October 7, 2020

Laurie McLain
International Paper
Pensacola Mill
375 Muscogee Rd.
Cantonment, FL 32533

Re: Perdido Bay System Model Work Plan

Dear Laurie:

As requested, HDR is providing the following work plan to develop and calibrate a time-variable, three-dimensional water quality model of the Perdido Bay System. The calibrated water quality model will be employed to support the International Paper (IP) Pensacola Mill NPDES permit renewal process. The model will be used to evaluate discharges from the mill wetland treatment system to lower Elevenmile Creek and Perdido Bay through Tee and Wicker Lakes; specifically, an evaluation of mill BOD and nutrient loads and their effect on bay dissolved oxygen (DO) and chlorophyll-a (chl-a) levels.

1. Introduction and Project Objectives

In the year 2012, the IP Pensacola Mill relocated their effluent outfall to a wetland system (Combined Effluent Distribution System) from its prior discharge point in upper Elevenmile Creek. The effluent is delivered to the wetland by a gravity-flow pipeline approximately 10 miles in length. As of October 2012, mill effluent was entirely removed from the upstream freshwater portions of Elevenmile Creek. The state regulatory agency (Florida Department of Environmental Protection) has requested IP Pensacola to perform a study to provide reasonable assurance that IP's discharge: a) does not cause or contribute to the low DO in Tee and Wicker Lakes and a downstream portion of Elevenmile Creek, b) does not cause or contribute to exceedances of Upper Perdido Bay's new estuary specific numeric nutrient criterion (NNC) and the revised DO criteria, and c) is consistent with the antidegradation requirements. For this purpose, a hydrodynamic/water quality model will be developed and calibrated against available water quality measurements. After the model is calibrated, the model will be configured to assess compliance with applicable Florida Department of Environmental Protection (FDEP) water quality standards. The proposed study area for the Perdido Bay model will include the following areas in the Perdido Bay system:

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- Tidal portion of lower Elevenmile Creek (upstream to a point where tidal influence is minimal);
- Tee and Wicker Lakes;
- Tidal portion of Perdido River (upstream to a point where tidal influence is minimal);
- Upper, middle and lower Perdido Bay; and
- A portion of the Gulf of Mexico immediately outside of Perdido Bay (this area included mainly for water quality modeling purposes, specifically the definition of oceanic water quality).

Figure 1 presents an overall map of the study area. More precise study area boundaries will be defined during the data analysis stage of the modeling project.

2. Perdido Bay and Tributaries Water Quality Data for Model Calibration

Nutter & Associates has been monitoring in Tee and Wicker Lakes, lower Elevenmile Creek and upper Perdido Bay as part of the required IP annual monitoring of the Combined Effluent Distribution System since 2012 (start of effluent discharge to the wetland treatment system). There are two monitoring stations in Tee and Wicker Lakes, three in lower Elevenmile Creek, two in lower Perdido River and four in upper Perdido Bay. Station GS05 is the primary outlet from the wetland treatment system. Perdido Bay stations are indicated with PB. TWR-01, TWT-01 and TWT-02 are marine marsh stations. SWD stations and 11M are Elevenmile Creek stations. Figures 2 and 3 present maps of the sampling locations. For reference purposes, Figure 3 includes an outline of the Effluent Distribution System (EDS). A brief description of all Nutter sampling locations is provided in Table 1.

Water quality data is available quarterly at the effluent outfall to the wetland treatment system, GS05, PB01, PB02, PB03, PB04, PB05, TWR-01, SWD-3, SWD-4, TWT-01 and TWT-02. Annual grab samples were collected at SWB-1, SWD-1, SWD-2 and SWU-1. At stations TWT-01, TWT-02 and 11M, continuous (sampled every 15 minutes) data is available for the period April 2014 to April 2015. A brief summary of this dataset is presented in Table 2. Although the purpose of this document is not to provide a detailed data analysis and interpretation, a few figures for some critical water quality constituents are presented for three selected stations on Figures 4a to 6c to make some observations.

These figures present time-series for the following water quality constituents: temperature, DO, DO saturation and conductivity (first page); total phosphorus (TP), total nitrogen (TN), dissolved inorganic phosphorus (DIP) and dissolved inorganic nitrogen (second page); color, total suspended sediments (TSS), secchi disk and chl-a (third page). The upper most panel of each figure also presents daily Perdido River flows at USGS gage #02376500 at Barrineau Park; this river flow is presented as a surrogate for precipitation in the study area.

