2018 Evaluation of Compliance with Numeric Nutrient Criteria (NNC) for Rocky Bayou (Choctawhatchee Bay)

Prepared for:

Regional Sewer Board (RSB) and Sweetgum Environmental

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1 EXECUTIVE SUMMARY

A primary purpose of this study was to collect four temporally independent water quality samples (measuring TN, TP, corrected chlorophyll a, dissolved oxygen percent saturation, temperature, pH, salinity, and Secchi depth) at four stations in Rocky Bayou. FDEP considered the stations sampled to be representative of the locations used to establish Numeric Nutrient Criteria for Rocky Bayou. The data collected by Frydenborg EcoLogic and analyzed by a Dept. of Health certified lab (Test America) indicated that the Annual Geometric Mean **TN (0.208 mg/L), TP (0.002 mg/L), and chlorophyll a (1.4 µg/L) all achieved their respective estuary-specific criteria in 2018**.

Subsequently, these data were compared to data available from FDEPs Watershed Information Network and Impaired Waters Rule (IWR) Database and a quality assurance exercise was conducted on data used by FDEP. Evidence presented in this report indicates that FDEP appears to have incorrectly used TKN and/or nitrate-nitrite values that were less than the Practical Quantitation Limit (PQL) in the Impaired Waters Rule Assessment without appropriately adjusting the values to be equivalent to the Method Detection Limit (as stated by FDEP policy and as specified in Chapter 62-4.246 F.A.C.). When the proper data adjustment was conducted by Frydenborg EcoLogic, there were no TN exceedances during the last 7 years, a finding that contradicts the FDEP Impaired Waters listing decision for Rocky Bayou.

The EPA-recommended biological endpoints continue to be achieved in Rocky Bayou, indicating that healthy conditions prevail.

It is requested that FDEP reanalyze the Rocky Bayou data using the appropriate Quality Assurance protocols, which would result in de-listing Rocky Bayou from the IWR category 4e listing.

2 INTRODUCTION

At the request of the Niceville/Valparaiso Regional Sewer Board (RSB) and Sweetgum Environmental, Frydenborg EcoLogic, LLC, conducted four water quality sampling events at four representative stations in Rocky Bayou during 2018. Additionally, Frydenborg EcoLogic compiled and evaluated data from the FDEPs Watershed Information Network as a quality assurance exercise.

The current NNC for Choctawhatchee Bay are shown in **Table 2-1,** and a plot of the TN criteria for all Choctawhatchee Bay segments is shown in **Figure 2-1**.

Table 2-1. Approved Numeric Nutrient Criteria for Choctawhatchee Bay and associated bayous.

(m) Choctawhatchee Bay	For bay segments with criteria expressed as annual geometric means (AGM), the values shall not be exceeded more than once in a three year period. For all other bay segments, the criteria shall not be exceeded in more than 10 percent of the measurements. Nutrient and nutrient response values do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.		
	TP	**TN**	**Chlorophyll a**
1. Alaqua Bayou	0.027 mg/L as AGM	0.41 mg/L as AGM	4.0 µg/L as AGM

2. Basin Bayou	0.019 mg/L as AGM	0.31 mg/L as AGM	4.7 µg/L
3. Boggy Bayou	0.015 mg/L as AGM	0.33 mg/L as AGM	3.0 µg/L as AGM
4. East Bay	0.027 mg/L as AGM	0.46 mg/L as AGM	4.4 µg/L as AGM
5. Garnier Bayou	0.017 mg/L as AGM	0.91 mg/L as AGM	4.0 µg/L as AGM
6. LaGrange Bayou	0.029 mg/L as AGM	0.58 mg/L as AGM	5.1 µg/L as AGM
7. Middle Bay	0.020 mg/L as AGM	0.36 mg/L as AGM	3.1 µg/L as AGM
8. Rocky Bayou	**0.016 mg/L as AGM**	**0.33 mg/L as AGM**	**3.1 µg/L as AGM**
9. West Bay	0.049 mg/L as AGM	0.54 mg/L as AGM	4.1 µg/L as AGM

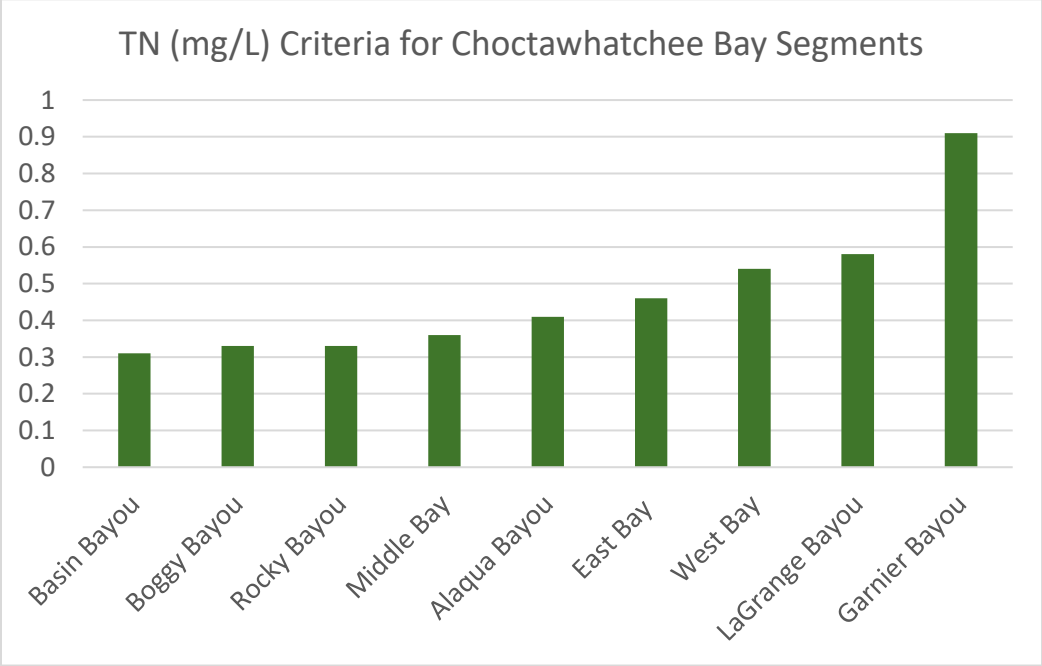

Figure 2-1. Bar graph of TN (mg/L) criteria for Choctawhatchee Bay Segments.

The location of Rocky Bayou in relation to other Choctawhatchee Bay segments is shown in **Figure 2-2**. Note that Submerged Aquatic Vegetation is naturally not found in Rocky Bayou (**Figure 2-3**).

In early 2016, Rocky Bayou (WBID 722) was placed on the draft verified Impaired Waters List based on exceedances of total nitrogen (TN). Based upon a request from the Niceville/Valparaiso Regional Sewer Board, FDEP subsequently placed Rocky Bayou (WBID 722) into assessment category 4e (impaired, but recently completed or on-going restoration activities are underway to restore the designated uses of the waterbody) in lieu of assessment category 5 (water quality standards are not attained and a TMDL is required). It has been the Niceville/Valparaiso Regional Sewer Board's opinion that the data FDEP used to list Rocky Bayou as impaired was in conflict with FDEP's Quality Assurance protocols, and therefore, an evaluation of the data in FDEP's IWR database was conducted as part of this study.

