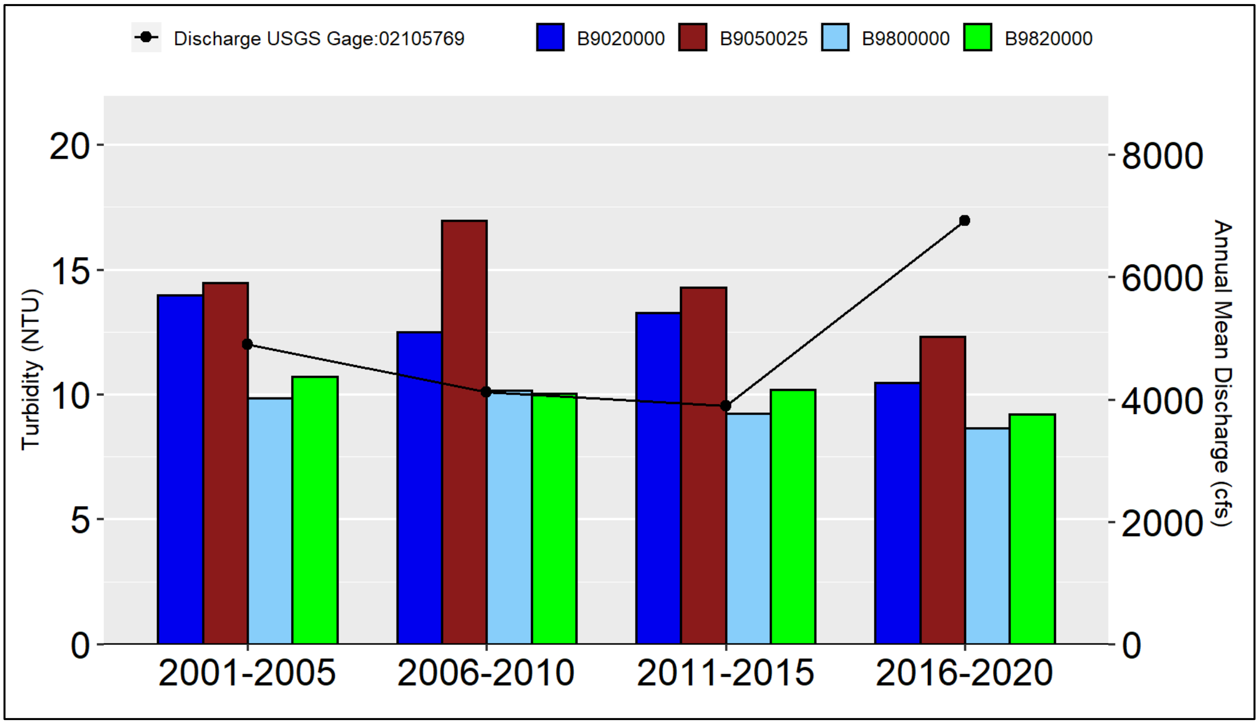

Figure 25: Brunswick River Mainstem Stations Five-Year Mean Specific Conductance

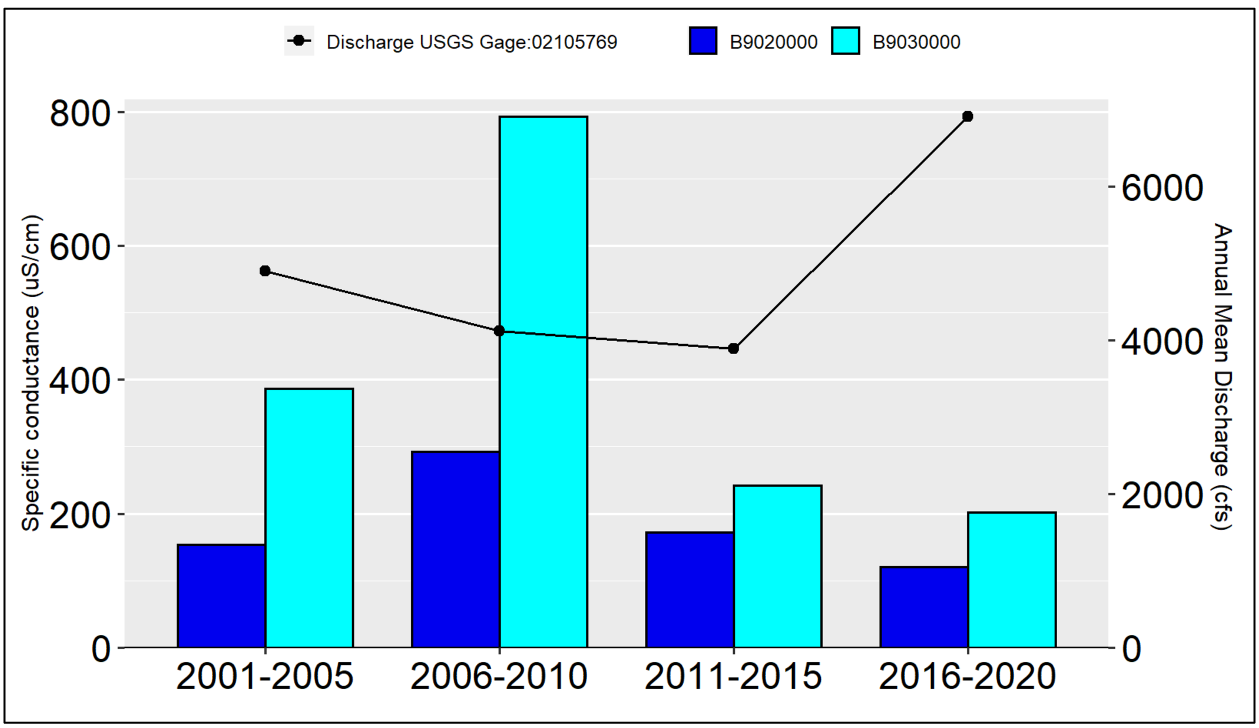

Figure 26: Brunswick River Mainstem Stations Five-Year Mean pH

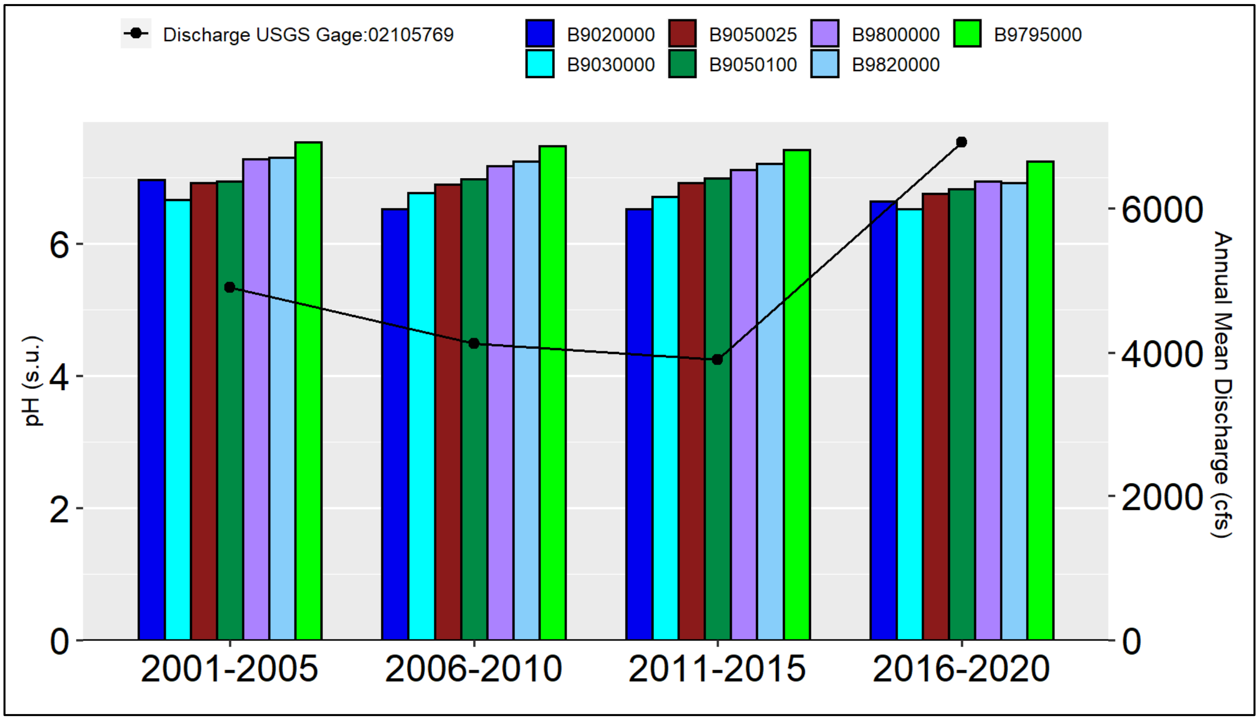

Figure 27: Brunswick River Mainstem Stations Five-Year Mean DO

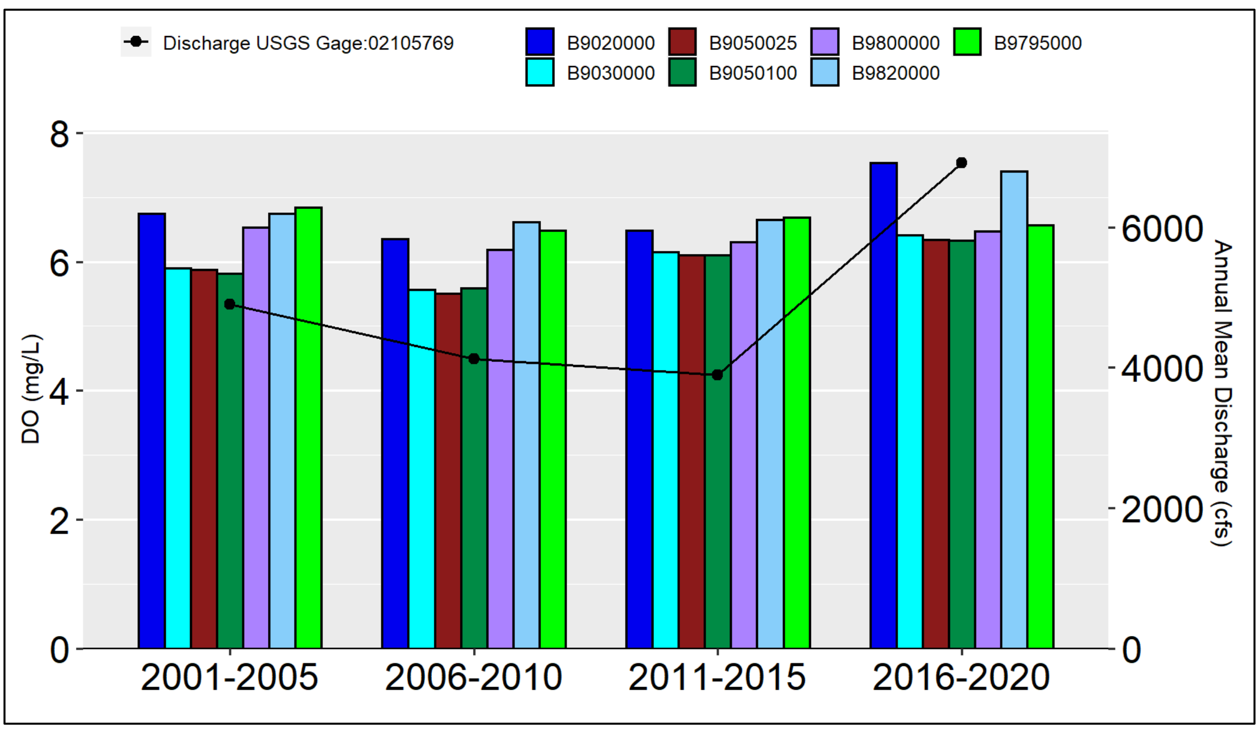

Figure 28: Brunswick River Mainstem Stations Five-Year Mean Fecal Coliform

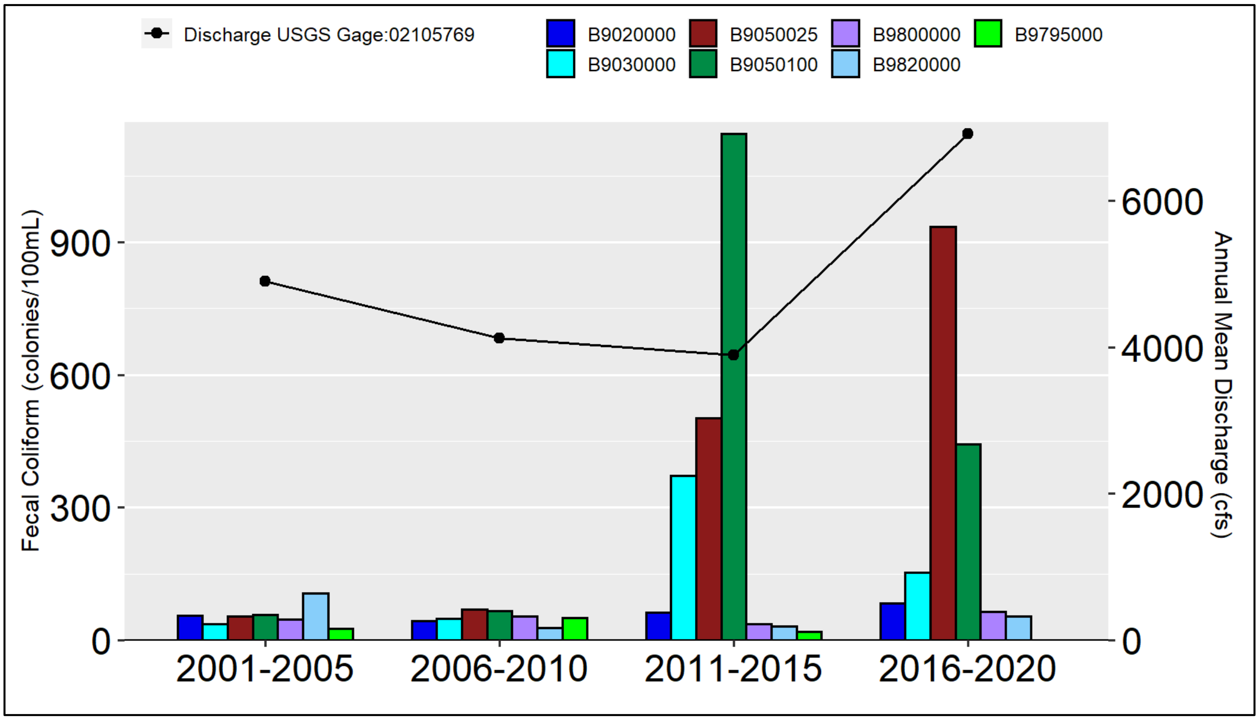

Figure 29: Brunswick River Mainstem Stations Five-Year Mean Total Nitrogen

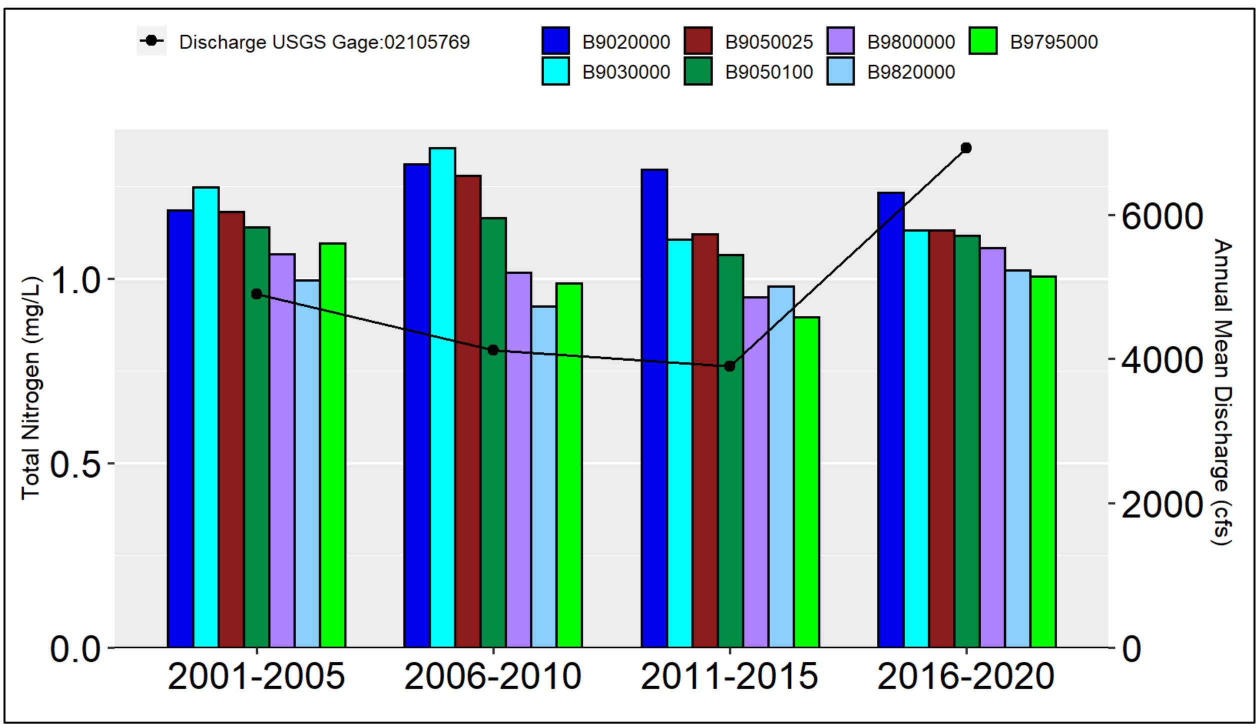

Figure 30: Brunswick River Mainstem Stations Five-Year Mean TKN

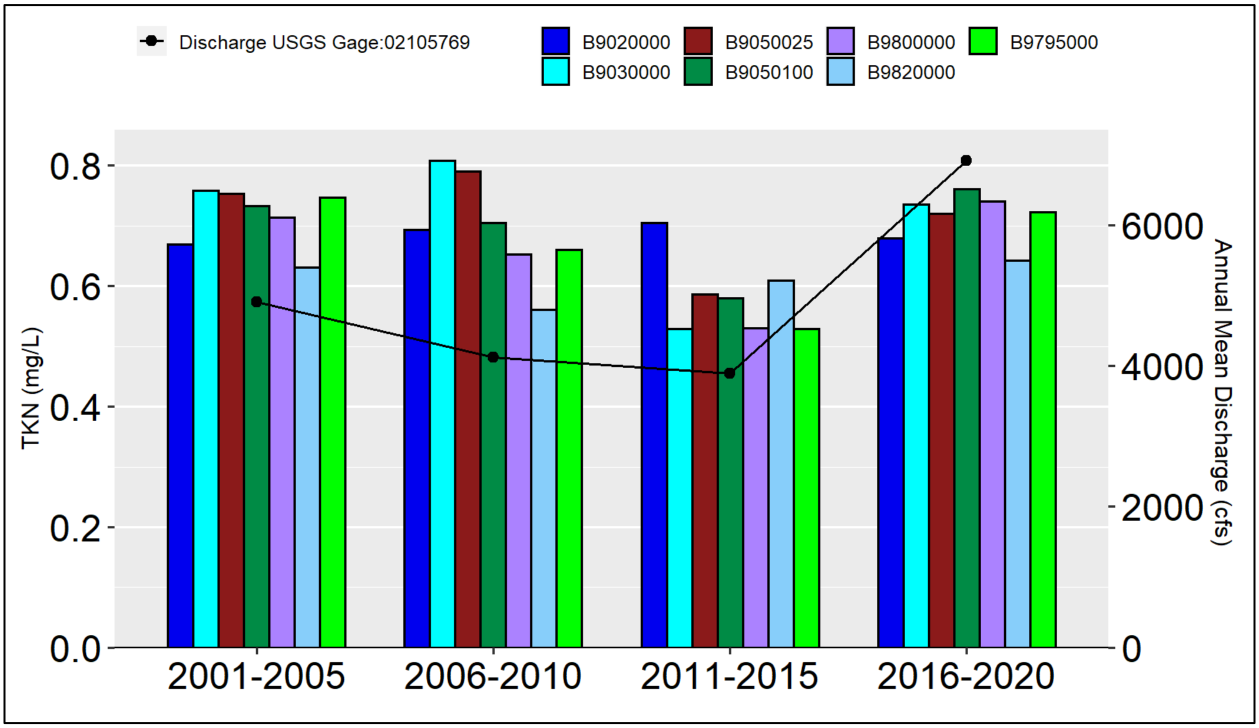

Figure 31: Brunswick River Mainstem Stations Five-Year Mean NOx