Table 1. Description of stations sampled by Nutter and Associates

Station ID	Station Description	Latitude	Longitude
SWD-1	Elevenmile Creek at County Road 297A	30.5477	-87.3298
SWD-2	Elevenmile Creek at U.S. Highway 90	30.4983	-87.3359
SWD-3	Elevenmile Creek approximately 1 mile upstream of mouth of Perdido Bay	30.4645	-87.3734
SWD-4	Elevenmile Creek at mouth of Perdido Bay	30.4574	-87.377
SWU-1	Elevenmile Creek upstream of effluent discharge	30.5731	-87.3223
SWB-1	Coffee Branch off of Jamesville Lane, 1.6 miles upstream of SWD-2	30.5154	-87.3472
PB01	Upper Perdido Bay	30.452875	-87.378521
PB02	Upper Perdido Bay	30.444677	-87.37074
PB03	Perdido Bay at mouth of Perdido River	30.451983	-87.402175
PB04	Upper Perdido Bay	30.432157	-87.35565
PB05	Upper Perdido Bay	30.421961	-87.387821
GS05	Primary outlet from freshwater wetlands into lower Elevenmile Creek	30.464231	-87.379148
Outfall	Effluent inflow to freshwater wetlands from pipeline	30.485256	-87.364654
TWT-01	Wicker Lake	30.462768	-87.384631
TWT-02	Tee Lake	30.457863	-87.386176
TWR-01	Reference brackish marsh station	30.465706	-87.415019

Table 2. Summary of Water Quality Data Collected by Nutter & Associates (2010-2020)

Station	Date Range	Frequency	Depths
Outfall	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
SWB-1	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S
SWU-1	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S
SWD-1	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S
SWD-2	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S
SWD-3	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S,M,B
	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
11M	4/10/2014 - 4/15/2015	every 30 mins	(1 ft from) Surface and Bottom
SWD-4	Julys 2010-2011 & Augusts 2012-2019	one day per year, one grab sample	S,M,B
	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
GS05	Quarterly (2005-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at M
TWT-01	Quarterly (2004-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
	4/10/2014 to 4/15/2015	every 30 mins	(1 ft from) Surface and Bottom
	2013-2016, 2018-2019 (February, May, August, December)	every 15 mins for 1-3 days every quarter	S
TWT-02	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
	4/10/2014 to 4/15/2015	every 30 mins	(1 ft from) Surface and Bottom
	2013-2016, 2018-2019 (February, May, August, December)	every 15 mins for 1-3 days every quarter	S
TWR-01	Quarterly (2003-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/B
PB01	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/M/B
PB02	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/M/B
PB03	Quarterly (2012-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/M/B
PB04	Quarterly (2013-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/M/B
PB05	Quarterly (2013-2020) (Mostly February, May, Aug, December)	one day per quarter, one grab sample	in-situ samples at S/M/B

The first page indicates substantial temperature and DO stratification possibly as a function of river flow, tidal conditions and proximity of the station to freshwater sources; the second page may indicate a decreasing temporal trend for TP, there is also some indication of both nitrogen and phosphorus limiting algal growth depending on the season and location of the station; and the third page presents constituents relevant to water transparency and, therefore, useful data for representation of water column light attenuation in the water quality model. Similar temporal plots for all stations are presented in Appendices A, B and C. These figures are presented to highlight the complexity of the Perdido Bay system, freshwater and tidal dynamics that produce water quality temporal and spatial variability as well as significant stratification events. A time-variable, three-dimensional hydrodynamic and water quality model is necessary to represent such complex system dynamics. A review of the water quality database performed after the development of Appendices A to C identified some minor database issues (e.g., pH & DO data transposed for a few stations); the database will be corrected and the corresponding data figures updated during the modeling phase of this project.

Additionally, to complement the water quality data collected by Nutter & Associates, a data retrieval was performed from the FDEP Impaired Waters Rule (IWR) Database (IWR Run 58). IWR data in the study area is available for 26 stations (surface only). Figures 7 and 8 present maps of these IWR stations. IWR data at these stations is available for the period 2010-2019 as quarterly grab samples; however, the data is very unevenly distributed in that time-period, some stations only have data for one or two years. Relevant parameters included in the IWR dataset for the development of a hydrodynamic and water quality model include salinity, temperature, chl-a, DO, TN, TP, ammonia (NH4), nitrite plus nitrate (NO2+NO3), and color. A brief summary of the data is shown in Tables 3 and 4. Appendix D presents temporal plots of this data. Stations with sufficient data to be considered for model calibration will be selected during the modeling stage of this study.

3. IP Pensacola Mill Effluent Water Quality Data

Daily recorded effluent water quality data for the IP Pensacola Mill is available for the period 2012 to 2020. The average effluent flow is 25.9 MGD and the average BOD5 concentration is 13.7 mg/L. Table 5 provides a summary of additional water quality constituents available. For time-variable modeling purposes it is important to appropriately represent the temporal variability of the mill effluent water quality. A sample time-series plot of the effluent data (flow and BOD5) is presented in Figure 9. Once the water quality model is calibrated and ready for use in determining compliance with the applicable FDEP water quality standards, an appropriate representation of effluent flows and water quality constituents will be determined.