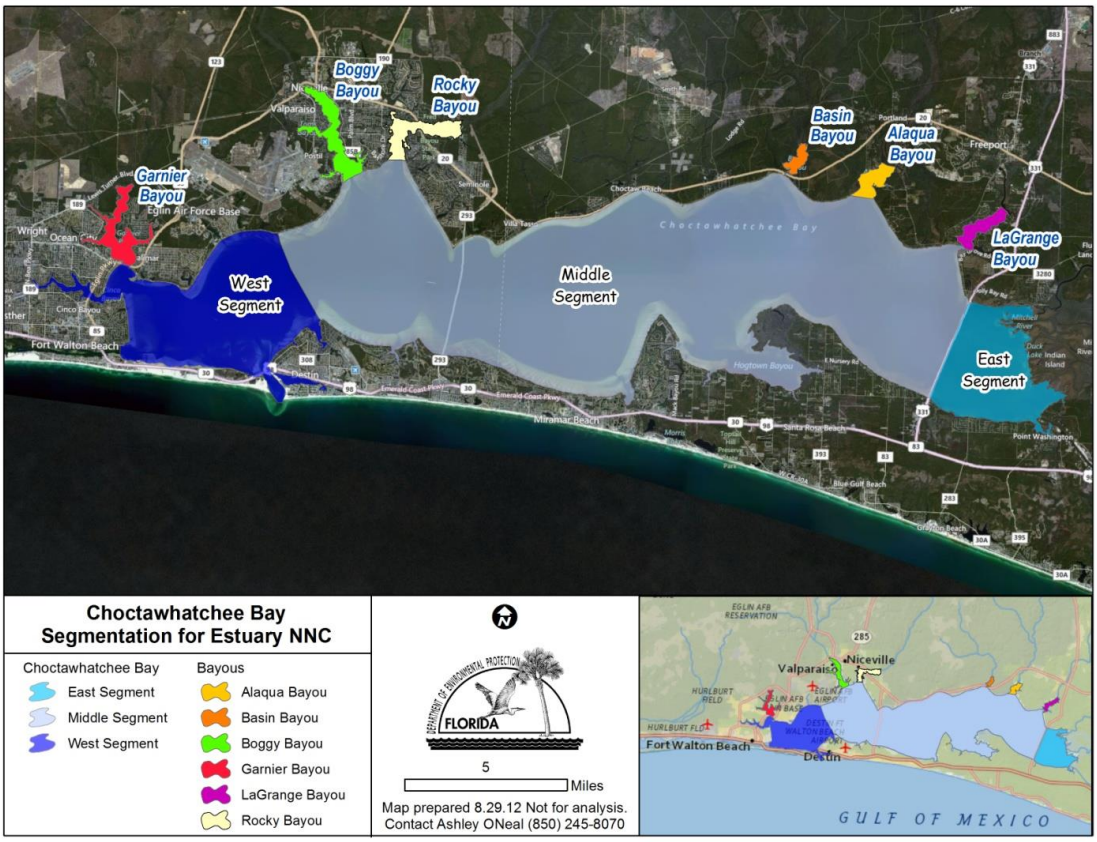

Figure 2-2. Location of Rocky Bayou in relation to other Choctawhatchee Bay segments (FDEP, 2013).

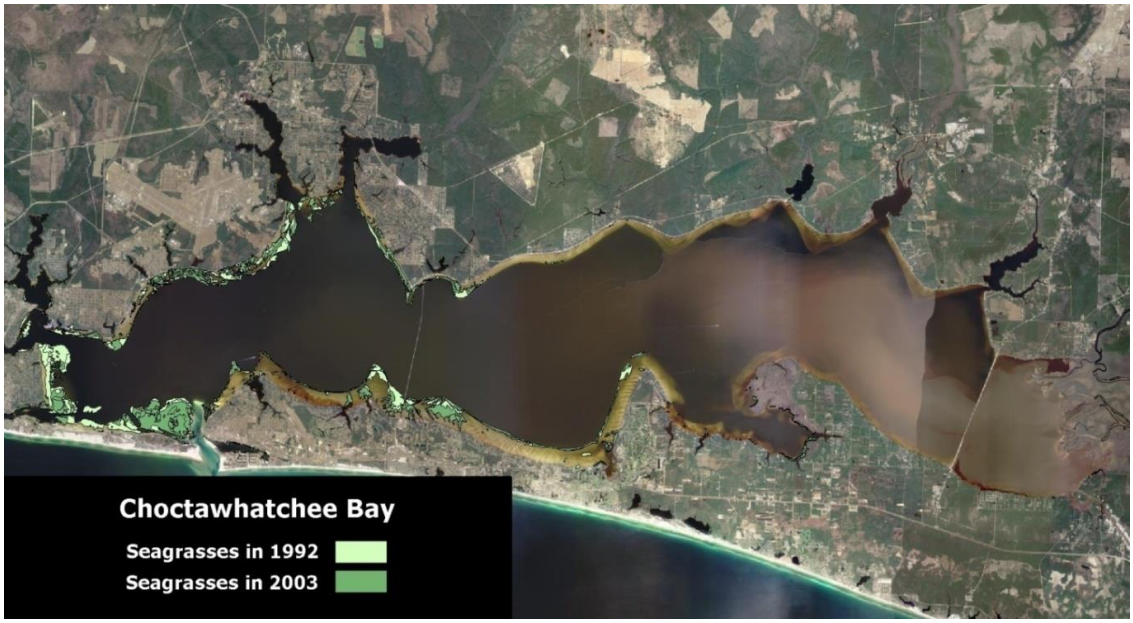

Figure 2-3. Choctawhatchee Bay seagrass coverage comparison, 1992 and 2003 (Alexander, 2010). Note that Rocky Bayou is naturally devoid of SAV.

This study consisted of examining three main issues:

1. Independently sampling and analyzing critical water quality parameters (TN, TP, chlorophyll a, dissolved oxygen, and Secchi depth) to compare with data in the FDEP Impaired Waters Rule (IWR) database and FDEP Water Information Network (WIN) database;
2. Conducting a quality assurance evaluation of past and present Rocky Bayou data to determine if the data were appropriately used for the IWR listing; and
3. Determining if the EPA-recommended biological endpoints for Secchi depth, chlorophyll *a*, and dissolved oxygen continued to be achieved in Rocky Bayou, which would indicate that no adverse ecological effects have occurred in the system.

3 METHODS

3.1 FIELD

FDEP SOPs (e.g., FA 1000, FS 1000, FQ 1000, FS 2000, FS 2100, FT 1000, FT 1700) were followed for collection of all parameters. The four stations were sampled during the same day via the subsurface grab technique. Because all sites were readily accessible by boat, sampling occurred at a variety of tidal cycles. Four sampling events were conducted during 20187 to enable calculation of annual geometric means for that year.