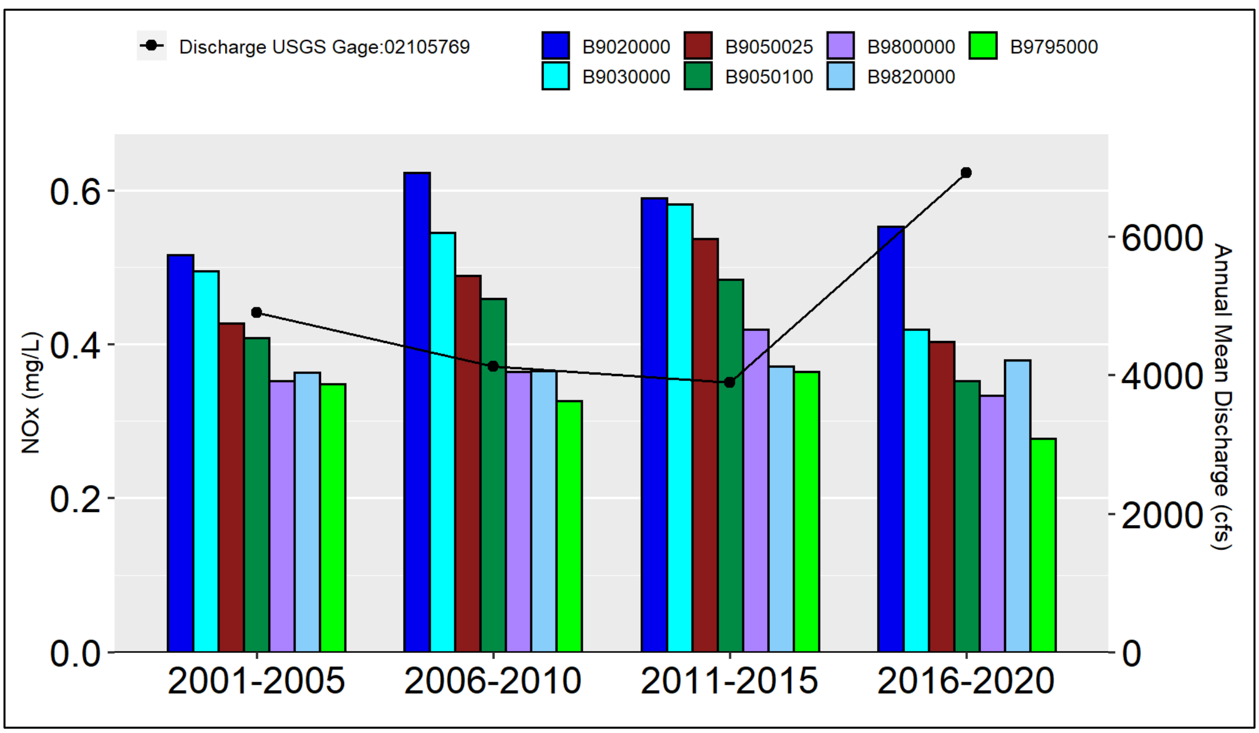

Figure 32: Brunswick River Mainstem Stations Five-Year Mean Ammonia

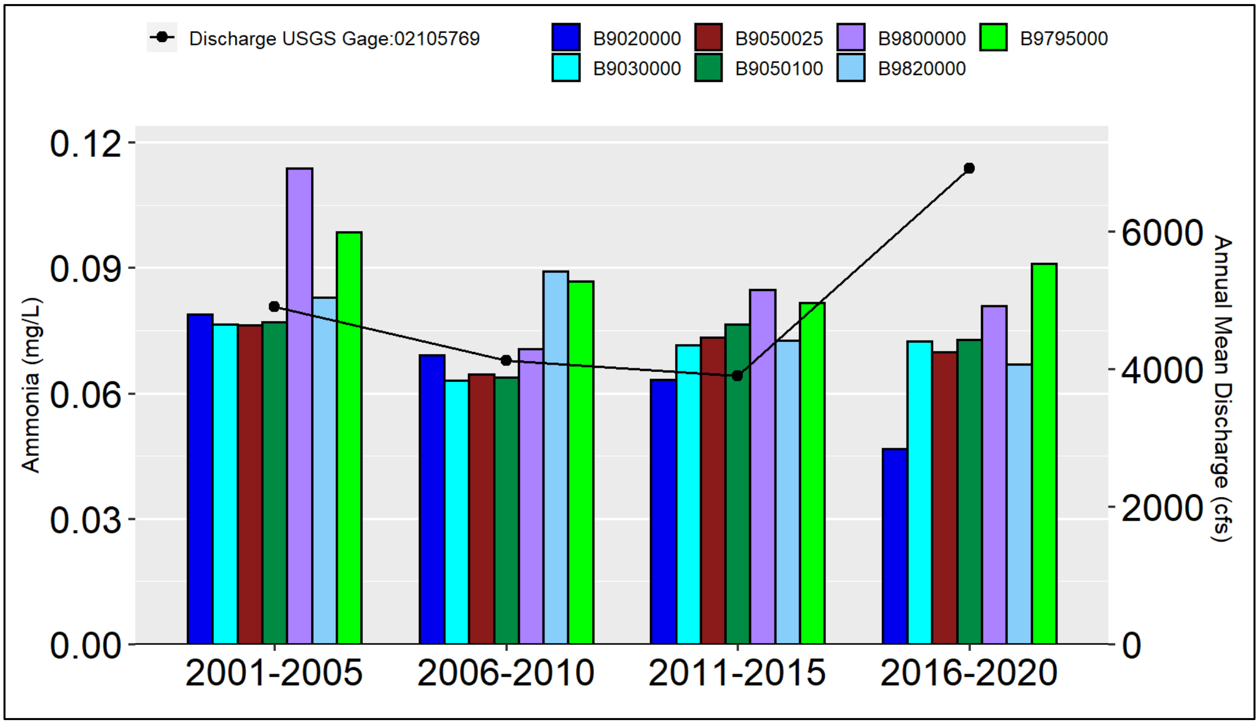

Figure 33: Brunswick River Mainstem Stations Five-Year Mean Phosphorus

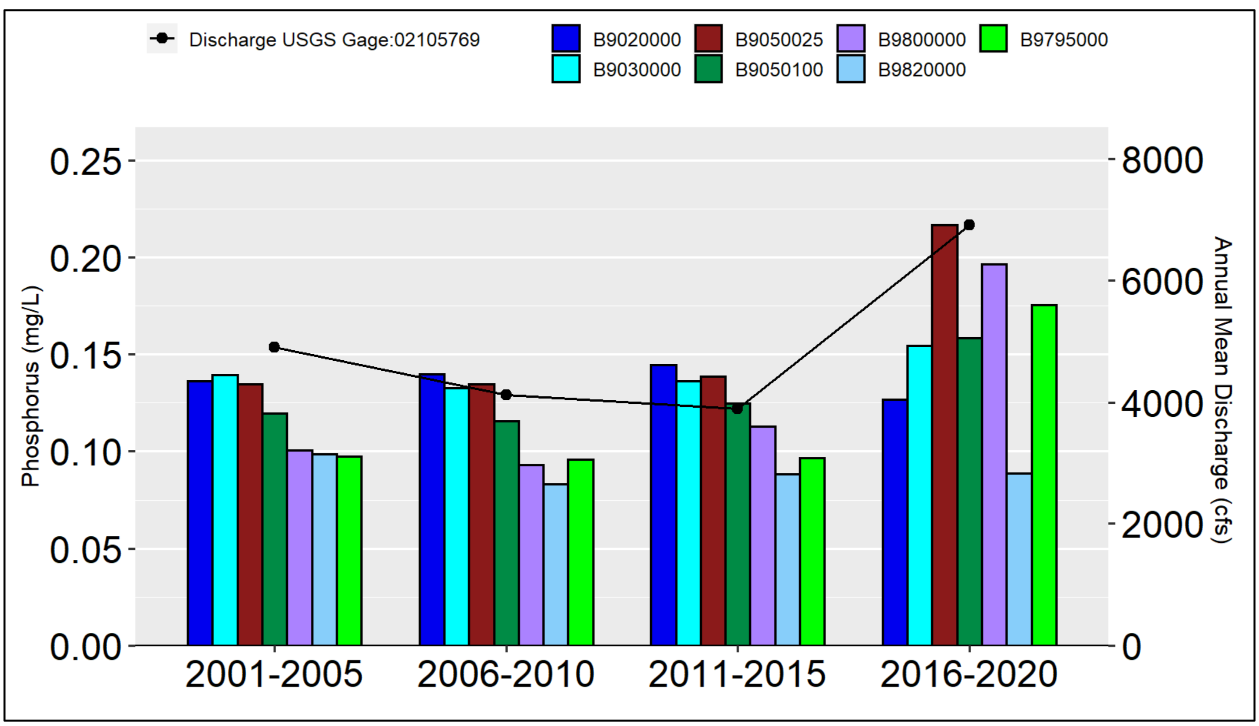

Figure 34: Lower Cape Fear River Estuary Mainstem Stations

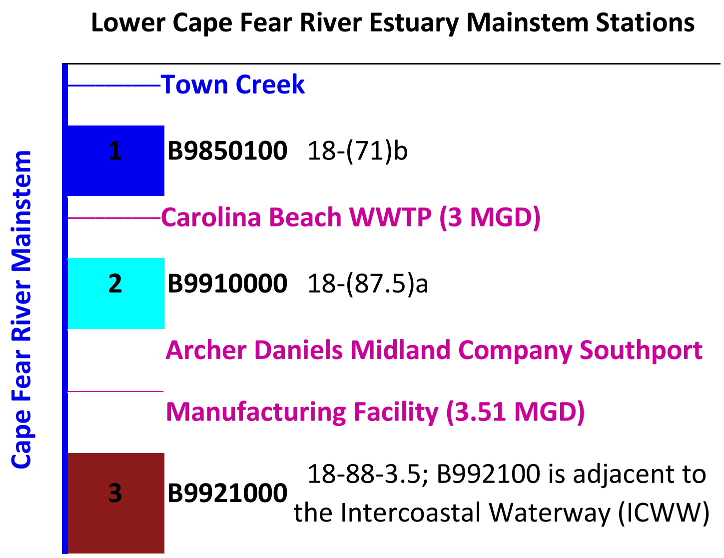

Figure 35: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean Turbidity

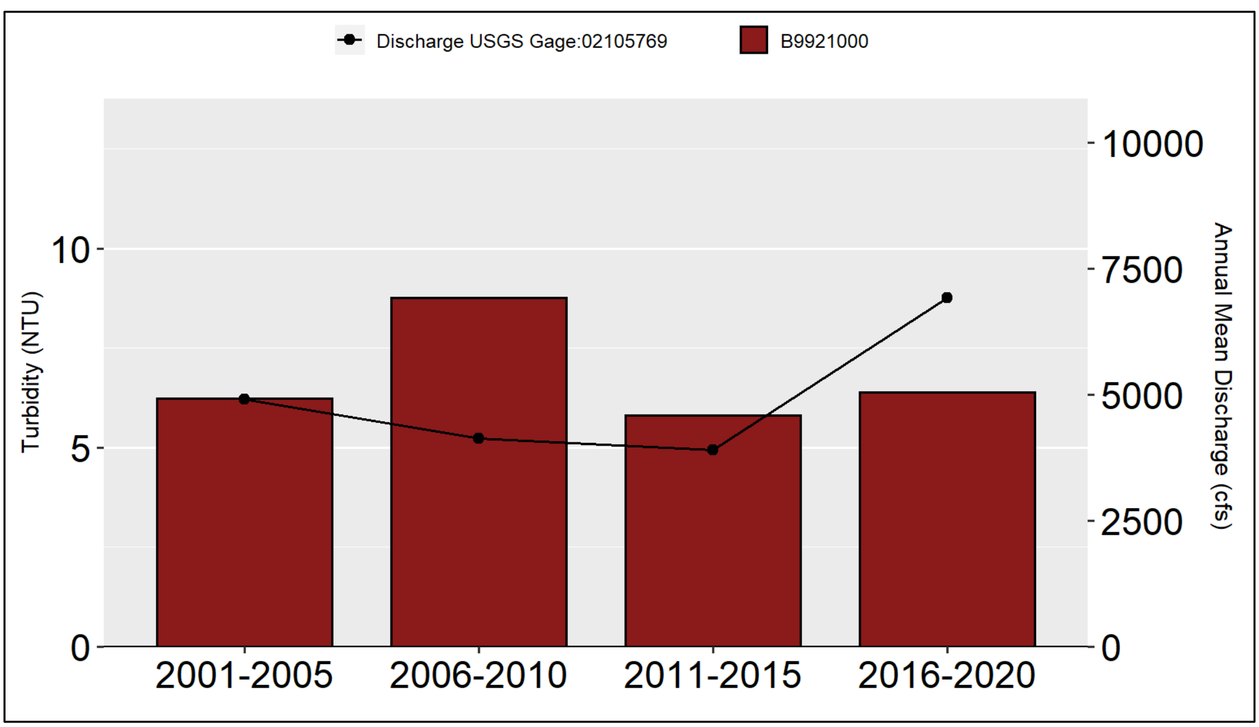

Figure 36: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean pH

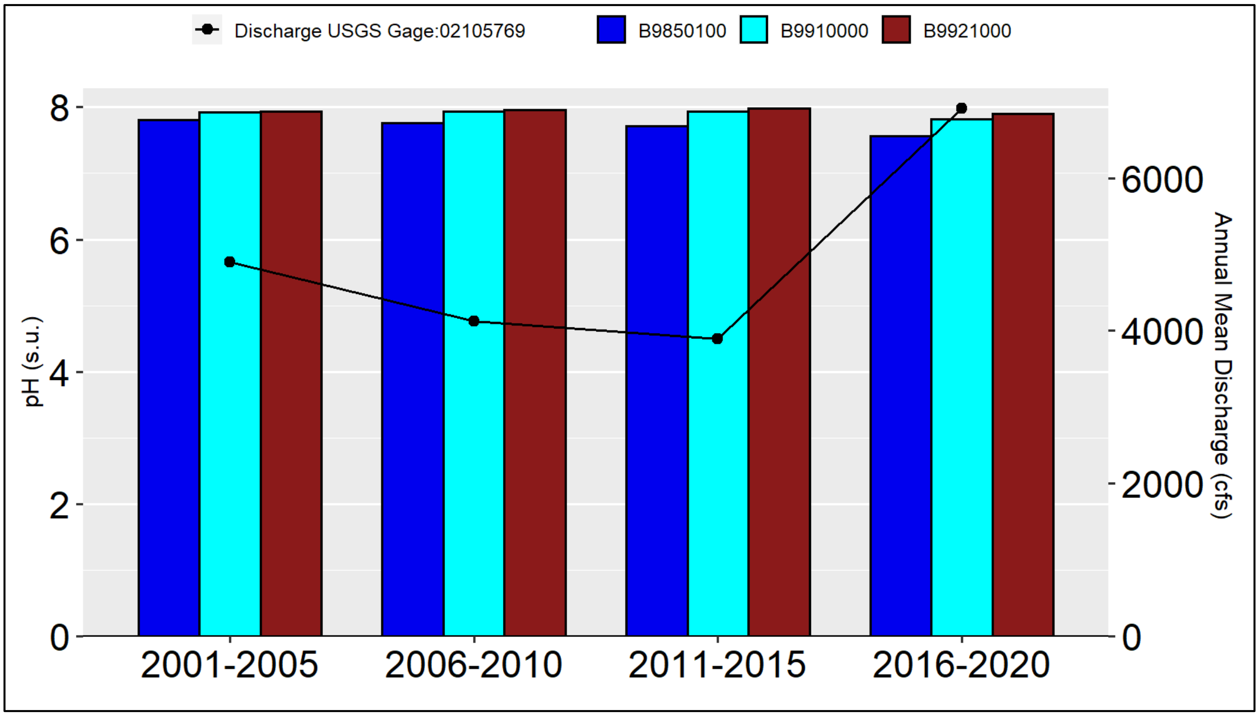

Figure 37: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean DO

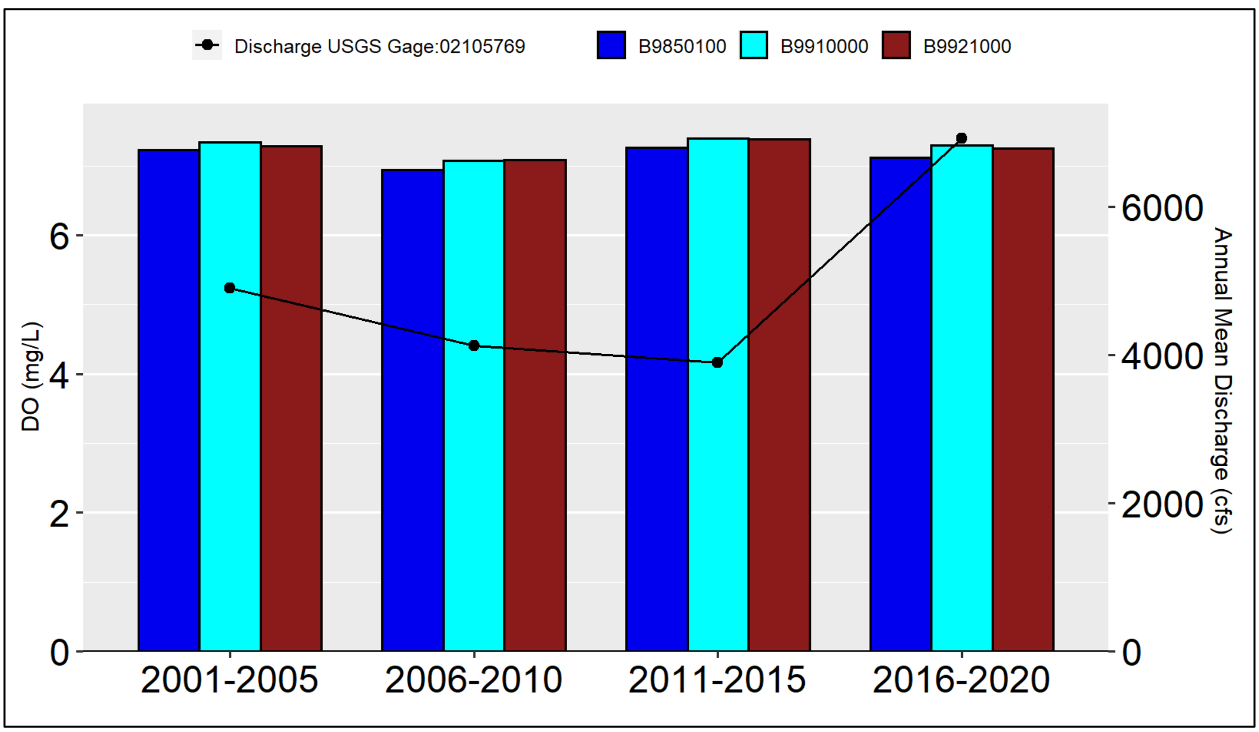

Figure 38: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean Fecal Coliform