3.2 SPATIAL

Table 3-1 provides the latitude and longitude of the four sampling locations, which were approved by Ken Weaver (FDEP) on 3-24-17. Photos of selected sites are shown in **Figure 3-1** through **Figure 3-3**. Frydenborg EcoLogic noted substantial birds and guano at the dock near RB04, from which other parties conduct sampling. Frydenborg EcoLogic sampled the area ~20 m away from the dock to avoid artificial contamination of the samples with bird guano. Maps of sampling sites were produced in QGIS 2.8.1 and in R using the ggmaps package (**Figure 3-4** and **Figure 3-5).**

Table 3-1. Sampling locations for the Rocky Bayou NNC study conducted by Frydenborg EcoLogic.

Station	Alternative names	FrEco Station Number	Longitude	Latitude
FREC RB01	(new station)	RB01	-86.423	30.50418
21FLKWATOKA-CB-BEACH-9	21FLCBA NVL01	RB02	-86.4324	30.50355
21FLKWATOKA-CEVILLE-2-1	21FLCBA NVL02	RB03	-86.4527	30.5073
21FLCMP 32010GR2	21FLCMP 32010GR3	RB04	-86.4537	30.50055

3.3 STATISTICAL

Data used in the analysis were derived from three sources: IWR, WIN, and Frydenborg Ecologic. IWR data (run 52) were downloaded as an Access database from this link: http://publicfiles.dep.state.fl.us/dear/IWR/. Frydenborg EcoLogic queried this database to obtain TN, TKN, NOx, TP, chlorophyll, Secchi, and dissolved oxygen percent saturation from 2002 to the most recent year (2018) for WBID 722 (Rocky Bayou). This query was exported as a CSV file, which was then loaded into Rstudio 1.0.44 with R 3.3.1. Data collected by Frydenborg Ecologic in 2017 and 2018 were joined to this data set within R. WIN and the IWR database were queried for data in WBID 722 for 2018. These data were downloaded as a text file, which as imported into R and joined with the other data sets. Data flagged for

being less than the PQL ("I"- qualified) were adjusted to be equal to the respective MDL, results flagged as "U" were halved, and duplicates (based on date, time, agency, parameter, and result) were removed. Annual Geometric Means (AGMs) were calculated from this cleaned data set using the geomean function from the EnvStats package. The TN AGMs from the IWR database (which did not appear to be adjusted for the "I" qualifier) were compared to the adjusted data. Adjusted TN was calculated by adding adjusted TKN and adjusted NOx. Not all TN values in the data set had associated nitrogen components, and adjusted TN could not be calculated for those values. These TN values were copied to the adjusted TN data column in order to not use a different number of samples when comparing the TN AGMs. The figure was made using ggplot2. A key question of the TN analyses was, "Does Rocky Bayou comply with NNC if the proper quality assurance protocols (adjusting for the "I" qualifier) are conducted?"

Figure 3-1. Rocky Bayou State Park Boat Ramp, with RB02 (mid-bay left) and RB01 (far right) in the distance.

Figure 3-2. Typical bird population associated with Frydenborg EcoLogic sampling location RB04.

Figure 3-3. Frydenborg EcoLogic station RB04.

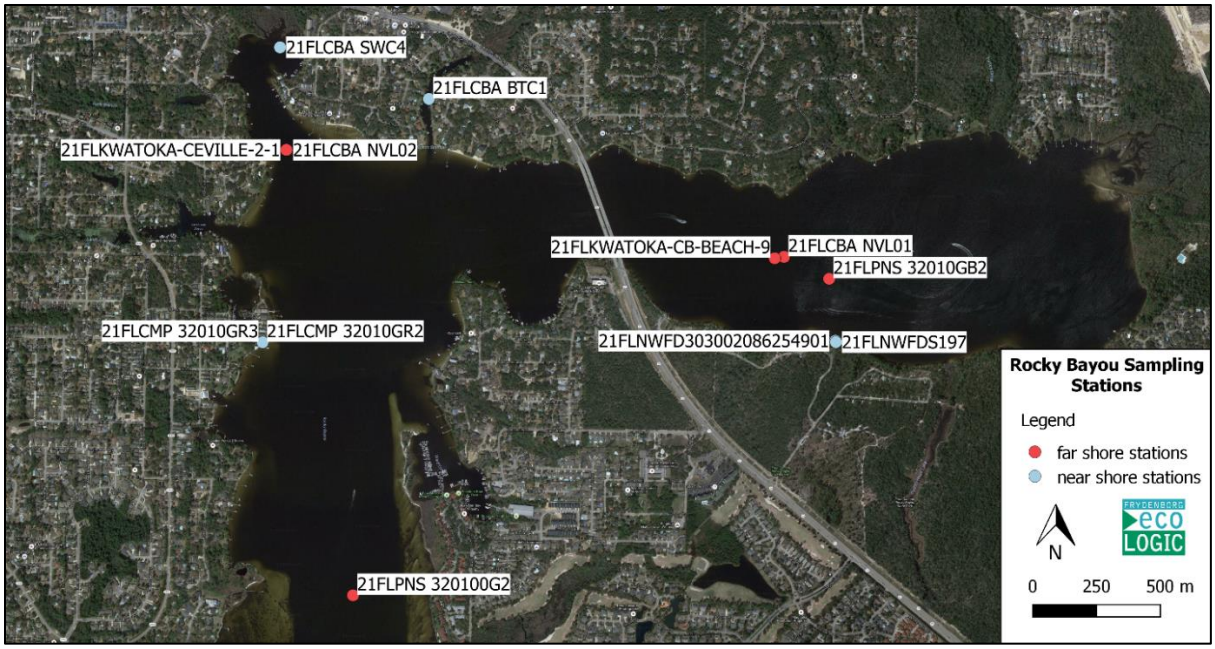

Figure 3-4. Location of historic stations in Rocky Bayou.

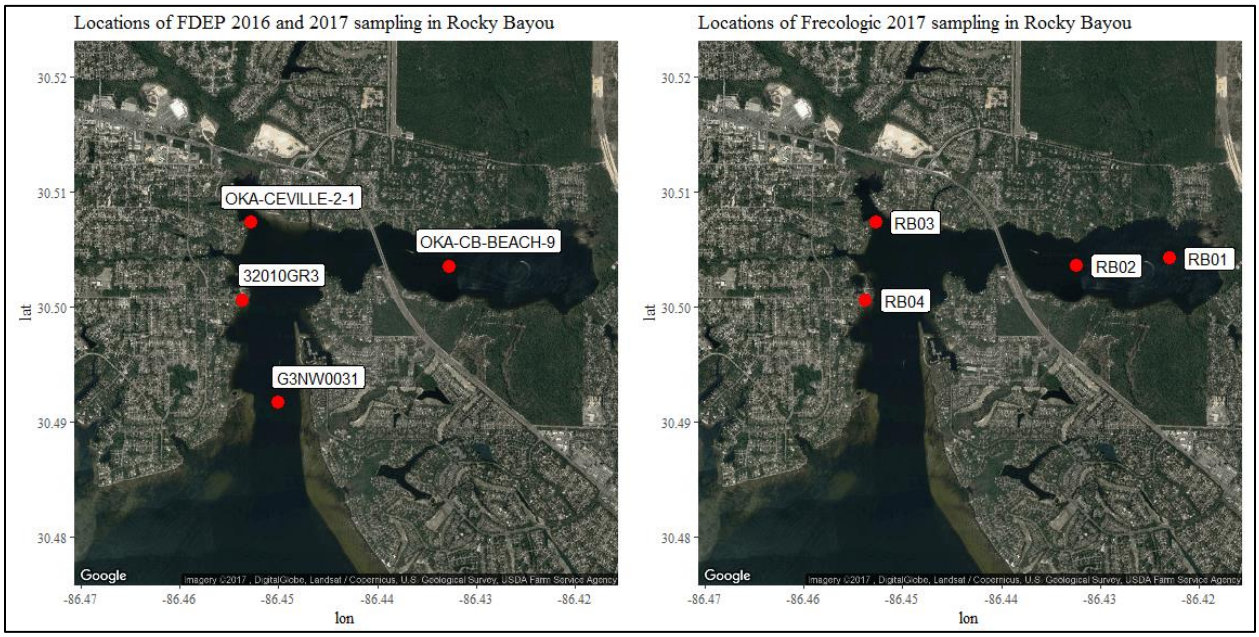

Figure 3-5. Sampling locations for data collected by FDEP and Frydenborg Ecologic in 2017 through 2018.

4 RESULTS AND DISCUSSION

4.1 RESULTS OF WATER QUALITY SAMPLING CONDUCTED BY FRYDENBORG ECOLOGIC IN 2018

The TN, TP, and chlorophyll *a* results for Rocky Bayou, collected by Frydenborg EcoLogic and analyzed by Test America, is shown in **Figure 4-1** through **Figure 4-3**.

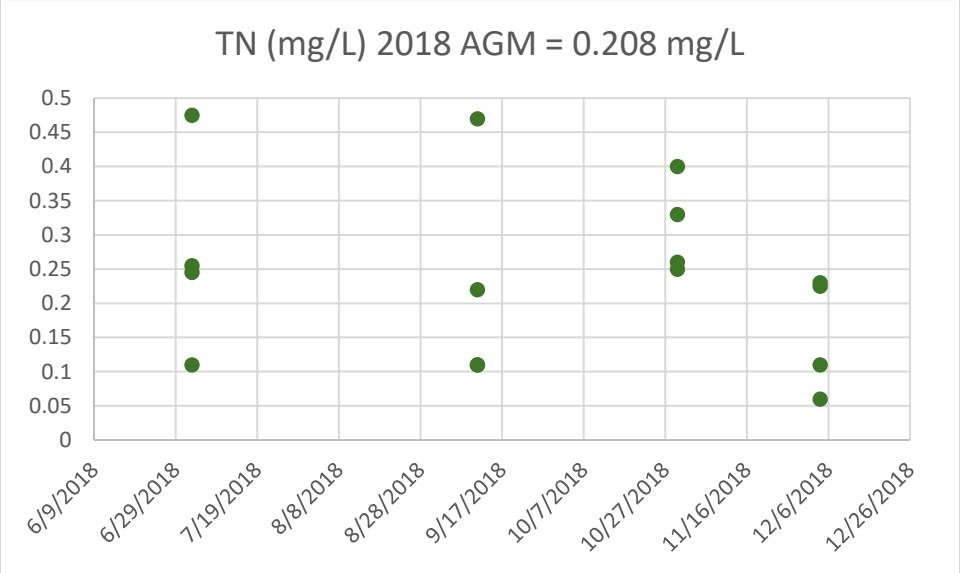

Figure 4-1. 2018 TN data collected by Frydenborg EcoLogic, with an Annual Geometric Mean of 0.208 mg/L.

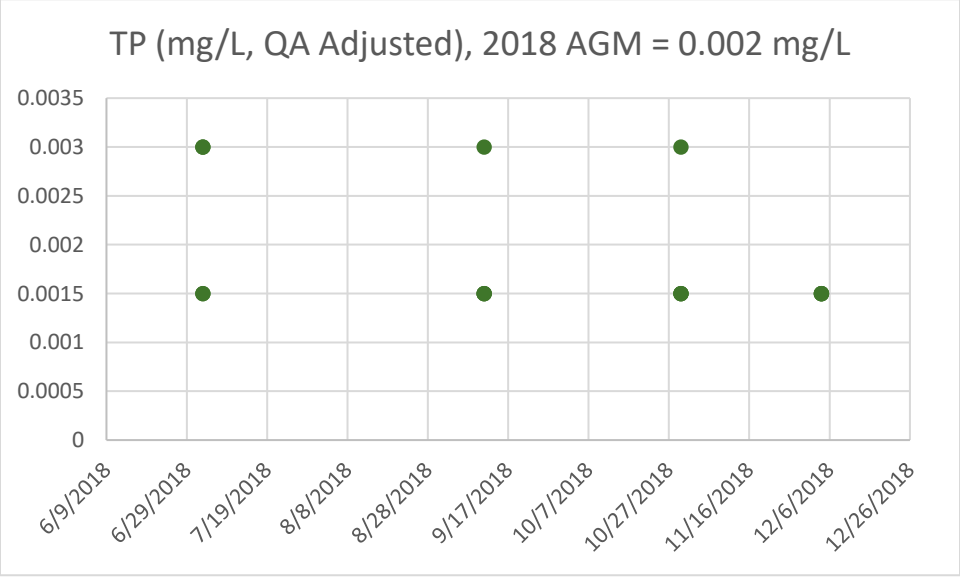

Figure 4-2. 2018 TP data collected by Frydenborg EcoLogic, with an Annual Geometric Mean of 0.002 mg/L. Due to MDL and PQL adjustments, some values overlap. Note that n = 4 for each sampling event.

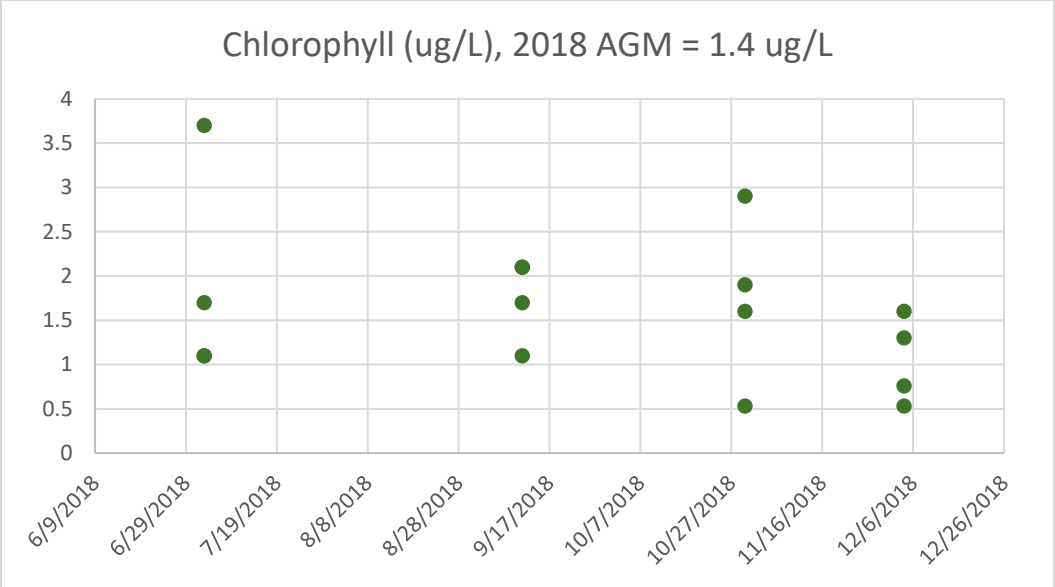

Figure 4-3. 2018 chlorophyll a data collected by Frydenborg EcoLogic, with an Annual Geometric Mean of 1.4 µg/L.