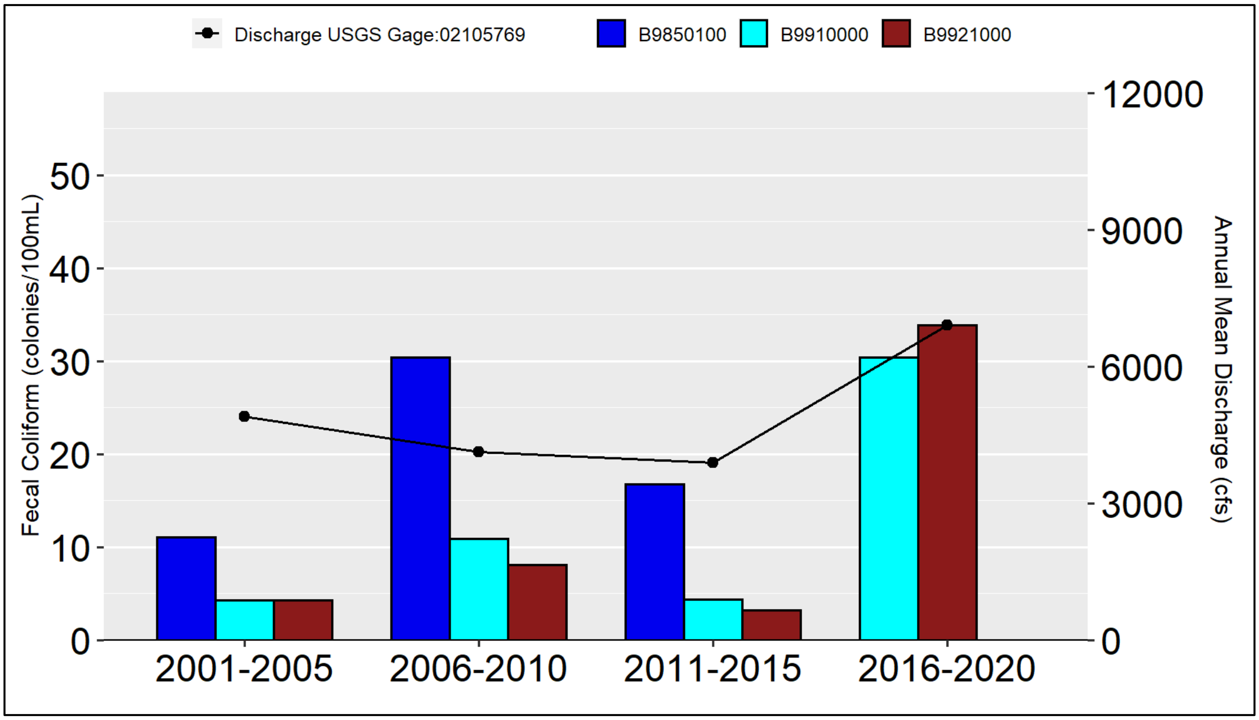

Figure 39: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean Total Nitrogen

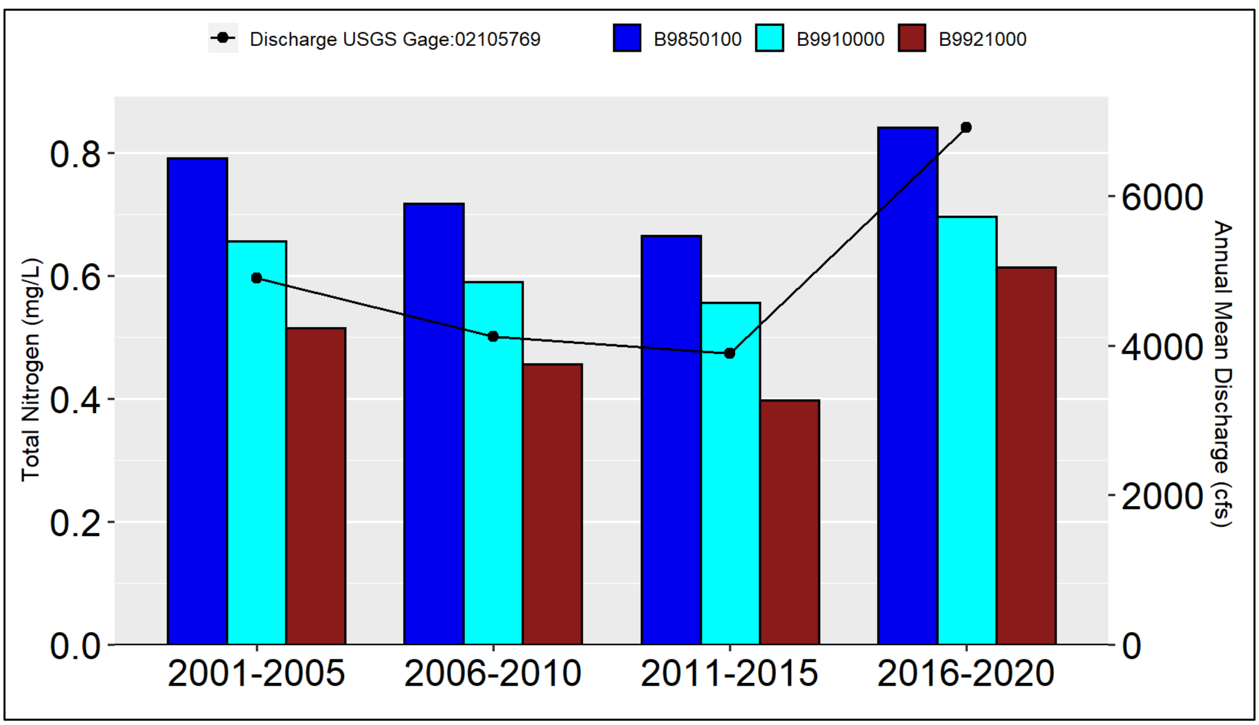

Figure 40: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean TKN

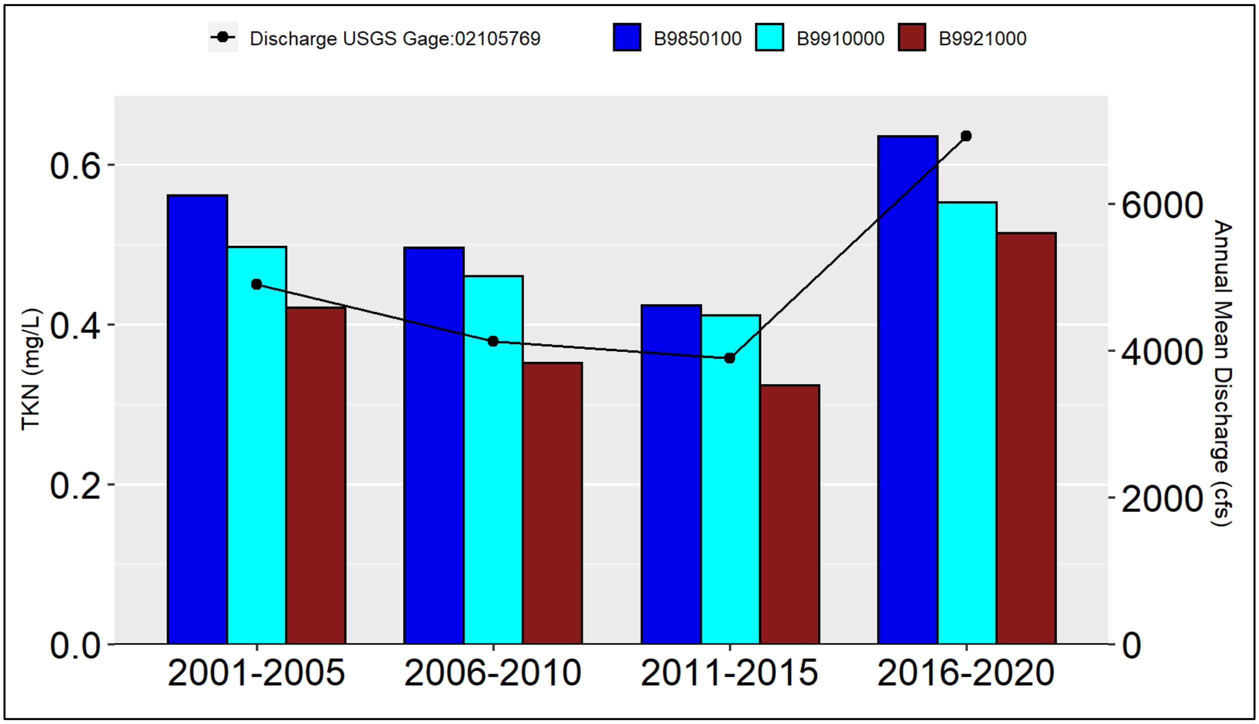

Figure 41: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean NOx

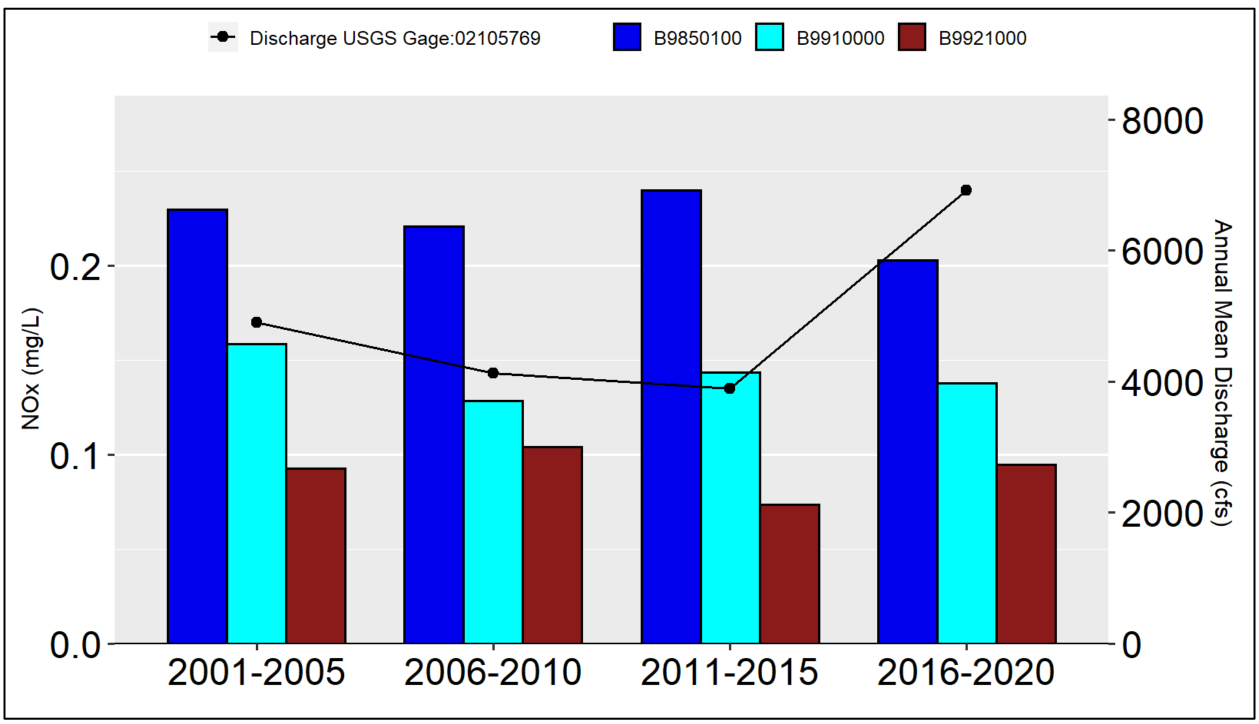

Figure 42: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean Ammonia

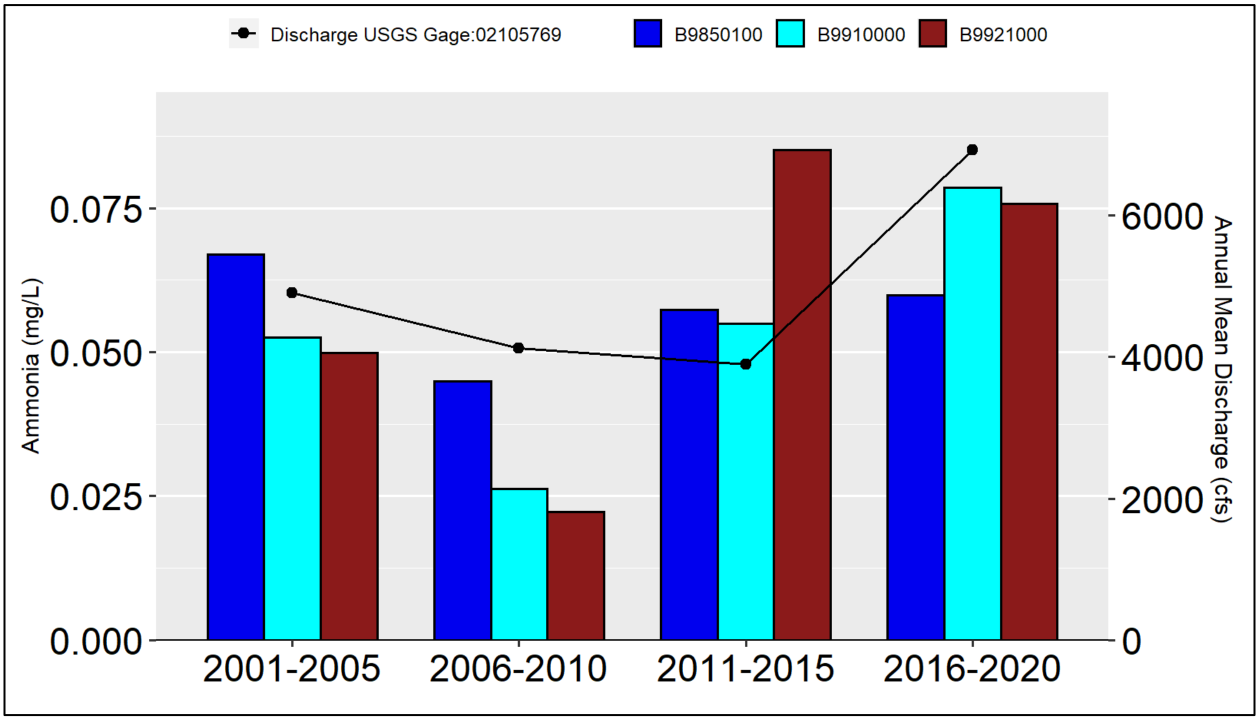

Figure 43: Lower Cape Fear Mainstem Estuary Stations Five-Year Mean Phosphorus

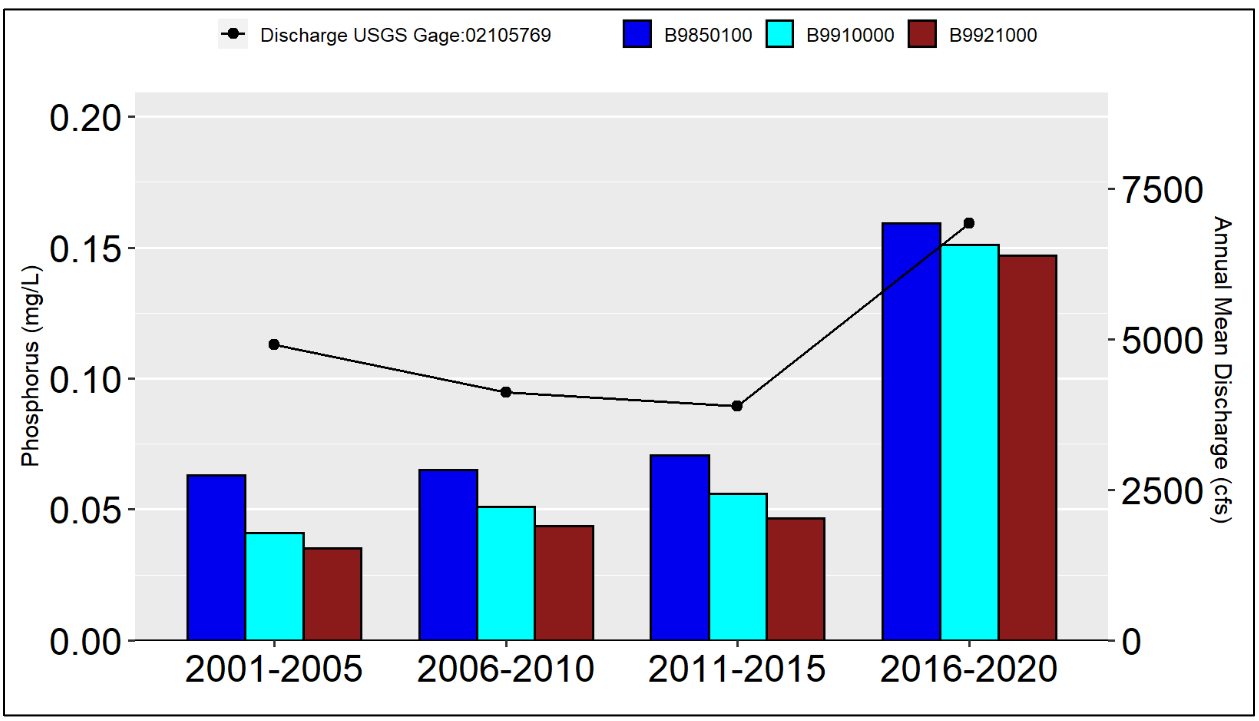

Table 2: Compliance and Enforcements at Beau Rivage Plantation WWTP, Kure Beach WWTP, and The Cape WWTP in HUC 0303000507

Violation Type	Year	PARAMETER	Unit	Limit Value	Min Calculated Value	Max Calculated Value	Min % Over	Max % Over	Number of Occurrences
Beau Rivage Plantation WWTP (NC0065480)									
Daily Maximum Exceeded	2012	Enterococci	cfu/100ml	276	500	1130	81.16	309.42	2
Monthly Geometric Mean Exceeded	2012	Enterococci	cfu/100ml	35	95.62	95.62	173.19	173.19	1
Weekly Geometric Mean Exceeded	2012	Enterococci	cfu/100ml	276	500	1130	81.16	309.42	2
Daily Maximum Exceeded	2012	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	35	35.6	44.7	1.71	27.71	2
Monthly Average Exceeded	2012	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	20	21.22	28.32	6.13	41.63	2
Daily Maximum Exceeded	2012	Solids, Total Suspended - Concentration	mg/l	45	54	54	20	20	1
Daily Maximum Exceeded	2013	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	91	91	102.22	102.22	1
Monthly Average Exceeded	2013	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	30	37.8	37.8	26	26	1
Daily Maximum Exceeded	2013	Chlorine, Total Residual	ug/l	13	50	50	284.62	284.62	2
Daily Maximum Exceeded	2013	Enterococci	cfu/100ml	276	388	2420	40.58	776.81	3
Monthly Geometric Mean Exceeded	2013	Enterococci	cfu/100ml	35	76.07	93.07	117.34	165.93	2
Weekly Geometric Mean Exceeded	2013	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	1
Daily Maximum Exceeded	2013	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	35	37.5	59.9	7.14	71.14	3
Monthly Average Exceeded	2013	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	20	24.86	34.92	24.3	74.6	2
Daily Maximum Exceeded	2015	Enterococci	cfu/100ml	276	1200	2420	334.78	776.81	3

Violation Type	Year	PARAMETER	Unit	Limit Value	Min Calculated Value	Max Calculated Value	Min % Over	Max % Over	Number of Occurrences
Monthly Geometric Mean Exceeded	2015	Enterococci	cfu/100ml	35	41.28	41.28	17.95	17.95	1
Daily Maximum Exceeded	2015	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	35	37.4	186	6.86	431.43	4
Monthly Average Exceeded	2015	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	20	29.33	41.66	46.63	108.3	3
Daily Maximum Exceeded	2016	Enterococci	cfu/100ml	276	1047	2420	279.35	776.81	6
Monthly Geometric Mean Exceeded	2016	Enterococci	cfu/100ml	35	58.5	202.84	67.15	479.54	2
Monthly Average Exceeded	2016	Flow, in conduit or thru treatment plant	mgd	0.1	0.1	0.12	4.97	18.85	3
Daily Maximum Exceeded	2016	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	35	36.7	36.7	4.86	4.86	1
Monthly Average Exceeded	2016	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	20	24.5	29.2	22.5	46	3
Daily Maximum Exceeded	2017	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	49	234	8.89	420	3
Monthly Average Exceeded	2017	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	30	65.8	65.8	119.33	119.33	1
Daily Maximum Exceeded	2017	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	4
Monthly Average Exceeded	2017	Flow, in conduit or thru treatment plant	mgd	0.1	0.11	0.12	8.05	18.87	2
Daily Maximum Exceeded	2017	pH	su	8.5	8.63	8.63	1.53	1.53	1
Daily Minimum Not Reached	2017	pH	su	6.8	6.19	6.19	-8.97	-8.97	1
Daily Maximum Exceeded	2017	Solids, Total Suspended - Concentration	mg/l	45	51.3	51.3	14	14	1
Daily Maximum Exceeded	2018	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	103	103	128.89	128.89	1
Monthly Average Exceeded	2018	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	30	41.25	41.25	37.5	37.5	1

Violation Type	Year	PARAMETER	Unit	Limit Value	Min Calculated Value	Max Calculated Value	Min % Over	Max % Over	Number of Occurrences
Daily Maximum Exceeded	2018	Enterococci	cfu/100ml	276	326	2420	18.12	776.81	6
Monthly Geometric Mean Exceeded	2018	Enterococci	cfu/100ml	35	1080.49	1080.49	2987.1	2987.1	1
Daily Maximum Exceeded	2018	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	35	103	103	194.29	194.29	1
Monthly Average Exceeded	2018	Nitrogen, Ammonia Total (as N) - Concentration	mg/l	20	42.82	42.82	114.13	114.13	1
Kure Beach WWTP (NC0025763)									
Monthly Geometric Mean Exceeded	2011	Enterococci	cfu/100ml	35	48.72	48.72	39.19	39.19	1
Weekly Geometric Mean Exceeded	2012	Enterococci	cfu/100ml	276	1000	1000	262.32	262.32	1
Weekly Average Exceeded	2013	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	79	79	75.56	75.56	1
Monthly Average Exceeded	2015	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	30	36.6	36.6	22	22	1
Weekly Average Exceeded	2015	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	62	69	37.78	53.33	2
Daily Maximum Exceeded	2015	Chlorine, Total Residual	ug/l	13	50	50	284.62	284.62	1
Weekly Geometric Mean Exceeded	2016	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	1
Weekly Average Exceeded	2016	Solids, Total Suspended - Concentration	mg/l	45	66	66	46.67	46.67	1
Weekly Average Exceeded	2017	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	75	75	66.67	66.67	1
Monthly Geometric Mean Exceeded	2017	Enterococci	cfu/100ml	35	48.57	48.57	38.78	38.78	1
Weekly Geometric Mean Exceeded	2017	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	1
The Cape WWTP (NC0057703)									

Violation Type	Year	PARAMETER	Unit	Limit Value	Min Calculated Value	Max Calculated Value	Min % Over	Max % Over	Number of Occurrences
Daily Maximum Exceeded	2013	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	72	74	60	64.44	2
Monthly Average Exceeded	2013	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	30	33.8	33.8	12.67	12.67	1
Daily Maximum Exceeded	2013	Enterococci	cfu/100ml	276	771	2420	179.35	776.81	5
Daily Maximum Exceeded	2013	Solids, Total Suspended - Concentration	mg/l	45	50	50	11.11	11.11	1
Daily Maximum Exceeded	2015	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	3
Monthly Geometric Mean Exceeded	2015	Enterococci	cfu/100ml	35	107.22	107.22	206.35	206.35	1
Daily Maximum Exceeded	2016	BOD, 5-Day (20 Deg. C) - Concentration	mg/l	45	55	55	22.22	22.22	1
Daily Maximum Exceeded	2016	Enterococci	cfu/100ml	276	2420	2420	776.81	776.81	4
Monthly Geometric Mean Exceeded	2016	Enterococci	cfu/100ml	35	56.98	73.56	62.8	110.18	2
Daily Maximum Exceeded	2017	Enterococci	cfu/100ml	276	326	2420	18.12	776.81	10
Monthly Geometric Mean Exceeded	2017	Enterococci	cfu/100ml	35	66.17	442.05	89.05	1163	5
Daily Maximum Exceeded	2018	Enterococci	cfu/100ml	276	1120	2420	305.8	776.81	5
Monthly Geometric Mean Exceeded	2018	Enterococci	cfu/100ml	35	81.28	188.72	132.23	439.2	2

Chapter 10 Black River

Chapter 11 Northeast Cape Fear River

See Report here - 2016 Rocky River D.O. Assessment Study FINAL

NC Division of Water Resources
Water Sciences Section

February 20, 2017

MEMORANDUM

To: Nora Deamer

From: Joseph Smith JS
Katharine DeVilbiss KD

Subject: Rocky River Monitoring Study 2016
Chatham County
HUC 030300030503

Summary

The following report contains the results of a recent study conducted by the Intensive Survey Branch (ISB) assess the impact of Charles Turner Reservoir and Hackney Dam on dissolved Oxygen (D.O.) levels along a 6.7-mile stretch in the Rocky River system May to July, 2016. This stretch is currently impaired due to low D.O. readings at a gauging station located on US 64, downstream of the Hackney dam. Physical and chemical parameters were collected from eight sites in the area of study. During the study period (July 8th, 2016), a pulse of 20 cubic feet per second (cfs) was released by the town of Siler City and ISB staff were able to capture in situ physical parameters downstream of Charles Turner Reservoir (CPFRR01) and in the headwaters of the reservoir upstream of Hackney Dam (CPFRR03).

Findings

D.O. exhibited a downward trend on average from Charles Turner Reservoir to Hackney Dam. Based on instantaneous field readings no exceedances of the state standard of <4.0 mg/L D.O. at surface were observed during the study period in the reach of river found between the headwaters of the Charles Turner Reservoir and Hackney Dam. One exceedance at surface was observed by the gauging station located at Hwy 64 during the study period (3.8 mg/L, 7/14/2016) and one exceedance at surface was observed by the ISB at site CPFRR05 (2.29 mg/L, 5/26/2016). Low D.O. was consistently observed at depths > 1 meter (m) in both Charles Turner Reservoir and the reservoir upstream of Hackney Dam. Charles Turner Reservoir was classified as hypereutrophic, while Hackney Dam was classified as eutrophic based on the North Carolina trophic state index (NCTSI) during the course of this study. During the pulse event, increased flows were observed by ISB staff upstream of Hackney Reservoir, but not below the dam at the US 64 gauging station.

cc: Cyndi Karoly
Danny Smith
Jason Green

Impact Assessment on Physical Water Quality Related to Hackney Dam in Rocky River

Rocky River, Chatham County (Cape Fear Basin)

HUC: 0303000305

February 20, 2017

North Carolina Department of Environmental Quality

Division of Water Resources

Water Sciences Section-Intensive Survey Branch

Background

The following report contains the results of a recent study conducted by the NC Division of Water Resources' (DWR) Intensive Survey Branch (ISB) at the request of the Basinwide Planning Branch (BPB), Modeling and Assessment Branch (MAB), and the Raleigh Regional Office (RRO). This study was performed to assess the impact of Charles Turner Reservoir and Hackney Dam on dissolved oxygen (D.O.) levels along a 6.7-mile stretch in the Rocky River system near Siler City in Chatham County from May to July, 2016 (Figure 1). This stretch of Rocky River is currently classified as impaired and listed on the US Environmental Protection Agency's (USEPA) 303d list due to recurring low D.O. below the state standard of an instantaneous reading of 4.0 mg/L during the late summer months.

The Rocky River is located in the Level IV 45c Ecoregion known as the Carolina Slate Belt (USEPA Ecoregions of North Carolina and South Carolina, 2002). This area is characterized by trellised drainage patterns, Silty and Silty Clay soils, streams that tend to dry up, and low yielding groundwater wells. The area of study runs adjacent to the town of Siler City, located in Chatham County with a population of <10,000 people. The area of drainage is 67 square miles and watershed land use is mainly classified as "Mixed Upland Hardwoods" with some "Managed Herbaceous Cover" (Chatham County GIS). Some areas of grazing pasture for livestock are also located along the drainage area directly adjacent to the Charles Turner Reservoir and the Hackney Dam area. Charles Turner Reservoir is classified as Water Supply-III while the remaining section of the Rocky River in this study area is classified as Type C.

Charles Turner Reservoir was upgraded in the early 2000s and reached full pool in November of 2009. It serves as the second largest of Siler City's four drinking water reservoirs after City Lake (Upper Rocky River Reservoir), with a total capacity of 359 million gallons. Hackney Dam is older, originally serving as a mill pond. Both Charles Turner Reservoir and the reservoir upstream of Hackney Dam are narrow and relatively shallow with a maximum depth of 6.78 m behind the Hackney dam and 5.74 m in Charles Turner Reservoir. Their respective upstream reaches are shallow. The town of Siler City operates a water treatment plant with a water intake at the dam in Charles Turner Reservoir. As part of their 401 certification, the water plant maintains a continuous discharge of water below the dam at various rates depending on the month. Water for this discharge is generally taken at a depth of 1 m.

Downstream from Charles Turner Reservoir, the Rocky River is characterized by a meandering mix of pools and riffles with the dominant bottom substrate consisting of embedded coble and gravel. The reservoir upstream from Hackney Dam consists of 1.17 miles of river beginning 2.75 miles downstream of the dam at Charles Turner Reservoir. During the course of this study, stage varied from 2.0 m to 3.2 m at site CPFRR04 located behind the Hackney Dam (Figure 1). Primary discharge from Hackney Dam flows through two sluice way openings at the bottom of the structure, and additional seepage from the dam itself (Figures 2 and 3). Below Hackney Dam, the Rocky River broadens, flow is slower, and the bottom is characterized as a silty mixture of clay and sediment with steep banks characteristic of a typical piedmont river system. Five creeks discharge into the Rocky River in the area of study, of these, only Loves Creek has an active major discharge, the Siler City Wastewater Treatment Plant, with an average discharge of 1.8 million gallons a day.

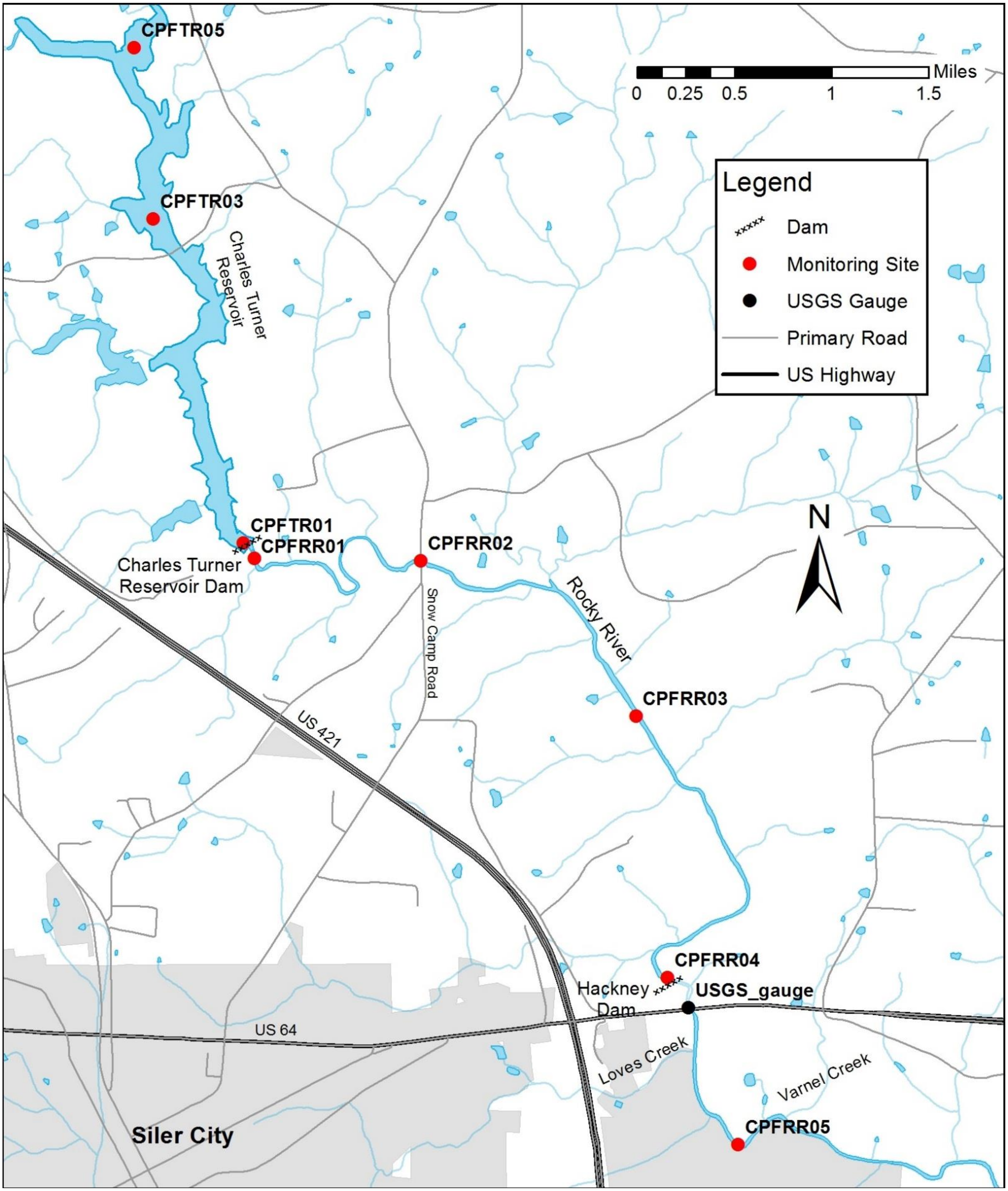

Figure 1. Sampling sites on Rocky River, Chatham County, 2016


Figure 2. Sluice gates of Hackney Dam, taken 6/13/2016 by ISB staff


Figure 3. Looking Downstream of Hackney Dam, taken 6/13/2016 by ISB staff

Study Design/Methods

Physical and chemical parameters were collected from eight sites in the area of study (Figure 1): three in Charles Turner Reservoir, four downstream of Charles Turner Reservoir and upstream of Hackney Dam, and one site downstream of Hackney Dam (Table 2). In addition to data collected by the ISB, water quality information was collected from a United States Geological Survey (USGS) gauging station (02101726) at US 64 near Siler City where US 64 crosses the Rocky River, downstream of Hackney Dam.

Site Name	Site Description	Latitude	Longitude
CPFTR05	Charles Turner Reservoir- Muddy Lick Creek Arm	35.79256	-79.46442
CPFTR03	Turner Reservoir Upstream of SR 1312 Near Unnamed Tributary	35.78265	-79.46296
CPFTR01	Turner Reservoir at Dam	35.76300	-79.45625
CPFRR01	Rocky River Below Charles Turner Dam	35.76232	-79.45561
CPFRR02	Rocky River at Siler City-Snow Camp Road	35.76202	-79.44323
CPFRR03	Rocky River 1.7 miles Upstream of Hackney Dam	35.74845	-79.42344
CPFRR04	Rocky River at Hackney Dam	35.73687	-79.42473
CPFRR05	Rocky River Near Medical Park Drive	35.73117	-79.42293

Table 2. Sites sampled on Rocky River

Beginning in May of 2016 physical water quality parameters were collected using a Hydrolab HL4 multiparameter meter. Dissolved oxygen (mg/L), Temperature (°C), Specific Conductivity (µS), and pH (s.u.) were collected near the water surface (0.15 m), then at depth increments of 0.5 m to bottom in both reservoirs, and at surface only in riverine sites. During the study, physical parameters were collected at surface only when depth < 1 m at site CPFRR03. During the period from 7/7/2016 to 7/14/2016 two HL4 meters were deployed at sites CPFRR01 and CPFRR03 and programmed to collect physical water quality conditions at 15 minute intervals, to monitor a scheduled pulse release conducted by the Siler City Water Treatment Plant (WTP) on 7/8/2016. Physical readings from this meter deployment were corrected as needed based on differences between "clean" and "dirty" readings compared to a calibrated field meter. This correction accounts for biofouling that occurs during deployment of multiparameter meters. These correction limits are based on standard practices documented in the USGS *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting 2006*. When all data was reviewed, dissolved oxygen (D.O.) was the only physical parameter in need of correction at site CPFRR01, and no parameter corrections were needed at site CPFRR03.

Chemical parameters were collected by the ISB at all eight sites in conjunction with physical water quality according to the *Intensive Survey Branch Standard Operating Procedures Manual: Physical and Chemical Monitoring Version 2.1, December 2013*. Chemical parameters were collected from the Photic zone, an area defined as twice secchi depth, at reservoir sites, with the exception of hardness (mg/L) collected only at site CPFTR01. Hardness is collected as a surface grab (0.15m) near water intakes as part of the Ambient Lakes Monitoring Program (ALMP). At riverine sites all samples were collected as a surface grab. Chemical parameters collected include: Ammonia (NH_3, mg/L), Nitrite + Nitrate (NO_2+NO_3, mg/L), Total Kjeldahl Nitrogen (TKN, mg/L), Total Phosphorous (TP, mg/L), Total Organic Carbon (TOC, mg/L), 5-day Biological oxygen Demand (BOD_5, mg/L), Chlorophyll *a* (Chl *a*, mg/L) and Phytoplankton. Physical and chemical parameters were collected at least 5 times during the course of this study. A complete table of collected physical and chemical parameters is shown below (Table 3). Algal bloom surface skims were collected in addition to regular samples as needed (Appendix I).