Table 4-1. Comparison of Rocky Bayou water quality criteria with 2018 data collected by Frydenborg EcoLogic and analyzed by Test America.

Rocky Bayou Criteria	TP 0.016 mg/L as AGM	TN 0.33 mg/L as AGM	Chloro 3.1 µg/L as AGM
2018 FrEco Rocky Bayou Results	TP 0.002 mg/L as AGM	TN 0.208 mg/L as AGM	Chloro 1.4 µg/L as AGM
Pass?	Yes	Yes	Yes

Table 4-1 summarizes the calculated Annual Geometric Means of each parameter with a comparison to the Rocky Bayou Numeric Nutrient Criteria. As seen in the table, the data collected by Frydenborg EcoLogic and analyzed by Test America indicated that the TN, TP, and chlorophyll a criteria were achieved in 2018.

4.2 Quality Assurance Concepts and Assessment of Rocky Bayou IWR Data

4.2.1 Quality Assurance Concepts

Quality assurance concepts relevant to proper data interpretation are presented here. The **Method Detection Limit (MDL, qualified by "U")** is the minimum concentration that can be measured with 99% confidence that the analyte concentration is greater than zero (FDEP, 2005). This is determined via a Method Detection Limit Study, generally in which many replicates of analyte-free water are analyzed for the parameter in question (e.g., TKN). The standard deviation of the resulting measurements is calculated and multiplied by a factor of three (3) to establish the MDL. This provides a value, above which the method can determine that the analyte is "present" with a 99% confidence limit (FDEP, 2005).

The Practical Quantitation Limit (PQL, with values between the MDL and PQL, qualified by "I") is the lowest level of measurement that can be **reliably achieved** during routine laboratory operating conditions within **specified limits of precision and accuracy** (FDEP, 2005). A default PQL is generally determined as the MDL multiplied by a factor if 4.

Data between the MDL and PQL are considered qualitative only, and indicate detection, but NOT true quantification of the analyte (FDEP, 2005).

Chapter 62-4.246, F.A.C., specifies the following:

- Results greater than or equal to the PQL are reported as measured;
- Results less than the PQL and greater than or equal to the MDL shall be deemed as equal to the MDL (see **Figure 4-4**); and
- Results less than the MDL shall be reported as "non-detects". Generally, one half of the specified MDL is used for calculations.

FDEP's Impaired Waters Rule (IWR) assessment is consistent with Chapter 62-4.246, F.A.C. On November 2, 2017, Kevin O'Donnell, Administrator of the Watershed Assessment Section, stated in an e-mail that, "In the IWR assessment, if the water quality result is I-qualified, the result value will be set to be equal to the MDL".

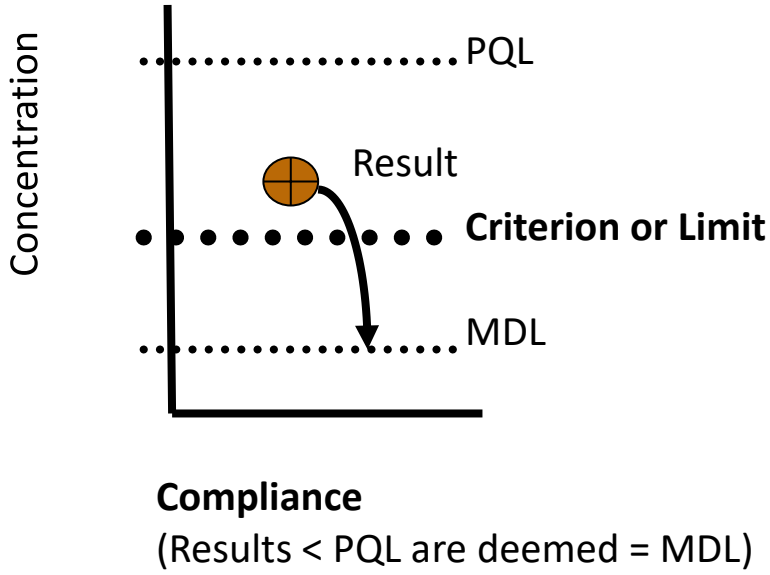

Figure 4-4. Visual example of properly interpreting the provisions of Chapter 62-4.246, F.A.C, when a reported value is less than the PQL.

4.2.2 Quality Assurance Assessment of Rocky Bayou IWR Data

Frydenborg EcoLogic examined data from the Watershed Information Network (WIN) and the Impaired Waters Rule (IWR) database, in conjunction with the 2017 and 2018 data we collected. During 2015 and 2016, there appeared to be a noteworthy increase in the TKN MDL and PQL, with a large number of data points receiving an "I" qualifier. As shown above, results less than the PQL and greater than or equal to the MDL shall be deemed as equal to the MDL. However, it appeared that this adjustment did not occur during the IWR database TN calculation step, where TKN and NOx are added together. When the data were systematically adjusted to transform "I"-qualified TKN data to be equal to the MDL before calculating TN, there was a large difference in the AGMs for 2012-2015 (**Figure 4-5, Table 4-2**). In fact, after the appropriate adjustment, there were no exceedances of the Rocky Bayou TN criterion during 2012-2018 period. This indicates that FDEP should recalculate the AGMs using the correct procedure which would result in removal of Rocky Bayou from the 4e Impaired Waters list.

Table 4-2. Rocky Bayou TN Annual Geometric Means, including FDEP IWR database values (without adjusting "I"- qualified values to be equal to the MDL) and with TN values properly adjusted (corrected values).