Stream flow was measured at two sites: CPFRR01 and CPFRR02. Flows were collected using a Marsh McBirney 4200 flow meter. Estimated flow was also used from the USGS maintained gauging station located at US 64 below Hackney Dam. Bathymetry data was also collected at site CPFRR04 for modeling purposes.

Sample Type	Parameter	Frequency (minimum)
Physical	Temperature(°C) pH (s.u.) D.O. (mg/L) Specific Conductivity (µS/cm)	5 discrete site visits 1 session of continuous
	Flow (m/s)	5 discrete site visits
	Bathymetry (m)	once
	Water Level (m)	5 discrete site visits 1 session of continuous
Chemical	NH3 (mg/L) NO_2+NO_3 (mg/L) TKN & Dissolved TKN (mg/L) TP & Dissolved TP (mg/L) TOC (mg/L) BOD5 (mg/L) Chl *a* (µg/L) Phytoplankton/Bloom	5 discrete site visits

Table 3. Physical and Chemical Parameters collected as part of the Rocky River Monitoring Study 2016.

Historical DWR Sampling

The Rocky River watershed was previously sampled by the ISB in 2002 to 2003 and in the summer 2013 as part of the ALMP. During January of 2002 ISB staff noted water quality issues related to elevated conductivity (375 µS) and nuisance algal growth in the stream bed. Filamentous green algae (Oedogonium & Spirogyra) covered with filamentous blue greens (scillatoria), epiphytic diatoms, and bacteria were identified attached to up to 100% of the substrate. The algae identified are indicators of nutrient rich waters. Five algae bloom complaints in four years in this watershed from citizens and NC Division of Water Quality (DWQ) staff were investigated by Division staff prior to 2002. During this time period staff from the ISB collected physical and chemical parameters in the Rocky River watershed, in a larger area of study than the scope of this report. These are the range of physical and chemical median values from 2002 to 2003 found in *Rocky River Survey Chatham County, Sub-basin 03-06-12, 2004* are listed in Table 4.

Sample Type	Parameter	Median Values
Physical	Temperature(°C)	21.1-24.4
	pH (s.u.)	6.3-7.0
	D.O. (mg/L)	5.8-7.5
	Specific Conductivity (µS/cm)	83-193
Chemical	NH_3 (mg/L)	<0.02-0.04
	NO_2+NO_3 (mg/L)	0.13- 3.00
	TKN (mg/L)	0.45-0.74
	TP (mg/L)	0.13-0.38

Table 4. Ranges of Physical and Chemical median values collected from October, 2002 to October, 2003

Sampling for the previous special study in 2002-03 was conducted during a dry and wet year, with sampling during late 2002 occurring during a record drought. Physical readings remained normal during the course of the study. Waters in the upper stretches of the river were noted as slightly acidic, with colors characteristic of tannins, which cleared up in lower reaches. High specific conductivity was noted throughout the river system. Typical conductance ranges from 12 - 90 µS/cm in North Carolina based on historic DWR ambient monitoring program data. High specific conductance serves as an estimate of dissolved solids and salts, and is generally indicative of watershed development. The report also notes that rivers in the Carolina Slate belt have higher conductivity on average than other piedmont rivers due to the mineralized flows over the substrate materials. Chemical samples collected at that time indicated elevated nutrient levels in the watershed when compared against reference DWR ambient monitoring data.

The ISB also sampled six sites in the Charles Turner Reservoir five times from May to September in 2013 as part of the ALMP. The reservoir was classified as Hypereutrophic, indicating elevated productivity levels. An Algal Growth Potential Test (AGPT) performed by the Regional EPA laboratory on samples from the reservoir indicated that Nitrogen was the limiting nutrient throughout the lake; however, based on the test, nutrient levels present in the lake were great enough to support nuisance blooms without the introduction of any additional nutrients. TP values ranged from 0.08 to 0.31 mg/L in the photic zone, while total nitrogen (TKN + NO_2+NO_3) values ranged from 1.04 to 2.02 mg/L. High levels of Chl *a* were also noted in the reservoir with a range of 15 to 180 µg/L. Of the 30 samples collected from May to September, 27 exceeded the Chl *a* state water quality standard of 40 µg/L. D.O. levels at the surface varied across the six sites, with field staff noting a low reading of 4.0 mg/L during June of 2013 at site CPFTR01. D.O. was consistently low at depths >1m at that particular site. Other physical parameters remained within normal levels at surface, with pH ranging from 7.1 to 8.3 s.u. during the course of the 2013 summer and slightly elevated specific conductivity values ranging from 78 to 99 µS/cm, consistent with those observed from 2002- 2003 in the Rocky River watershed.

Study Results

Physical Results

Charles Turner Reservoir

Three sites were sampled in Charles Turner Reservoir: CPFTR05, CPFTR03, and CPFTR01. Charles Turner Reservoir is a relatively shallow, run of river impoundment with shallow headwaters fed by the Muddy Lick Creek and the Rocky River. Temperature remained below the state standard of <32 °C; although, it was elevated in shallower areas at site CPFTR05 and CPFTR03 with a maximum value of 31.8 °C at CPFTR03 on 7/14/2016, the last day of the study. Median values for temperature ranged from 27.1 to 27.3 during the course of the study, decreasing closer to the dam. Median pH values increased moving towards the dam, with median values of 7.62, 7.92, and 8.30 s.u. at CPFTR05, CPFTR03, and CPFTR01 respectively. A maximum pH value of 8.97 s.u. was observed at CPFTR01 on both 7/7/2016 and 7/14/2016. This pH value comes close to but does not exceed the state's upper limit of <9.0 s.u. Specific conductivity remained relatively constant throughout the reservoir with median values of 87.5, 93, and 83.5 µS/cm at CPFTR05, CPFTR03, and CPFTR01 respectively. Dissolved oxygen at the surface remained above the state standard of an instantaneous reading of 4.0 mg/L during the course of this study, with a minimum value of 6.48 mg/L at site CPFTR05 on 6/13/2016. Maximum D.O. values of 11.51 mg/L were observed at site CPFTR03 on 5/26/2016 (Table 5).

	CPFTR05	CPFTR03	CPFTR01
Temperature	**°C**	**°C**	**°C**
Minimum	24.78	25.07	23.31
Median	27.15	27.33	27.15
Maximum	31.30	31.82	29.48
D.O.	**mg/L**	**mg/L**	**mg/L**
Minimum	6.48	7.10	7.10
Median	7.50	8.38	8.85
Maximum	11.02	11.51	11.49
pH	**s.u.**	**s.u.**	**s.u.**
Minimum	7.19	7.22	7.26
Median	7.62	7.92	8.30
Maximum	8.43	8.72	8.97
Specific Conductivity	**µS/cm**	**µS/cm**	**µS/cm**
Minimum	83	84	82
Median	88	87	84
Maximum	93	93	89

Table 5. Minimum, median, and maximum values for sites in Charles Turner Reservoir at the surface, May to July 2016 (Full data set in Appendix II).

High pH and D.O. values in Charles Turner Reservoir observed during the month of July corresponded with visible algal blooms at surface on the majority of the lake. Skim samples were collected on 7/7/2016 and 7/14/2016 for phytoplankton identification by the WSS (Appendix I). Below 1.5m depth, D.O. was consistently low (<2mg/L) for all sites. This is typical for hypereutrophic waterbodies.

Rocky River Between Charles Turner Reservoir and Hackney Reservoir
Downstream of Charles Turner Reservoir and upstream of the Hackney Dam reservoir, two riverine samples were collected at sites CPFRR01 and CPFRR02. CPFRR01 was located directly downstream of the Charles Turner Dam discharge. Site CPFRR02 was sampled upstream of the bridge at Snow Camp Road. No exceedances of state water quality standards were observed during the course of this study for D.O., temperature, or pH. Minimum, Median, and Maximum values for physical parameters are listed in Table 6.

	CPFRR01	**CPFRR02**
Temperature	**°C**	**°C**
Minimum	24.4	22.9
Median	26.5	25.5
Maximum	29.5	27.2
D.O.	**mg/L**	**mg/L**
Minimum	5.7	5.4
Median	6.8	6.2
Maximum	7.7	7.6
pH	**s.u.**	**s.u.**
Minimum	7.2	6.8
Median	7.5	7.1
Maximum	7.9	8.4
Specific Conductivity	**µS/cm**	**µS/cm**
Minimum	83	85
Median	84	88
Maximum	92	100

Table 6. Minimum, median, and maximum values for Rocky River sites CPFRR01 and CPFRR02 at the surface, May to July 2016.

Hackney Reservoir
Sites CPFRR03 and CPFRR04 were designated as the upstream and downstream sites of the reservoir located upstream of Hackney Dam. CPFRR03 remained relatively shallow during the course of the study, with a maximum depth of 1.48 m. Physical conditions for surface measurements did not exceed state water quality standards at this site during the course of the study; however, lower D.O. values were observed with a median value of 5.0 mg/L and a minimum value of 4.6 mg/L observed on 6/20/2016. At site CPFRR04, depth varied from 2.0 m to 3.2 m. The maximum temperature observed at this site, 31.8 °C on 7/7/2016, was close to the state standard of 32 °C, but no exceedances occurred during discrete site visits. Surface measurements for D.O. and pH remained elevated at CPFRR04 during the course of this study, indicative of increased algal productivity. Water column profile information was collected and bottom readings are included in Table 7. During periods of low flow in this segment of the Rocky River, the primary source of discharge from the Hackney Dam comes from subsurface waters at site CPFRR04 through the dam sluice gates. During the course of the study, subsurface D.O. remained consistently low, with a median value of 1.8 mg/L. Thermal stratification with hypoxic conditions at depth are normal summer conditions for eutrophic standing bodies of water, and this situation is the main contributor to reduced D.O. levels observed downstream of the Hackney Dam in Rocky River.

	CPFRR03	CPFRR04	
	Surface	Surface	Bottom
Temperature	**°C**	**°C**	
Minimum	23.2	23.8	18.8
Median	24.9	27.6	24.1
Maximum	26.8	31.8	26.7
D.O.	**mg/L**	**mg/L**	
Minimum	4.6	7.4	0.6
Median	5.0	9.4	1.8
Maximum	6.7	13.3	3.9
pH	**s.u.**	**s.u.**	
Minimum	6.7	7.2	6.6
Median	7.0	8.1	6.6
Maximum	7.0	9.0	6.8
Specific Conductivity	**µS/cm**	**µS/cm**	
Minimum	84	84	85
Median	90	90	92
Maximum	99	92	96

Table 7. Minimum, median, and maximum values for Rocky River sites CPFRR03 and CPFRR04, May to July 2016 (full dataset in Appendix II).

Downstream of Hackney Dam

Below Hackney Dam, a gauging station is maintained by the USGS in cooperation with the town of Siler City to collect physical parameters every 15 minutes using a multiparameter sonde. For the purpose of this study, readings collected from the station at 12:00 pm on days when ISB collected samples at the other eight sites were used as representative readings for the site at Highway 64. Temperature remained below the state standard with a maximum value of 28.7 °C and a median value of 25.9 °C. Specific Conductivity remained consistent with the rest of the watershed and had a median value of 95 µS/cm. The median and minimum pH values of 6.8 and 6.6 s.u., respectively, are similar to those observed in other riverine sections of the Rocky River and do not exceed state standard limits. Dissolved oxygen remained relatively low with a median D.O. of 5.1 mg/L and a minimum value of 3.8 mg/L recorded on 7/14/2016. While both the median and average (5.5 mg/L, n= 7) values remained above the state standard of an average not less than 5.0 mg/L during this study period, however the observed reading of 3.8 mg/L is below the instantaneous state standard of >4.0mg/L. Additional readings taken after the conclusion of field sampling for this study exhibited periods of D.O. concentrations below the state standard in August and September 2016. This time period had overall decreased rainfall and reduced streamflow.

CPFRR05 is the furthest downstream site in the area of study, and is located 150 m downstream of the confluence of Rocky River and Loves Creek. During the study, temperature remained below the state standard with maximum and median values of 28.6 and 26.0 °C respectively. Specific conductivity was elevated at CPFRR05, with a median value of 205 µS/cm and a maximum value of 347 µS/cm observed on 7/7/2016. Elevated conductivity is mostly likely a result of the close proximity to the discharge of the Siler City waste water treatment plant (WWTP) and not a result of instream mineralization. The minimum pH value of 7.1 s.u. and the maximum of 9.7 s.u. are elevated in comparison to the gauging station located immediately upstream, and the maximum value of 9.7 s.u. exceeds the state standards of <9.0 s.u.. While a higher pH value is often associated with increased algal production, the elevated levels could also be a result of interactions with the nearby WWTP discharge. The median and minimum D.O. values of 5.9 and 2.3 mg/L do not indicate consistent algal blooms similar to those seen in upstream reservoir areas of this study. The minimum value was observed on the first day of sampling, 5/26/2016. Subsequent sampling events showed instantaneous readings >4.0 mg/L and a maximum value of 6.7 mg/L on 6/9/2016 (Table 8).

	US64	**CPFRR05**
Temperature	**°C**	**°C**
Minimum	22.1	22.3
Median	25.9	25.9
Maximum	28.7	28.6
D.O.	**mg/L**	**mg/L**
Minimum	3.8	2.3
Median	5.1	5.9
Maximum	7.9	6.7
pH	**s.u.**	**s.u.**
Minimum	6.6	7.1
Median	6.8	7.3
Maximum	7.2	9.7
Specific Conductivity	**µS/cm**	**µS/cm**
Minimum	87	159
Median	95	205
Maximum	100	347

Table 8. Minimum, median, and maximum values for Rocky River sites US64 gauging station and CPFRR05 at the surface, May to July 2016.

A complete table of physical water quality parameters for the entire area of study are shown by site in Appendix-II.

Chemical Results

Total Kjeldhal Nitrogen (TKN), a measure of recently introduced organic nitrogen, ranged from a low of 0.58 mg/L observed at CPFRR02 to a high of 1.30 mg/L observed at CPFTR05 and CPFTR01 during the month of July, 2016. Highest median values for TKN were observed in the upstream section of Charles Turner Reservoir (Table 9). Similar values were observed at CPFRR01, directly downstream of the Charles Turner Reservoir, as well as at site CPFRR04 located upstream of the Hackney Dam.

Total Phosphorous values ranged from 0.06 mg/L to 0.11 mg/L throughout the area of study. TP values in the Charles Turner Reservoir were higher than downstream sections of the watershed.

Dissolved Kjeldhal Nitrogen (DKN) and Dissolved Phosphorous (DP) were also collected as part of this study. Dissolved nutrients are sampled at the same time then filtered through a 0.45 µm glass fiber filter. Filtering removes Kjeldhal (organic) Nitrogen and Phosphorus associated with particulate matter, like sediment and phytoplankton. A high ratio of DKN and DP relative to total levels can indicate increased bioavailability of nutrients in the water column. DKN and DP remained relatively constant in the area of study, with medians ranging from 0.85 to 0.54 mg/L for DKN and 0.02 to 0.04 mg/L for DP.

Ammonia levels remained at or below detection levels for all sites with the exception of CPFRR05 (Table 9). NO_2+NO_3 results ranged from below detection limits (<0.02 mg/L) to 0.05 mg/L in Charles Turner Reservoir, with slightly higher values observed downstream at CPFRR01. Sites CPFRR02, CPFRR03, and CPFRR05 all showed higher NO_2+NO_3 with a maximum value of 6.7 mg/L observed at CPFRR05 on 7/7/2016. These higher nutrient levels observed at CPFRR05 are most likely due to the close proximity of the permitted WWTP discharge located immediately upstream at Loves Creek, which do not exceed permitted discharge limits of <0.5 mg/L for TP limits for the Rocky River.

Site	TKN mg/L	DKN mg/L	TP mg/L	Dissolved P mg/L	NH_3 mg/L	NO_2+NO_3 mg/L
CPFTR05	1.1	0.63	0.09	0.03	0.02	0.03
CPFTR03	1.15	0.61	0.10	0.03	0.02	0.03
CPFTR01	0.99	0.62	0.07	0.02	0.02	0.03
CPFRR01	0.94	0.62	0.07	0.03	0.02	0.04
CPFRR02	0.67	0.57	0.06	0.04	0.02	0.31
CPFRR03	0.67	0.54	0.08	0.04	0.03	0.17
CPFRR04	0.92	0.55	0.07	0.03	0.02	0.04
CPFRR05	0.84	0.85	0.06	0.04	0.05	2.4

Table 9. Median values for nutrient parameters from May 2016 to July 2016.

Total organic carbon (TOC) and 5-day biochemical oxygen demand are indicators of productivity in the water column. There is no state standard for TOC in North Carolina; however average values are generally <10 mg/L for both TOC and BOD_5 based on USEPA guidance for monitoring and assessing water quality. TOC values showed minor variability with a minimum of 8.2 mg/L observed at site CPFRR05 and maximum of 12 mg/L observed at CPFTR03. Median values for TOC in Charles Turner Reservoir were slightly elevated compared to downstream sites (Table 10). BOD_5 showed a similar pattern, with higher values observed in Charles Turner Reservoir and immediately downstream, then lower values observed at sites CPFRR02 and CPFRR05.

Chlorophyll *a* values were elevated in Charles Turner Reservoir and at CPFRR04 (upstream of Hackney Dam), median values were over state standards of 40 µg/L. Chlorophyll *a* values at these four sites were only below state standards once during the course of the study, with a value of 31 µg/L observed at CPFTR01 on 6/13/2016. The highest recorded value was also observed at CPFTR01: 210 µg/L on 7/7/2016. An algal bloom was also noted on this day at this site, with concurrent elevated D.O. and pH levels (Appendix II). Calculated NCTSI scores indicate that Charles Turner Reservoir is Hypereutrophic with a score of 5.8 and Hackney Reservoir is eutrophic with a score of 4.2.

Site	TOC mg/L	BOD_5 mg/L	Chlorophyll *a* µg/L
CPFTR05	10	5.6	51
CPFTR03	11	6.1	76
CPFTR01	11	6.9	73
CPFRR01	11	5.3	33
CPFRR02	9.8	2.7	7.3
CPFRR03	9.6	4.5	19
CPFRR04	10	4.7	47
CPFRR05	9	2.8	3.6

Table 10. Median TOC, BOD_5, and Chlorophyll *a* values from May 2016 to July 2016.

Total solids, Suspended solids, and Turbidity were only collected as part of the monitoring conducted in Charles Turner Reservoir (Table 11), and showed a downward trend consistent with settling expected to occur in a reservoir system. Turbidity remained below the state lake standard of 25 NTU. The reservoir was generally noted as turbid brown or green water.

Site	Total Solids mg/L	Suspended Solids mg/L	Turbidity NTU
CPFTR05	91.5	12	13.5
CPFTR03	89.5	12	14
CPFTR01	85	8.9	9.6

Table 11. Median Total Solids, Suspended Solids, and Turbidity in Charles Turner Reservoir, May 2016 to July 2016.