Year	TN AGM	TN n	TN corrected AGM	TN corrected n
2002	0.25	23	**0.25**	23
2003	0.32	34	**0.30**	34
2004	0.25	26	**0.24**	26
2005	0.26	23	**0.24**	23
2006	0.23	26	**0.21**	26
2007	0.23	22	**0.23**	22
2008	0.27	25	**0.27**	25
2009	0.32	24	**0.30**	24
2010	0.30	30	**0.27**	30
2011	0.27	38	**0.24**	38
2012	0.32	44	**0.29**	44
2013	0.32	54	**0.29**	54
2014	0.30	40	**0.27**	40
2015	0.35	46	**0.32**	46
2016	0.34	59	**0.32**	59
2017	0.26	40	**0.21**	40
2018	0.28	22	**0.25**	22

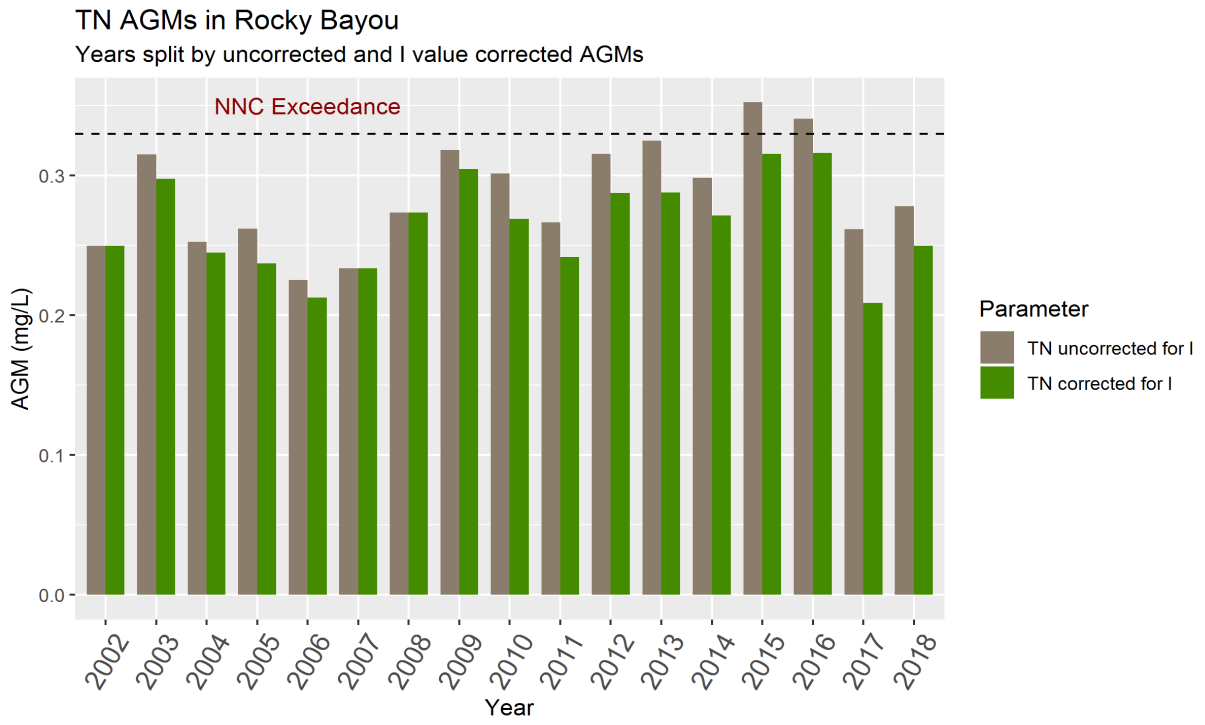

Figure 4-5. Rocky Bayou Annual Geometric Mean TN from 2002 to present, including original values and "I"-qualified values (below the Practical Quantitation Limit) adjusted to be equal to the Method Detection Limit. Data was from the IWR, WIN, and Frydenborg EcoLogic.

4.3 EPA AND FDEP-RECOMMENDED BIOLOGICAL ENDPOINTS FOR ESTUARY NNC DEVELOPMENT

FDEP originally used the "reference conditions approach" (also called the "maintain existing conditions" approach) for developing Numeric Nutrient Criteria for Choctawhatchee Bay. Although FDEP noted Submerged Aquatic Vegetation (SAV) losses in the main body of the bay over time, these SAV losses were attributed to factors other than nutrients, such as physical disruption, salinity changes, color, and Total Suspended Solids. FDEP noted extremely low chlorophyll *a* was characteristic of the system (FDEP, 2013).

After the NNC were established for Choctawhatchee Bay, EPA developed a recommended approach for estuarine NNC, which involved three biologically based targets:

- Dissolved Oxygen of 42% saturation;
- Chlorophyll *a* levels < 20 µg/L more than 90% of the time; and
- Site-specific Secchi depth targets to protect SAV.

Subsequent to developing NNC for Choctawhatchee Bay, FDEP analyzed these EPA targets (with some exceptions) for the various bay segments to ensure the existing NNC were consistent with these ecological goals. For examples of the exceptions, FDEP did not use Secchi depth in areas where SAV was not naturally found (e.g., many bayous and eastern Bay Segment 301. FDEP (2013) states, "Because the biological targets were met for the majority of the segments and times, these results support the application of a Reference Period Approach for development of NNC in Choctawhatchee Bay". Additionally, EPA's mechanistic modeling showing that the Kd (light penetration) was insensitive to changes in nutrient load. In the EPA models, light targets were not met in their natural background scenario or in their 2002-2009 calibration period.

If the following endpoints are achieved in a given year, EPA and FDEP consider the associated nutrient and chlorophyll data to be protective of healthy, well balanced communitites (FDEP, 2013):

- Site-specific seagrass depth (Z_c) and water clarity (K_d) targets to **achieve 20% of surface light at the mean depth of the deep edge of seagrass beds**, relative to mean sea level, based on historic or recent seagrass coverages (where applicable, as proposed by EPA (2012), using Secchi depth measurements;

- A chlorophyll *a* target to prevent nuisance algal blooms (**not to exceed 20 µg/L >10% of the time based on annual data**); and

- Dissolved Oxygen (DO) targets to protect aquatic life, such that the daily average percent DO saturation is not be below 42 percent saturation in more than 10 percent of the values.

4.3.1 Site-Specific Seagrass Colonization Depth (Zc) and Water Clarity (Kd) Targets

EPA (2012) proposed a seagrass depth of colonization target for different segments of Choctawhatchee Bay. EPA found that the light attenuation coefficient based on the depth of colonization target could not be met for segments 0302 and 0303 using either the light attenuation coefficient based on 2002–2009 nutrient loads or the light attenuation coefficient based on the non-anthropogenic nutrient scenario. An evaluation of model sensitivity revealed that the DO and light targets were insensitive to changes in nutrients (EPA, 2012). FDEP calculated a Secchi depth target (SD_{target}) from the depth target (D_{target}) as follows:

$$\mathrm{SD}_{\mathrm{target}} = \frac{1.44}{-\ln(0.2)}\mathrm{D}_{\mathrm{target}}$$

As part of a weight of evidence approach to generating NNC for the Choctawhatchee Bay, FDEP compared annual average Secchi depth target ($\mathrm{SD}_{\mathrm{target}}$) with the colonization target (D_{target}) to identify years in which water clarity supported seagrass depth targets.

FDEP examined all available SD data in the Impaired Waters Rule Database (IWR) Run 47 database after removal of SD values that were greater than 10 meters and values for which the Secchi disk was visible on bottom (VOB). The dataset was also visually inspected for erroneous values, which were removed. If the annual average SD for a segment was deeper than the Z_c, then the segment was considered to achieve the target of 20% surface light available on bottom for seagrass support for that year. If the segment did not achieve the target based on the annual average SD, the site depth of VOB measurements was compared with Z_c (FDEP, 2013).