Flow and Pulse Monitoring Results

Flow readings were collected at CPFRR01 and CPFRR02 by the ISB field staff as well as at the US 64 gauging station using a historical rating curve established by the USGS. As part of the 401 certification discharge, the town of Siler City maintains a constant discharge from the dam at Charles Turner Reservoir. During the course of this study, minimum flows of 8.0 cfs for May, 5.0 cfs for June, and 2.5 for the month of July were recorded by the WTP at a constant rate in addition to overspill from the dam. During low flow periods when reservoir dams were not topped, flow readings collected at CPFRR01 by ISB staff were consistent with flow measured by the Town of Siler City WTP (6/13/2016, Table 12). Flow was also estimated by the gauging station located at US 64 using a rating curve based on stage.

Date	CPFRR01	CPFRR02	US 64
6/2/2016	6.0 cfs	6.2 cfs	9.5 cfs
6/13/2016	6.3 cfs	5.4 cfs	7.6 cfs
6/20/2016	5.2 cfs	5.5 cfs	5.7 cfs
*7/8/2016 **7/9/2016	26.9 cfs	25.1 cfs	3.2 cfs 5.0 cfs

Table 12. Discharge rates for three sites in cubic feet per second, June & July, 2016

* Active pulse conducted by Siler City WTP as part of 401 Certification requirement.

** Max flow measured by the US64 gauging station on the following day was also monitored in case of delay.

Discharge rates during the month of June were similar between sites CPFRR01 and CPFRR02. While there is some input from an unnamed ephemeral stream between these two sites, changes in stream flow are most likely due to groundwater infiltration and the nature of streambeds in the carolina slate belt. Discharge rates calculated at US64 show a general downward trend independent from Charles Turner Reservoir discharge, unlike those seen at CPFRR01 and CPFRR02. This is most evident with stream flow measured on 7/8/2016 and 7/9/2016 at the three sites during a scheduled release conducted to mimic storm flow events by the Siler City WTP. During this flow event, in stream measurements at CPFRR01 and CPFRR02 showed flows greater than the 20 cfs required as part of the 401 certification (Table 12). Subsequent flows recorded by the gauging station located at US64 on the following days however, show a peak flow of 5.0 cfs with only a minor increase in average stage from 7/7/2016 (2.02 ft, n=96) to 7/9/2016 (2.07, n= 96). Increase in stage and flow at the gauging station downstream of Hackney Dam is most likely due to increased hydraulic head pressure behind the dam, and not overflow of the dam itself.

Multiparameter sondes were deployed from 7/7/2016 to 7/14/2016 at sites CPFRR01 and CPFRR03 to monitor physical parameters every 15 minutes (figures 4, 5, & 6). Physical measurements collected at CPFRR01 and CPFRR03 show a rapid rise in stage at CPFRR01 consistent with increased flow from the pulse event from 08:37 to 19:52 on 7/8/2016. Depth rose from an average of 0.11 m (n=42) on 7/7/2016, to an average of 0.28 m (n=46) during the pulse (Figure 4). Dissolved oxygen at CPFRR01 exhibited values below the state standard of >5.0 mg/L sustained average (3.2 mg/L, n=76) from 13:37 on 7/7/2016 immediately prior to detection of increased stage resulting from the increased discharge. During the pulse, D.O. increased to an average of 6.48 mg/L (corrected, n=46) before returning to low values with an average of 1.49 mg/L (corrected, n=96) on 7/9/2016. The increase in D.O. seen during the pulse correlates with the increased aeration of the discharge and is not indicative of increased biological production at CPFRR01. Dissolved oxygen resumed a diurnal cycle on the 9th, with periods of increased D.O. seen in the late afternoon on 7/9/2016. D.O. remained below the standard for the rest of the sonde deployment. During the pulse event, pH at CPFRR01 showed a minor increase from an early morning average of 6.9 s.u. (n=30) to an average of 7.0 s.u. (n=46) (Figure 5). A rise in pH is commonly seen in reservoir systems as part of a diurnal production cycle and could be the cause of this increase. Conductivity showed a minor increase in average values from 79 µS/cm (n=76) to 81 µS/cm (n=46). No change from normal temperature fluctuations were observed (Figure 6).

Stage increase was delayed and more gradual at site CPFRR03 with peak stage of 1.16m at 1:25 on 7/9/2016, up from a pre-pulse average of 0.74 m (n=36) observed on 7/7/2016 (Figure 7). After reaching peak, water level dropped gradually over the rest of the deployment period in contrast to the flash flow observed at CPFRR01 concurrent with the pulse events beginning and end. Dissolved oxygen exhibited a spike during the initial rise in stage reaching a peak of 5.9 mg/L at 13:40 on 7/8/2016, up from a pre-pulse average of 1.5 mg/L (n=67). D.O. levels decreased gradually over 7/9/2016 before returning to pre-pulse levels and resuming a normal diurnal fluctuation pattern on 7/10/2016 (Figure 4). A similar pattern was observed for pH; a peak of 7.0 s.u. was at 13:25 on 7/8/2016 before gradually decreasing to pre-pulse levels on 7/9/2016 (Figure 5). Temperature also exhibited an increase from an average value of 25.8 °C (n=83) to a maximum of 28.0 °C at 16:40 on 7/8/2016 before returning to pre- pulse levels on 7/9/2016 (Figure 6). Taken together, these values indicate a mixing event caused by the initial flush of the pulse in the upstream portion of the Hackney Reservoir. Conductivity did not show a major change during the pulse, with only a minor increase observed in averages from 7/7/2016 (92 µS/cm, n=36) to 7/9/2016 (93 µS/cm, n=96).

At the US 64 gauge, there was little change in stage compared to the rapid rise and fall observed at CPFRR01 and the gradual increase at CPFRR03 (Figure 7). A minor increase from an average of 0.62 m (n=96) on 7/7/2016 to an average of 0.63 m (n=96) on 7/9/2016 was observed before gradually returning to previous levels over the following days. Stage data at the US 64 gauging station from the time period of the pulse indicates that stage in Hackney Reservoir was not elevated enough to top the dam and flow over. No major fluctuations from normal cycles in D.O., temperature or major changes in pH were observed (Figures 8 -10). Conductivity remained constant with an average of 96 µS/cm (n=96) on 7/72016, and 96 µS/cm (n= 96) on 7/10/2016.

Based on field observations, Hackney Dam is topped at a range of 3.0 to 3.2 m. Depth readings on 7/7/2016 collected by ISB staff indicate the stage upstream of the dam at site CPFRR04 was at 2.3 m the day before the pulse event (Appendix-II). By an estimation of change from average stage at CPFRR03 (0.4m), the pulse event was insufficient to raise stage at CPFRR04 high enough to flow over the Hackney Dam.

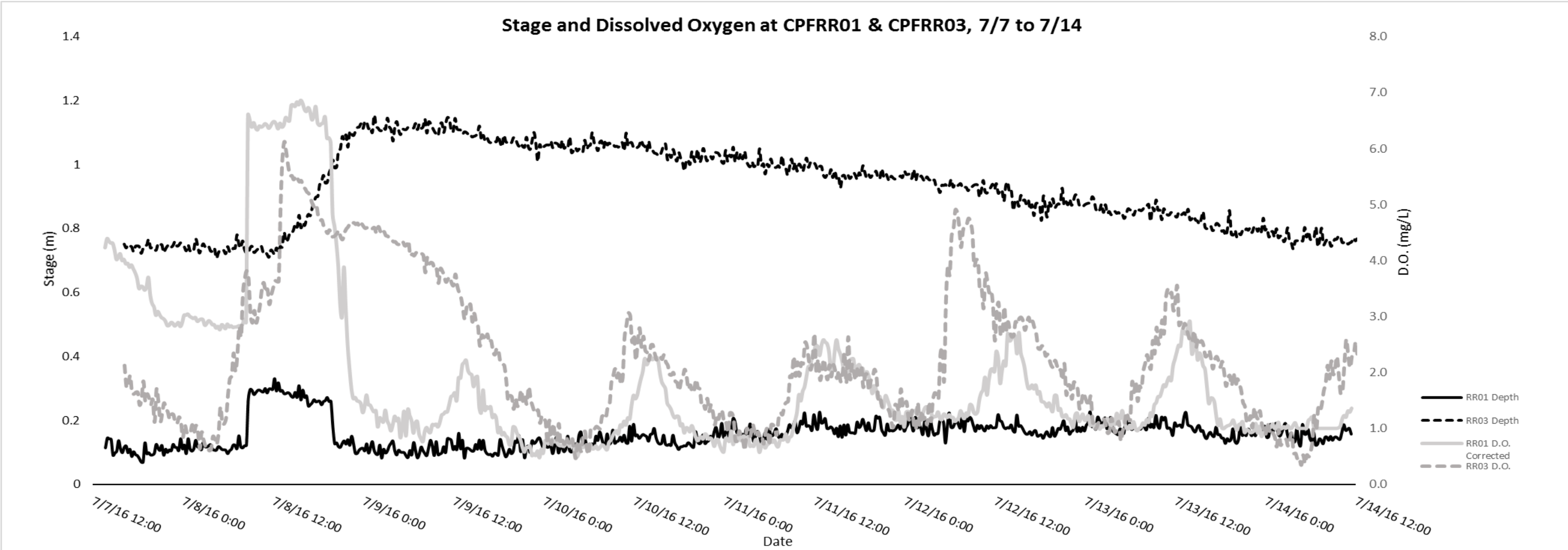

Figure 4. Dissolved oxygen and depth at CPFRR01 and CPFRR03 pre and post 20 CFS pulse released on 7/8/2016

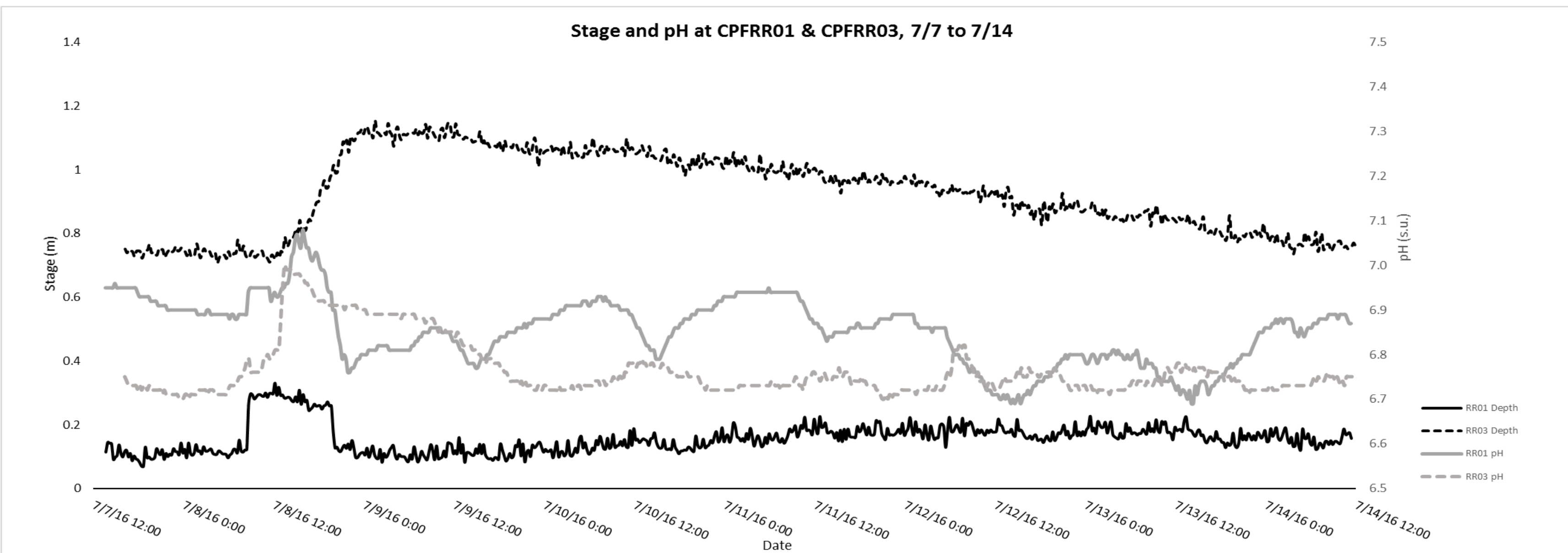

Figure 5. Stage and pH at CPFRR01 and CPFRR03 pre and post 20 CFS pulse released on 7/8/2016

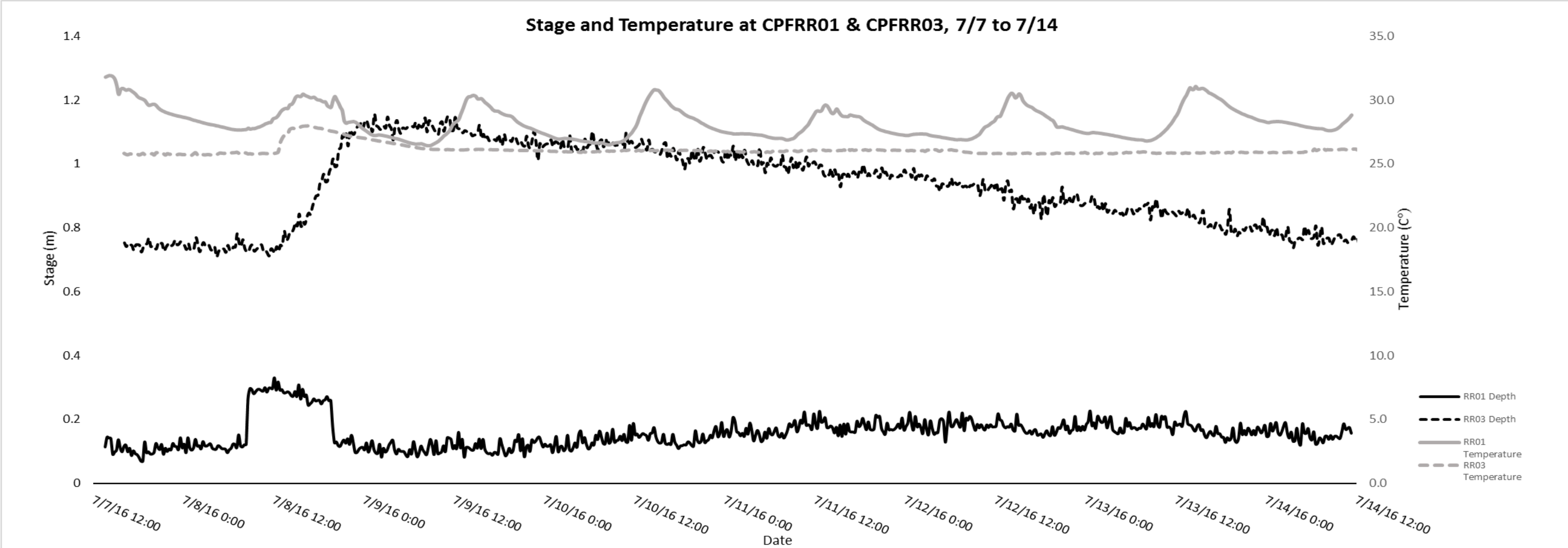

Figure 6. Temperature and stage at CPFRR01 and CPFRR03 pre and post 20 CFS pulse released on 7/8/2016

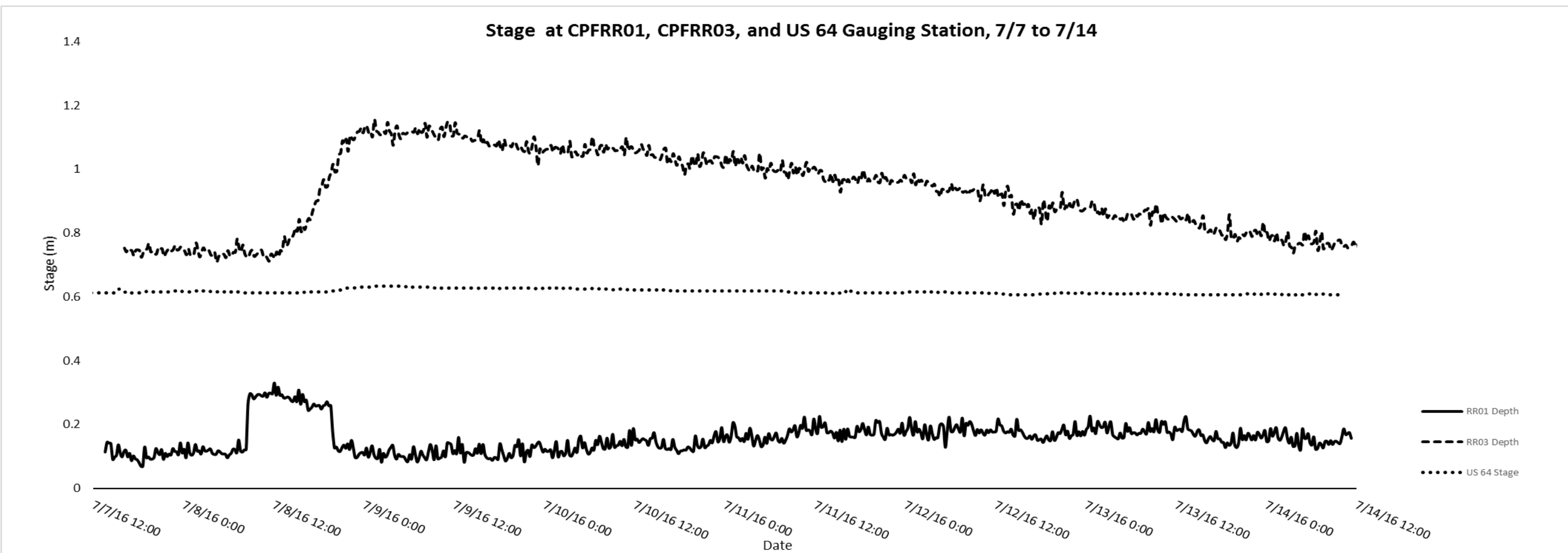

Figure 7. Stage at CPFRR01, CPFRR03, and US 64 gauging station pre and post 20 CFS pulse released on 7/8/2016