Although the annual average Secchi depth (SD) measurement frequently achieved the EPA depth to seagrass colonization target (Zc), **this endpoint was shown by EPA to be insensitive to nutrients in Choctawhatchee bay, and therefore, it was not applicable for NNC development** (FDEP, 2013).

4.3.2 Chlorophyll a

Chlorophyll *a* is an indicator of phytoplankton biomass and can reflect the integrated effects of many ecological factors, including nutrient loading. Increased phytoplankton biomass, expressed as increased chlorophyll *a* concentrations, is the mechanism by which anthropogenic nutrient enrichment can cause excess organic matter and reduced water clarity, leading to ecosystem changes such as SAV loss. As an indicator, chlorophyll *a* responds to increased or excess nutrient loading, is relevant to the biological health of an estuary, and is practical to measure (FDEP, 2013).

For criteria development, FDEP analyzed available chlorophyll *a* data to determine if chlorophyll a concentrations exceeded 20 µg/L in more than 10% of the measurements for each year (EPA 2012). If chlorophyll *a* in a given estuary segment did not exceed 20 µg/L in more than 10% of the annual measurements, the segment was considered to be attaining the designated use with respect to chlorophyll *a* for that year (FDEP, 2013).

For Choctawhatchee Bay, FDEP used the IWR Run 47 database (the most recent IWR run). For "T" or "U"- qualified data, one half of the value was used (see Table of Qualifier Codes in Appendix A). Chlorophyll *a* results less than 1 µg/L were set to 1 µg/L. FDEP excluded data with fatal qualifier codes (rcode or xcode): H, J, K, N, O, Q, Y, and ? (FDEP, 2013).

The 2018 Annual Geometric Mean chlorophyll a for Rocky Bayou was 1.4 µg/L, with no values exceeding 20 µg/L (**Figure 4-3, Table 4-1**).

4.3.3 Dissolved Oxygen

Nutrient enrichment potentially may cause reductions in dissolved oxygen (DO) concentrations and changes in the DO regime through increased respiration from plants (algae or macrophytes) and decomposition of organic material produced from excess nutrients. The marine DO criterion is 42% saturation. DO concentrations below the water quality criteria can also occur naturally in Florida estuaries in association with water column stratification or naturally high organic matter levels (FDEP, 2011). Based on 2018 data collected by Frydenborg EcoLogic, the marine DO criterion was achieved during all dates and all stations (**Figure 4-6**).

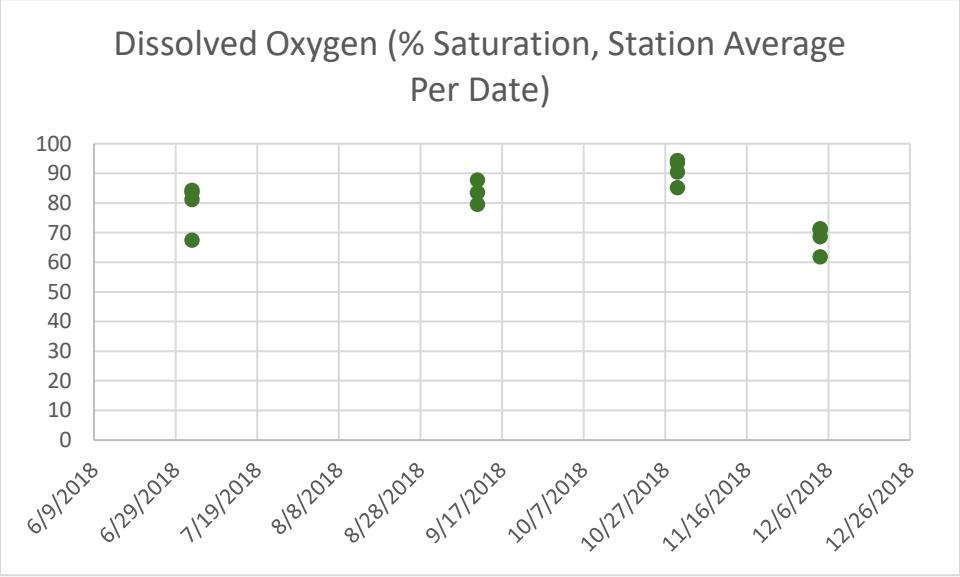

Figure 4-6. Rocky Bayou dissolved oxygen (% saturation) measured by Frydenborg EcoLogic in 2018.

4.3.4 Assessment of EPA and FDEP-Recommended Biological Endpoints in Rocky Bayou

DO, chlorophyll *a*, and Secchi data were retrieved from the IWR data base Run 52 and evaluated by year for achievement of the biological endpoints presented in above in the Section "EPA and FDEP-Recommended Biological Endpoints for Estuary NNC Development". The results are presented in **Table 4-3.**

Table 4-3. Achievement of EPA and FDEP-Recommended Biological Endpoints for Estuary NNC Development by year for Rocky Bayou.

Year	# DO failures (<42% sat.)	# DO Obs.	# Chloro failures (>20 ug/L)	# Chloro Obs.	% DO Exceed.	% Chloro Exceed.	Secchi 90% CI (m)	Secchi target (> 2.35 m)
2012	**2**	**44**	**0**	**0**	**4.5, Pass**	**NA**	**4.7**	**Pass**
2013	**1**	**55**	**0**	**10**	**1.8, Pass**	**0, Pass**	**3.4**	**Pass**
2014	**0**	**44**	**0**	**0**	**0, Pass**	**NA**	**NA**	**NA**
2015	**1**	**40**	**0**	**6**	**2.5, Pass**	**0, Pass**	**3.8**	**Pass**
2016	**0**	**0**	**0**	**23**	**0, NA**	**0**	**3.0**	**Pass**
2017	**0**	**16**	**0**	**16**	**0, Pass**	**0, Pass**	**2.8**	**Pass**
2018	**0**	**16**	**0**	**16**	**0, Pass**	**0, Pass**	**3.1**	**Pass**

For each year when data were available, all the targets were achieved, indicating that there were no adverse ecological effects in Rocky Bayou during the last seven years.

5 CONCLUSIONS

The data collected by Frydenborg EcoLogic and analyzed by Test America indicated that the Annual Geometric Mean **TN (0.208 mg/L), TP (0.002 mg/L), and chlorophyll a (1.4 µg/L) all achieved their respective criteria in 2018**.

Evidence presented in this report indicates that in the past, FDEP incorrectly used TKN and/or nitrate-nitrite values that were less than the Practical Quantitation Limit (PQL) in the Impaired Waters Rule Assessment without appropriately adjusting the values to be equivalent to the Method Detection Limit (as stated by FDEP policy and as specified in Chapter 62-4.246 F.A.C.). When the proper data adjustment was conducted by Frydenborg EcoLogic, there were no TN exceedances during the last 7 years, a finding that contradicts the FDEP Impaired Waters listing decision for Rocky Bayou.

The EPA-recommended biological endpoints continue to be achieved in Rocky Bayou, indicating that healthy conditions prevail.

It is requested that FDEP reanalyze the Rocky Bayou data using the appropriate Quality Assurance protocols which would result in removal of Rocky Bayou from the impaired waters 4e listing.