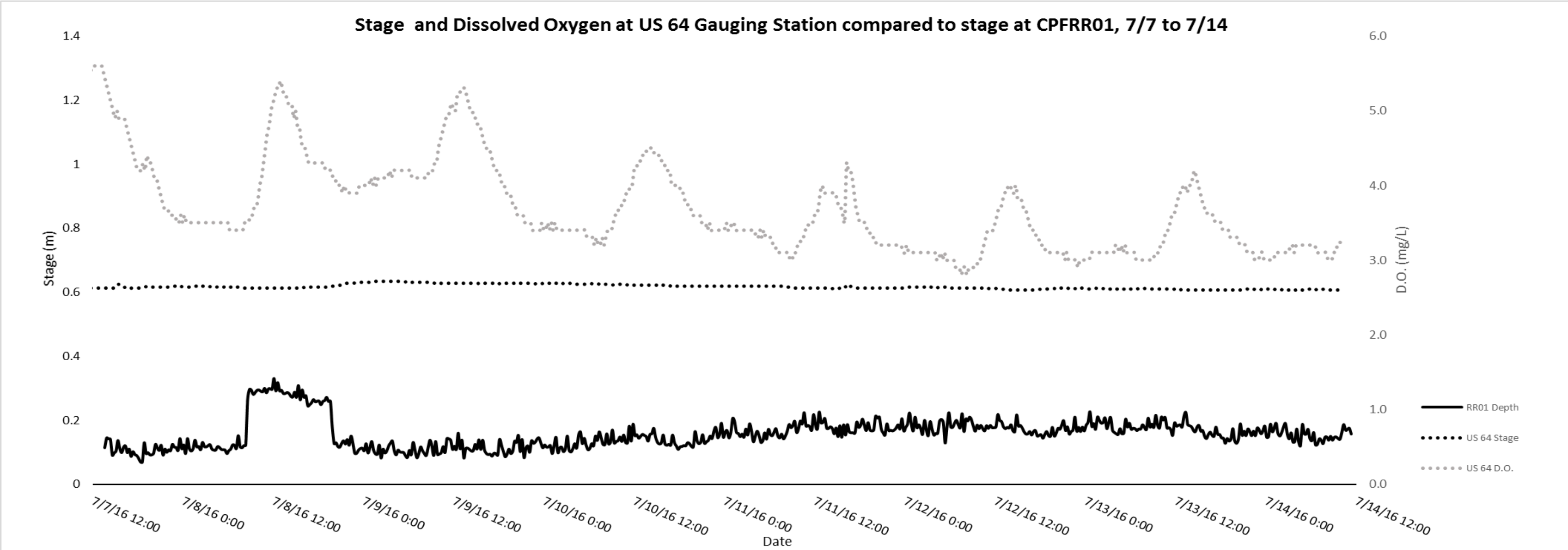

Figure 8. Stage and dissolved oxygen at US 64 gauging station compared to stage at CPFRR01 pre and post 20 CFS pulse released on 7/8/2016

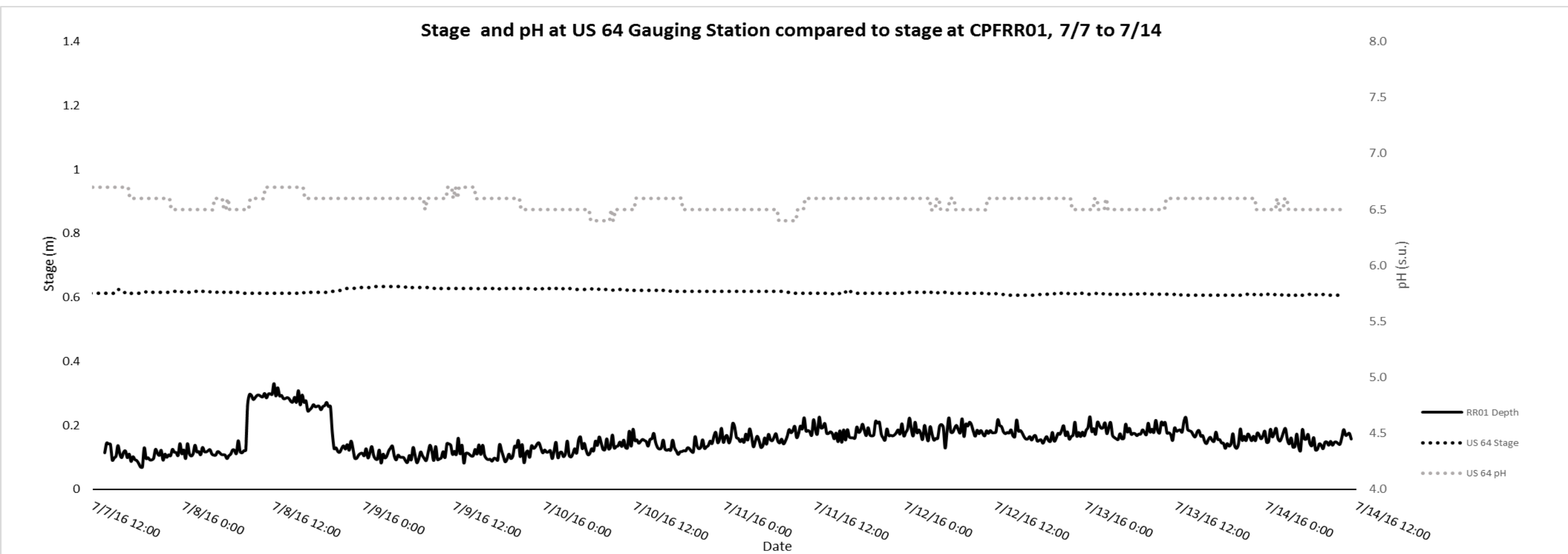

Figure 9. Stage and pH at US 64 gauging station compared to stage at CPFRR01 pre and post 20 CFS pulse released on 7/8/2016

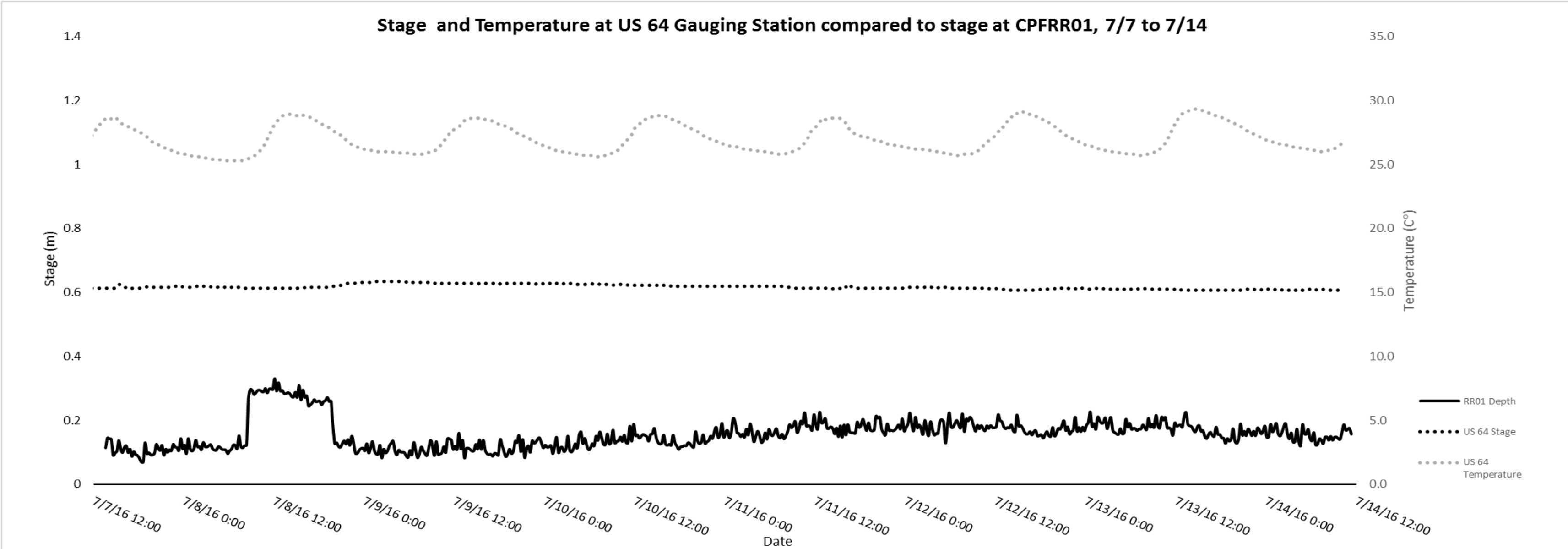

Figure 10. Stage and temperature at US 64 gauging station compared to stage at CPFRR01 pre and post 20 CFS pulse released on 7/8/2016

Conclusions

Chemical and physical parameters collected during the course of this study indicate that chain of reservoirs in the Rocky River watershed can be classified as eutrophic to hypereutrophic based on calculated NCTSI scores. Nutrient levels exist in sufficient levels to sustain nuisance algal blooms, supported by the elevated Chlorophyll *a* values as well as visible surface blooms observed in both Charles Turner and Hackney reservoirs. These algal blooms covered large portions of both reservoirs and have been historically observed in the Rocky River watershed. Eutrophic conditions are often closely correlated with hypoxic and anoxic water at depths >1 m due to anaerobic breakdown of algal matter in bottom sediment, which can negatively impact native fauna. No fish kills were observed during the course of this study and field observations noted an abundance of small fish in the Rocky River system. During summer, low flow conditions may exacerbate low D.O. conditions due to thermal stratification and inadequate mixing of waters. Low D.O. was consistently observed at depths >1.5 m in both the Charles Turner and Hackney reservoirs. During periods of low flow, this potentially hypoxic bottom water is the major source of streamflow for the Rocky River between Hackney Dam and the confluence of Loves Creek, resulting in D.O. levels frequently below state standards at the gauging station located at US 64.

The Rocky River never reached drought status during the course of this study, but communication with involved parties have indicated dry stream bed conditions observed in previous years. Stage data indicates that during periods of low flow, flows between the Charles Turner Reservoir and upstream portions of Hackney are mostly dependent on the continual release conducted as part of the 401 certification by Siler City WTP. While spill over the Charles Turner Dam contributes to flow downstream, the relatively small size of the watershed for the Rocky River doesn't allow for long term periods of high flow without consistent rains. Stage data from site CPFRR03 and the gauging station at US 64 indicate that water leaves the Hackney Reservoir at a relatively constant rate and during pulse events Hackney Reservoir may not be topped, leading to minimal water quality changes downstream of the dam.

Appendix I

Algal Analysis Report **October 28, 2016**

Collector: Joseph Smith, Intensive Survey Branch

Date Collected: 7/14/2016

Location: Charles Turner Reservoir

Reason Collected: Surface Film Identification

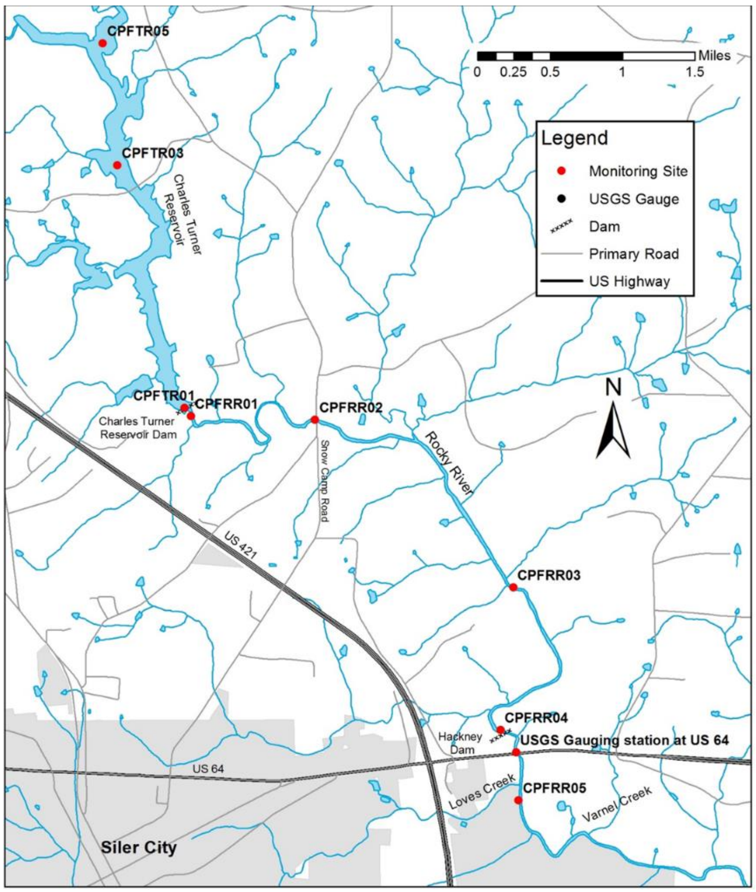

Figure 1. Area of Study for Rocky River 2016

Sample Information: Staff noted a surface bloom beginning to form in the upper end of the Charles Turner Reservoir while conducting field work for the DWR Rocky River Special Study on 7/7/16 (Figure 2). The bloom was still present on 7/14/16 but had moved down and concentrated at the dam (Figures 3 & 4). A grab sample was collected at the station closest to the dam (CPFTR01) for identification and enumeration. Staff continued to document the bloom down the Rocky River noting a heavier coverage at the Hackney Reservoir (Figure 5).

Results of Analysis: Algal assemblages are measured in terms of units (units being a filament, colony or unicellular), cell density (the number of cells in the filaments, colonies or unicellular), and biovolume (the volume of the algal cell). The density at CPFTRO1 was at

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12,000 units/ml, 182,000 cells/ml and 5,500 mm^3/m^3 representing a mild bloom (Table 1). The assemblage was dominated by cyanobacteria (bluegreens), primarily by the relatively smaller *Planktolyngbya* in unit density and *Dolichospermum* (formerly classified as *Anabaena*) in biovolume (Table 2).

Table 1. Results of the Quantitative analysis

Station	Date	Total Unit Density	Total Cell density	Total Biovolume
CPFTR01	7/14/2016	12,000	187,000	5,600

Table 2. Dominant Taxa in the Charles Turner Reservoir on 7/14/2016

Algal Group	Taxon	Unit density	Cell density	Biovolume
Bluegreen	*Planktolyngbya*	2,400	36,600	< 100
Bluegreen	*Dolichospermum*	1,700	49,000	3,200
Bluegreen	*Aphanocapsa*	1,700	20,000	< 100
Bluegreen	*Anabaenopsis*	1,300	9,000	300
Bluegreen	*Cuspidothrix*	1,000	12,000	170

Ecological Significance:

Bluegreen algae commonly dominate lakes, rivers and ponds during summer. Some of the algae, for instance the *Planktolyngbya* and *Aphanocapsa*, stay suspended throughout the water column but other forms, such as the *Dolichospermum* and *Cuspidothrix*, have gas vacuoles (aerotrophs) that allow them to regulate their buoyancy and often collect as films or clumps on the waters' surface. Bluegreens are notorious bloom formers, cause taste and odors in drinking water, ruin aesthetics and some taxa, such as *Dolichospermum*, *Anabaenopsis* and *Cuspidothrix* (Figures 5-7), may produce cyanotoxins. More information on precautions to take around bluegreen algal blooms can be found on the NC Division of Health and Human Services website (link provided below).

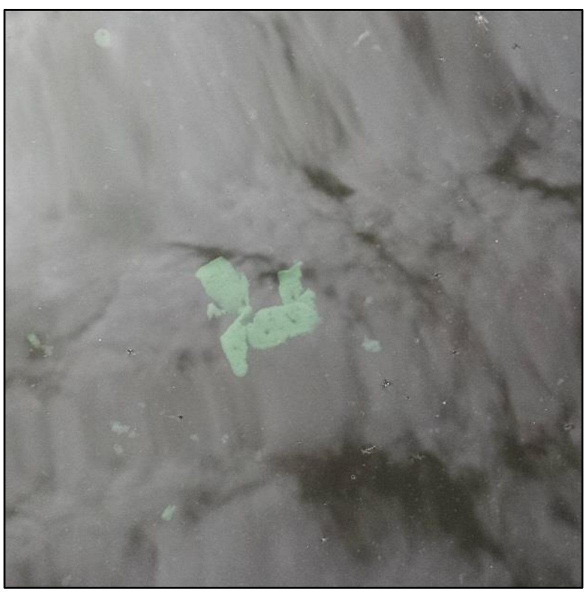

Figure 2. Clumps of bluegreen algae in the upper end of the Turner Reservoir near CPFTR03 on 7/7/16

Figure 3. Distribution of clumps of bluegreen algae in the upper end of the Turner Reservoir near CPFTR03 on 7/14/16

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Figure 4. Bluegreen algae concentrated along shoreline in the lower end of the Turner Resevoir near CPFTR01 on 7/14/16

Figure 5. Flecks and clumps of bluegreens ½ miles upstream from CPFRR04 on 7/14/16

Figure 6. Micrograph image of the bluegreen alga *Anabaenopsis*

Appendix I

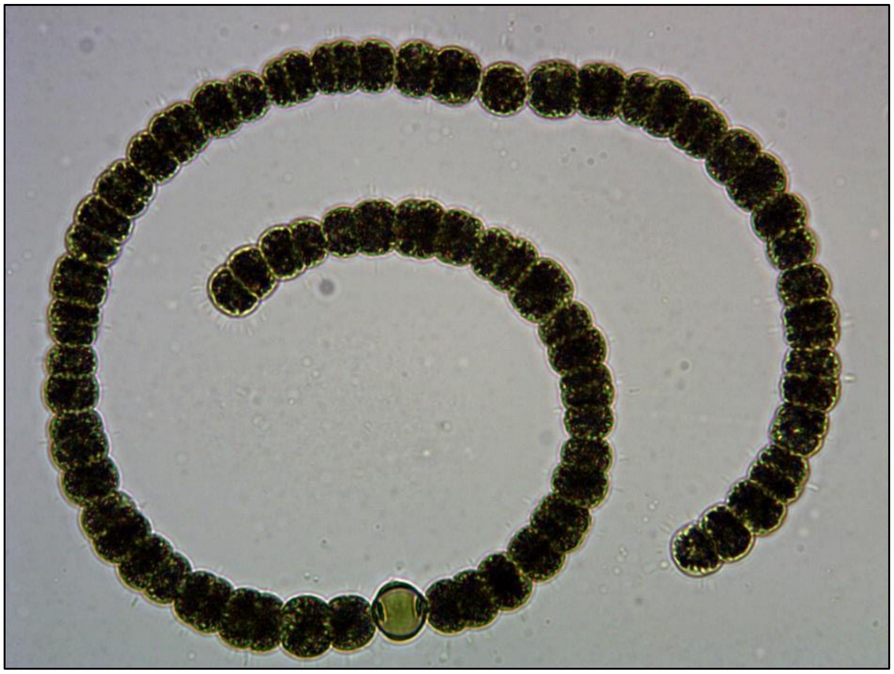

Figure 7. Micrograph image of the bluegreen alga *Dolichospermum*

Figure 8. Micrograph image of the bluegreen alga *Cuspidothrix*

DHHS website: http://epi.publichealth.nc.gov/oee/algae/protect.html

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Appendix II

CPFTR05	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
Secchi- 0.5m	0.2	24.8	11.0	8.4	83
	1.0	22.4	9.1	7.6	83
	2.0	19.3	0.1	6.8	87
	3.0	16.3	0.0	7.2	228
6/2/2016					
Secchi- 0.6m	0.2	26.4	7.9	7.4	87
	0.5	26.1	6.9	7.2	87
	1.0	25.6	4.4	6.9	87
	1.5	24.2	0.3	6.6	88
	1.7	22.9	0.0	6.6	91
6/9/2016					
Secchi- 0.5m	0.2	26.2	6.8	7.2	87
	0.5	25.7	6.4	7.1	87
	1.0	25.3	5.5	7.0	87
	1.2	25.3	5.1	7.0	87
6/13/2016					
Secchi- 0.5m	0.2	27.9	6.5	7.2	88
	0.5	27.9	6.4	7.2	88
	1.0	27.5	5.4	7.1	88
	1.5	26.7	1.3	6.8	87
	2.0	25.3	0.0	6.7	90
7/7/2016					
Secchi- 0.5m	0.2	29.3	7.1	7.9	92
	0.5	29.3	6.7	7.8	91
	0.8	29.0	6.0	7.8	91
7/14/2016					
Secchi-0.5m	0.2	31.3	9.0	8.2	93
	0.5	30.6	5.7	7.1	93
	1.0	30.2	3.4	6.8	94
	1.6	28.8	0.0	6.6	99