6 REFERENCES

Alexander, S. (2010). Choctawhatchee Bay. A presentation to the Pensacola public workshop, February 10, 2010, in support of the development of numeric nutrient criteria in Florida estuaries and coastal waters.

EPA (2012). Technical Support Document for U.S. EPA's Proposed Rule for Numeric Nutrient Criteria for Florida's Estuaries, Coastal Waters, and South Florida Inland Flowing Waters. Volume 1: Estuaries.

FDEP (2005). Detection and Quantitation Limit Concepts.

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FDEP (2013). Site-Specific Information in Support of Establishing Numeric Nutrient Criteria for Choctawhatchee Bay.

7 APPENDIX

7.1 FRYDENBORG ECOLOGIC DATA

7.1.1 Metered Parameters

Date	Time	Station	Depth (m)	Temp (°C)	pH (SU)	Cond (umhos/cm)	Salinity (PSU)	DO%	Station DO %	DO mg/L	Secchi (m)
7/3/2018	1021	RB01	0.2	28	7.4	8495	4.8	85.4		6.5	1
7/3/2018	1021	RB01	2	29.7	7.5	13850	8	88		6.4	
7/3/2018	1021	RB01	3.8	30.7	7.7	17450	10.3	77.4	83.6	5.5	
7/3/2018	1030	RB02	0.2	27	7.2	5695	3.1	80		6.3	0.8
7/3/2018	1030	RB02	2.2	29.6	7.2	14670	8.1	90.3		6.6	
7/3/2018	1030	RB02	4.1	31.3	7.7	21600	12.9	73.2	81.17	5	
7/3/2018	1042	RB03	0.2	27.8	7.3	5111	2.8	91.5		7.1	1
7/3/2018	1042	RB03	1.6	28	7.2	7424	4.2	83.5		6.3	
7/3/2018	1042	RB03	3.7	30.5	7.3	18300	10.8	78	84.33	5.5	
7/3/2018	1051	RB04	0.2	27.5	7	6370	3.5	82.9		6.4	0.9
7/3/2018	1051	RB04	1.8	29.9	7.3	16770	9.7	85.1		6.1	
7/3/2018	1051	RB04	3.9	30.4	7.5	29800	16.9	34.4	67.47	3.2	
9/11/2018	914	RB01	0.2	30.5	7.5	20400	12.4	99.6		6.9	2.3
9/11/2018	914	RB01	1.2	31	8	27550	16.9	101		6.9	
9/11/2018	914	RB01	2.5	29	7.8	34730	21.8	62.5	87.7	4.1	
9/11/2018	927	RB02	0.2	28.3	7.7	13360	7.4	91.9		6.9	1.8
9/11/2018	927	RB02	1.8	30.5	7.8	29520	18.3	95.4		6.6	
9/11/2018	927	RB02	3.5	28.1	7.8	37710	24	51.3	79.53	3.5	
9/11/2018	939	RB03	0.2	28.3	7.5	6320	3.5	97.2		6.7	2
9/11/2018	939	RB03	1	30.9	7.8	28060	17.3	85.9		5.8	
9/11/2018	939	RB03	2.2	29.2	7.8	55900	21.2	67.6	83.57	4.6	
9/11/2018	947	RB04	0.2	NA	NA	NA	NA	NA		NA	2.1
9/11/2018	947	RB04	1.6	NA	NA	NA	NA	NA		NA	
9/11/2018	947	RB04	3.3	NA	NA	NA	NA	NA		NA	
10/30/2018	1011	RB01	0.2	24	8.6	24300	15	107.4		8.4	2.4
10/30/2018	1011	RB01	2	23.4	8.8	28600	17.6	107.9		8.3	
10/30/2018	1011	RB01	4.1	24.1	8.5	30800	19.1	65.6	93.63	4.9	
10/30/2018	1022	RB02	0.2	23.1	9.7	17500	10.4	104.2		8.4	2.6
10/30/2018	1022	RB02	2	23.5	8.8	28570	17.6	106.7		8.2	
10/30/2018	1022	RB02	4.1	24	8.6	31000	19.2	72.2	94.37	5.4	
10/30/2018	1032	RB03	0.2	19.9	8.7	5500	3	92.8		8.3	2.3
10/30/2018	1032	RB03	2	23.6	8.5	29650	18.3	89.6		6.8	
10/30/2018	1032	RB03	4.2	23.6	8.5	31000	19.3	73	85.13	5.5	
10/30/2018	1041	RB04	0.2	20.6	8.4	9500	5.4	95.7		8.3	2.8
10/30/2018	1041	RB04	1.6	22.9	8.6	29600	18.2	104.6		8.1	
10/30/2018	1041	RB04	3.3	23.4	8.6	31300	19.5	71	90.43	5.2	
12/4/2018	1015	RB01	0.2	15.1	7	5510	2.8	83.3		8.2	2
12/4/2018	1015	RB01	2	17.2	7.5	29950	17.8	71.9		6.4	

12/4/2018	1015	RB01	4.1	18.9	7.6	40680	26.1	30.4	61.87	2.4	
12/4/2018	1025	RB02	0.2	15.4	7.1	2640	1.4	80.1		7.9	1.5
12/4/2018	1025	RB02	2	16.8	7.7	25860	15.7	91.7		8.1	
12/4/2018	1025	RB02	4.1	18.5	7.6	38920	26.5	34.2	68.67	2.6	
12/4/2018	1035	RB03	0.2	16.4	7.5	2900	12.6	93		8.4	2.2
12/4/2018	1035	RB03	2	16.9	7.7	26120	15.9	91		8	
12/4/2018	1035	RB03	4.1	18.9	7.6	41120	26.4	29	71	2.3	
12/4/2018	1043	RB04	0.2	15.5	7.4	11660	6.6	87.3		8.4	2.2
12/4/2018	1043	RB04	1.9	17	7.6	27790	17.4	77.9		6.8	
12/4/2018	1043	RB04	3.8	17.9	7.6	34780	21.8	48.7	71.3	4.1	

7.1.2 Nutrients and Chlorophyll

Date	Station	Chloro (ug/L)	TN (mg/L) Adj. QA	TP (mg/L) Adj. QA
7/3/2018	RB01	**1.1**	0.475	0.55
7/3/2018	RB02	1.1	0.245	0.55
7/3/2018	RB03	3.7	0.255	0.003
7/3/2018	RB04	1.7	0.11	0.003
9/11/2018	RB01	1.7	0.22	0.85
9/11/2018	RB02	1.1	0.11	0.55
9/11/2018	RB03	2.1	0.11	1.05
9/11/2018	RB04	2.1	0.47	0.003
10/30/2018	RB01	1.9	0.26	0.003
10/30/2018	RB02	2.9	0.4	1.45
10/30/2018	RB03	0.53	0.33	0.265
10/30/2018	RB04	1.6	0.25	0.8
12/4/2018	RB01	0.76	0.23	0.38
12/4/2018	RB02	0.53	0.225	0.265
12/4/2018	RB03	1.3	0.06	0.65
12/4/2018	RB04	1.6	0.11	0.8