CPFTR03	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
Secchi- 0.5m	0.2	25.1	11.5	8.7	84
	1.0	21.8	8.8	7.5	84
	2.0	19.4	2.7	6.9	83
	3.0	18.1	1.7	6.7	79
	3.4	17.5	1.3	6.6	80
6/2/2016					
Secchi- 0.7m	0.1	26.6	8.4	7.5	86
	0.5	26.4	7.0	7.2	86
	1.0	26.0	6.1	7.1	86
	1.0	25.8	5.3	7.0	86
	0.2	26.3	7.2	7.2	86
6/9/2016					
Secchi- 0.5m	0.5	25.9	6.2	7.1	85
	1.0	25.7	5.9	7.1	86
	1.5	25.5	5.5	7.0	86
	2.0	24.7	1.9	6.7	89
	2.5	23.1	0.1	6.6	92
	2.8	21.8	0.0	6.7	98

Appendix II

CPFTR03 con'd	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
6/13/2016					
Secchi- 0.4m	0.1	28.0	7.1	7.3	87
	0.5	28.0	6.7	7.3	88
	1.0	27.9	6.0	7.1	88
	1.5	26.8	1.6	6.8	86
	2.0	24.8	0.0	6.7	90
	2.5	22.5	0.0	6.8	101
	3.0	20.2	0.0	6.8	116
	3.3	19.4	0.0	6.9	119
7/7/2016					
Secchi- 0.5m	0.1	29.5	8.4	8.3	91
	0.6	29.1	7.6	8.1	91
	1.1	29.0	6.9	7.9	91
	1.5	27.8	0.7	7.5	93
	1.8	27.3	0.0	7.4	93
7/14/2016					
Secchi- 0.5m	0.1	31.8	9.7	8.6	93
	0.5	30.7	8.3	7.9	92
	1.0	30.0	4.2	6.9	94
	1.6	29.1	0.2	6.6	93
	2.1	27.5	0.0	6.8	115
	2.5	24.2	0.0	6.8	150
	3.1	21.3	0.0	7.0	181
	4.0	18.9	0.0	7.0	194
	4.2	18.5	0.0	7.0	197

CPFTR01	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
Secchi- 0.8m	0.2	23.3	11.5	8.5	82
	1.0	21.8	10.7	7.9	81
	2.0	19.8	0.3	6.8	84
	3.0	17.9	0.0	6.8	111
	4.0	17.2	0.0	6.8	117
	5.0	16.2	0.0	6.9	118
	5.7	15.1	0.0	7.0	150
6/2/2016					
Secchi- 0.6m	0.2	27.5	8.8	8.1	84
	0.5	27.3	8.2	7.6	84
	1.0	26.6	4.6	7.0	84
	1.5	24.5	1.1	6.7	83
	2.0	23.3	0.0	6.6	84
	3.0	18.7	0.0	6.7	111
6/9/2016					
Secchi- 0.5m	0.2	26.8	7.1	7.3	83
	0.5	26.4	6.7	7.2	83
	1.0	26.3	6.5	7.1	83
	1.5	26.1	6.0	7.1	83
	2.0	25.5	0.6	6.7	83
	2.5	21.7	0.0	6.7	100
	3.0	19.5	0.0	6.8	113
	4.0	17.9	0.0	6.9	124
	4.2	17.7	0.0	6.9	125

Appendix II

CPFTR01 con'd	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
6/13/2016					
Secchi- 0.6m	0.1	29.1	8.0	7.8	83
	0.5	29.0	8.1	7.7	83
	1.0	28.9	7.9	7.7	83
	1.5	28.7	7.3	7.5	83
	2.0	28.0	5.8	7.1	83
	2.5	25.5	0.0	6.6	80
	3.0	21.3	0.0	6.8	107
	3.7	19.0	0.0	6.8	121
7/7/2016					
Secchi- 0.6m	0.2	29.5	8.9	9.0	89
	0.5	29.4	8.8	8.9	88
	1.0	29.2	8.2	8.6	88
	1.5	27.8	1.8	7.4	88
	2.0	26.9	0.0	7.3	86
	2.5	24.2	0.0	7.3	152
	3.5	19.8	0.0	7.4	160
	4.5	17.8	0.0	7.4	149
	4.8	17.4	0.0	7.4	149
7/14/2016					
Secchi- 0.5m	0.2	29.5	8.9	9.0	89
	0.5	30.9	10.0	8.8	92
	1.1	30.3	8.4	8.1	91
	1.5	29.3	4.5	7.0	92
	2.1	27.7	0.3	6.7	101
	2.5	25.1	0.0	7.0	165
	2.8	23.5	0.0	7.0	178

CPFRR01	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
	0.2	24.4	7.7	7.5	83
6/2/2016					
	0.2	27.0	6.2	7.1	86
6/9/2016					
	0.2	26.5	7.2	7.4	84
6/13/2016					
	0.2	28.7	6.6	7.5	84
6/20/2016					
	0.2	26.5	6.8	7.2	87
7/7/2016					
	0.2	30.3	5.7	7.9	92

CPFRR02	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
	0.2	24.4	7.7	7.5	83
6/2/2016					
	0.2	27.0	6.2	7.1	86
6/9/2016					
	0.2	26.5	7.2	7.4	84
6/13/2016					
	0.2	28.7	6.6	7.5	84
6/20/2016					
	0.2	26.5	6.8	7.2	87
7/7/2016					
	0.2	30.3	5.7	7.9	92

Appendix II

CPFRR03	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
	0.2	23.2	6.7	7.0	88
	1.0	21.4	6.1	6.9	89
6/2/2016					
	0.2	24.9	4.8	6.9	90
	0.5	24.0	4.4	6.8	90
	1.0	23.7	3.8	6.8	91
	1.5	22.3	1.1	6.6	96
	2.0	20.5	0.0	6.7	118
6/9/2016					
	0.1	25.2	5.0	7.0	84
	0.5	25.0	5.1	7.0	85
	1.0	24.8	4.5	6.9	85
	1.5	24.8	4.6	6.9	85
6/13/2016					
	0.2	26.8	5.5	7.0	91
	0.5	25.6	5.0	6.9	91
	0.9	24.9	3.9	6.8	91
6/20/2016					
	0.1	24.9	4.6	6.7	99
	0.9	22.9	3.1	6.6	99
7/7/2016					
	0.1	27.4	4.9	7.9	96

CPFRR04	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
5/26/2016					
Secchi- 0.7m	0.2	23.8	8.2	7.2	88
	1.0	21.2	6.6	7.0	87
	2.0	19.5	4.3	6.7	85
	2.7	18.8	2.2	6.6	92
6/2/2016					
Secchi- 0.9m	0.2	26.7	13.3	9.0	91
	0.5	24.5	12.0	8.5	90
	1.0	23.5	5.7	6.9	91
	1.5	23.0	3.1	6.7	92
	2.0	22.3	1.4	6.6	94
6/9/2016					
Secchi- 0.6m	0.2	26.5	7.4	7.3	84
	0.5	25.8	6.2	7.1	84
	1.0	25.4	5.0	6.9	84
	1.5	25.3	4.6	6.9	84
	2.0	25.3	4.6	6.8	84
	2.5	25.2	4.3	6.8	84
	3.0	25.2	4.0	6.8	85
	3.2	25.1	3.9	6.8	85

Appendix II

CPFRR04 con'd	Depth (m)	Temp	D.O. (mg/L)	pH (s.u.)	Sp. Cond. (µS/cm)
6/13/2016					
Secchi- 0.7m	0.2	29.1	9.0	8.2	84
	0.5	27.0	9.5	8.3	84
	1.0	25.8	6.4	7.2	85
	1.5	25.3	4.1	6.8	85
	2.0	24.9	2.7	6.7	86
	2.5	24.4	1.3	6.6	87
	3.0	24.1	0.6	6.6	89
6/20/2016					
Secchi- 0.6m	0.2	28.5	9.9	8.0	91
	1.0	24.4	5.8	6.8	91
	2.0	24.1	3.9	6.7	92
7/7/2016					
Secchi- 0.8m	0.2	31.8	10.4	8.3	92
	0.5	28.7	10.9	8.4	90
	1.0	28.0	10.2	8.5	90
	1.5	27.6	6.2	7.5	90
	2.0	27.2	3.6	6.9	92
	2.3	26.7	1.1	6.7	96
Gauge @ US 64	**Depth (m)**	**Temp**	**D.O. (mg/L)**	**pH (s.u.)**	**Sp. Cond. (µS/cm)**
5/26/2016					
	0.2	22.1	7.9	7.2	89
6/2/2016					
	0.2	23.2	4.7	6.8	96
6/9/2016					
	0.2	25.9	6.8	7.1	87
6/13/2016					
	0.2	25.9	4.7	6.8	90
6/20/2016					
	0.2	25.4	5.1	6.7	95
7/7/2016					
	0.2	27.5	5.6	6.7	95
7/14/2016					
	0.2	28.7	3.8	6.6	100
CPFRR05	**Depth (m)**	**Temp**	**D.O. (mg/L)**	**pH (s.u.)**	**Sp. Cond. (µS/cm)**
5/26/2016					
	0.2	22.3	2.3	7.3	164
6/2/2016					
	0.2	24.5	5.8	7.3	221
6/9/2016					
	0.2	25.8	6.7	7.3	159
6/13/2016					
	0.2	26.1	5.2	7.2	189
6/20/2016					
	0.2	26.2	6.0	7.1	238
7/7/2016					
	0.2	28.6	6.1	9.7	347

Appendix III

5/26/2016	CPFTR05	CPFTR03	CPFTR01	CPFRR01	CPFRR02	CPFRR03	CPFRR04	CPFRR05
BOD_5 (mg/L)	5.5, *G5*	9.7, *G5*	7.7, *G5*	6, *G5*	7.5, *G5*	11, *G5*	4.3, *G5*	2.3, *G5*
Chl *a* (μg/L)	45	76	100	33	11	13	41	19
DP (mg/L)	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.03
TP (mg/L)	0.08	0.1	0.07	0.06	0.05	0.06	0.07	0.06
DKN (mg/L)	0.55	0.61	0.48	0.67	0.51	0.55	0.53	0.65
TKN (mg/L)	1	1.2	0.97	0.8	0.67	0.68	0.82	0.76
NH_3N (mg/L)	0.02	0.02, *U*	0.02, *U*	0.02	0.02	0.02	0.02	0.03
No_x (mg/L)	0.04	0.03	0.05	0.04	0.15	0.16	0.12	1.2
TOC (mg/L)	11	12	11	11, *J6*	9.9	9.8	10	9.2
Turbidity (NTU)	13	13	8.7					
T. Residue (mg/L)	91	91	84					
Sus. Residue (mg/L)	10	12	8.8					
Hardness (mg/L)			29					
6/2/2016	**CPFTR05**	**CPFTR03**	**CPFTR01**	**CPFRR01**	**CPFRR02**	**CPFRR03**	**CPFRR04**	**CPFRR05**
BOD_5 (mg/L)	6	6	8.7	6.7	3	4.4	5	3.1
Chl *a* (μg/L)	47	44	150	60	10	6.7	52	2.6
DP (mg/L)	*	*	*	*	*	*	*	*
TP (mg/L)	*	*	*	*	*	*	*	*
DKN (mg/L)	*	*	*	*	*	*	*	*
TKN (mg/L)	*	*	*	*	*	*	*	*
NH_3N (mg/L)	*	*	*	*	*	*	*	*
No_x (mg/L)	*	*	*	*	*	*	*	*
TOC (mg/L)	11	11	11	11, *J6*	10	8.8	9	8.2
Turbidity (NTU)	9	11	8.5					
T. Residue (mg/L)	86	86	88					
Sus. Residue (mg/L)	6.5	6.2, *U*	12, *U*					
Hardness (mg/L)			29					

G5-A single quality control failure occurred during biochemical oxygen demand (BOD) analysis. The sample results should be used with caution, the glucose/ glutamic acid standard exceeded the range of 198 ± 30.5 mg/L.

U- Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit.

J6- The laboratory analysis was from an unpreserved or improperly chemically preserved sample. The data may not be accurate.

* - on 6/2 dissolved nutrient samples were mislabeled and analyzed as total nutrient samples, the resulting data was not used in the preparation of this report.

6/9/2016	CPFTR05	CPFTR03	CPFTR01	CPFRR01	CPFRR02	CPFRR03	CPFRR04	CPFRR05
BOD_5 (mg/L)	4.4	4.6	5.1	3.7	2.3	3.1	3.8	2.5
Chl *a* (µg/L)	55	48	43	38	22	26	42	16
DP (mg/L)	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.04
TP (mg/L)	0.11	0.1	0.08	0.08	0.07, *J6*	0.08	0.09	0.08, *J6*
DKN (mg/L)	0.62	0.63	0.58	0.62	0.58	0.54	0.6	0.85
TKN (mg/L)	1.1	1.1	0.96	0.96	0.82, *J6*	0.9	0.97	0.95, *J6*
NH_3N (mg/L)	0.02, *U*	0.02, *U*	0.02, *U*	0.02, *U*	0.02, *J6,U*	0.02, *U*	0.02, *U*	0.05, *J6*
No_x (mg/L)	0.02	0.03	0.03	0.04	0.1, *J6*	0.08	0.04	2.0, *J6*
TOC (mg/L)	10, J6	11	11	11	11	9.8	9.9	10
Turbidity (NTU)	15	14	10					
T. Residue (mg/L)	92	88	86					
Sus. Residue (mg/L)	12	12	9.5					
Hardness (mg/L)			29					

6/13/2016	CPFTR05	CPFTR03	CPFTR01	CPFRR01	CPFRR02	CPFRR03	CPFRR04	CPFRR05
BOD_5 (mg/L)	5.6	5.6	6	4.6	2.3	4.6	4.4	2
Chl *a* (µg/L)	46	44	31	24	4.6	31	32	4.6
DP (mg/L)	0.03	0.02	*	0.02	0.05	0.04	0.02	0.04
TP (mg/L)	0.09	0.09	*	0.07	0.07	0.08	0.07	0.06, *J6*
DKN (mg/L)	0.65	0.6	*	0.61	0.57	0.57	0.51	0.81
TKN (mg/L)	1.1	1.1	*	0.93	0.68	0.78	0.91	0.98, *J6*
NH_3N (mg/L)	0.02, *U*	0.02, *U*	*	0.02, *U*	0.02	0.02, *U*	0.02, *U*	0.05, *J6*
No_x (mg/L)	0.03	0.04	*	0.04	0.33	0.24	0.03	2.2, *J6*
TOC (mg/L)	9.8	9.8	*	10	9.4	9.9	10	10
Turbidity (NTU)	13	16	9.1					
T. Residue (mg/L)	95	96	80					
Sus. Residue (mg/L)	12	12	7.2					
Hardness (mg/L)			24					

U- Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit.

J6- The laboratory analysis was from an unpreserved or improperly chemically preserved sample. The data may not be accurate.

* - on 6/13 TOC and Nutrient samples were not preserved in accordance with SOP, samples were discarded.

Appendix III

6/20/2016	CPFTR05	CPFTR03	CPFTR01	CPFRR01	CPFRR02	CPFRR03	CPFRR04	CPFRR05
BOD_5 (mg/L)	*	*	*	4.7, *G5*	3.8, *G5*	2.8, *G5*	6.7, *G5*	3.8, *G5*
Chl *a* (µg/L)	*	*	*	33	4	16	64	2.6
DP (mg/L)	*	*	*	0.02	0.04	0.04	0.03	0.04
TP (mg/L)	*	*	*	0.07	0.06	0.08	0.08	0.06
DKN (mg/L)	*	*	*	0.49	0.57	0.53	0.55	0.85
TKN (mg/L)	*	*	*	0.97	0.66	0.66	0.95	0.81
NH_3N (mg/L)	*	*	*	0.03	0.02, *U*	0.03	0.02, *U*	0.06
No_x (mg/L)	*	*	*	0.02, *U*	0.3	0.18	0.02, *U*	3.1
TOC (mg/L)	*	*	*	10	9.7	9.4	10	8.8
Turbidity (NTU)	*	*	*					
T. Residue (mg/L)	*	*	*					
Sus. Residue (mg/L)	*	*	*					
Hardness (mg/L)	*	*	*					
7/7/2016	**CPFTR05**	**CPFTR03**	**CPFTR01**	**CPFRR01**	**CPFRR02**	**CPFRR03**	**CPFRR04**	**CPFRR05**
BOD_5 (mg/L)	7.3, *G5*	7.9, *G5*	11, *G5*	5.9, *G5*	2.3, *G5*	5.4, *G5*	8.9, *G5*	5.3, *G5*
Chl *a* (µg/L)	67	100	210	15	1.1	22	80	2.4
DP (mg/L)	0.03	0.03	0.04	0.03	0.06	0.04	0.03	0.05
TP (mg/L)	0.09	0.08	0.1	0.08	0.06	0.07	0.07	0.06
DKN (mg/L)	0.63	0.6	0.66	0.68	0.51	0.48	0.55	0.85
TKN (mg/L)	1.1	1.2	1.3	0.94	0.58	0.63	0.92	0.87
NH_3N (mg/L)	0.02, *U*	0.02, *U*	0.02, *U*	0.08	0.02	0.03	0.02, *U*	0.05
No_x (mg/L)	0.02, *U*	0.02	0.02, *U*	0.08	0.44	0.13	0.02, *U*	6.7
TOC (mg/L)	9.9	10	11	11	8.9	8.3	9.6	8.3
Turbidity (NTU)	14	14	11					
T. Residue (mg/L)	88	86	84					
Sus. Residue (mg/L)	12	12, *U*	9					
Hardness (mg/L)			30					

* - 6/20 Samples were not collected in Charles Turner Reservoir.

G5-A single quality control failure occurred during biochemical oxygen demand (BOD) analysis. The sample results should be used with caution, the glucose/ glutamic acid standard exceeded the range of 198 ± 30.5 mg/L.

U- Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit.

Appendix III

7/14/2016	CPFTR05	CPFTR03	CPFTR01	CPFRR01	CPFRR02	CPFRR03	CPFRR04	CPFRR05
BOD_5 (mg/L)	6.4	6.1	4.2	*	*	*	*	*
Chl *a* (µg/L)	78	81	46	*	*	*	*	*
DP (mg/L)	0.04	0.03	0.02	*	*	*	*	*
TP (mg/L)	0.09	0.1	0.06	*	*	*	*	*
DKN (mg/L)	0.63	0.62	0.65	*	*	*	*	*
TKN (mg/L)	1.3	1.2	1	*	*	*	*	*
NH_3N (mg/L)	0.02, *U*	0.02, *U*	0.02, *U*	*	*	*	*	*
No_x (mg/L)	0.02	0.02, *U*	0.02	*	*	*	*	*
TOC (mg/L)	10	11	10	*	*	*	*	*
Turbidity (NTU)	18	19	15					
T. Residue (mg/L)	94	92	86					
Sus. Residue (mg/L)	15	15	8.2					
Hardness (mg/L)			29					

* - 7/14, Samples were only collected in Charles Tuner Reservoir.

U- Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit.

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