Table 3. Counts of Water Quality Data from IWR Stations (2010-2019)

Station	Years	Count										
		Temperature °C	Salinity ppt	Dissolved Oxygen mg/L	DO Saturation %	Total Organic Carbon mg/L	Ammonia mg/L	Nitrate-Nitrite mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	Chlorophyll-a ug/L	Color PCU
21FLBFA 33010011	2010-2019	33	33	28	28		33	33	33	33	2	6
21FLGW 3565	2010-2019	160	159	160	159	111	111	111	111	111	111	111
21FLGW 42369	2012-2012	2	2	2	2	1	1	1	1	1	1	1
21FLPNS 33010011	2010-2015	21	21	20	20	8	8	8	8	8	6	6
21FLPNS 33010012	2010-2015	16	16	16	17	4	4	4	4	4	4	4
21FLPNS 33010143	2010-2015	7	7	6	6							
21FLPNS G5NW0003	2014-2017	3	3	3	3	1	1	1	1	1	1	1
21FLPNS G5NW0126	2017-2017	3	3	3	3							
21FLPNS 330100A1	2015-2015	14	14	14	14	6	6	6	6	6	6	
21FLPNS 330100A4	2016-2016	1	1	1	1		1	1	1	1	1	1
21FLPNS 330100A7	2010-2017	279	266	221	221		28	28	28	28	27	27
21FLPNS 330100C6	2015-2015	14	14	14	14	6	6	6	6	6	6	
21FLPNS 330100D4	2015-2015	11	11	11	11	5	5	5	5	5	5	
21FLPNS 33010A10	2015-2015	3	4	4	4							
21FLPNS G5NW0022	2018-2018	10	10	10	10							
21FLPNS G5NW0127	2018-2018	10	10	10	10							
21FLPNS G5NW0128	2018-2018	10	10	10	10							
21FLPNS 33010006	2015-2017	17	17	17	17	8	8	8	8	8	8	
21FLPNS 3301462A3	2015-2017	13	13	13	13	8	8	8	8	8	8	
21FLPNS 3301A462A2	2015-2016	17	17	17	17	9	9	9	9	9	9	
21FLPNS G5NW0016	2017-2017	2	2	2	2	1	1	1	1	1	1	
21FLPNS G5NW0017	2017-2017	6	6	6	6	3	3	3	3	3	3	
21FLPNS G5NW0018	2017-2017	8	8	8	8	6	6	6	6	6	6	
21FLPNS G5NW0070	2015-2016	6	6	6	6	3	3	3	3	3	3	
21FLPNS 33010G10	2010-2017	289	273	229	229		32	32	32	32	31	30
21FLPNS G5NW0130	2019-2019	6	6	6	6	3	3	3	3	3	3	2

Table 4. Averages of Water Quality Data from IWR Stations (2010-2019)

Station	Years	Average										
		Temperature °C	Salinity ppt	Dissolved Oxygen mg/L	DO Saturation %	Total Organic Carbon mg/L	Ammonia mg/L	Nitrate-Nitrite mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	Chlorophyll-a ug/L	Color PCU
21FLBFA 33010011	2010-2019	23.3	0.2	7.8	88.0		0.144	0.485	1.51	0.166	3.5	232
21FLGW 3565	2010-2019	20.1	0.2	7.8	89.0	9.6	0.099	0.503	1.23	0.127	1.3	79
21FLGW 42369	2012-2012	26.9	0.2	6.5	80.7	12.0	0.150	0.580	1.34	0.160	1.2	100
21FLPNS 33010011	2010-2015	23.1	0.4	7.4	86.4	27.1	0.443	0.698	2.90	0.395	1.9	230
21FLPNS 33010012	2010-2015	22.4	0.3	7.6	84.9	21.8	0.200	0.718	2.39	0.300	1.8	173
21FLPNS 33010143	2010-2015	24.3	0.3	8.1	94.4							
21FLPNS G5NW0003	2014-2017	17.1	0.0	9.1	93.8	3.6	0.010	0.500	0.70	0.010	0.8	26
21FLPNS G5NW0126	2017-2017	22.3	0.0	8.1	92.7							
21FLPNS 330100A1	2015-2015	23.3	10.5	7.3	88.5	5.9	0.019	0.130	0.55	0.017	6.6	
21FLPNS 330100A4	2016-2016	30.4	16.6	3.5	51.0		0.003	1.100	1.26	0.004	23.0	15
21FLPNS 330100A7	2010-2017	22.6	8.0	7.2	84.4		0.023	0.045	0.59	0.031	15.7	45
21FLPNS 330100C6	2015-2015	23.5	11.2	7.5	92.4	6.3	0.012	0.073	0.53	0.020	9.3	
21FLPNS 330100D4	2015-2015	21.8	14.4	7.7	93.2	5.5	0.015	0.056	0.48	0.017	6.7	
21FLPNS 33010A10	2015-2015	24.9	16.0	8.1	99.4							
21FLPNS G5NW0022	2018-2018	24.7	9.9	6.0	74.6							
21FLPNS G5NW0127	2018-2018	25.0	10.0	6.8	85.5							
21FLPNS G5NW0128	2018-2018	24.6	6.8	6.5	79.5							
21FLPNS 33010006	2015-2017	24.8	10.8	6.3	79.7	5.6	0.004	0.077	0.50	0.020	9.3	
21FLPNS 3301462A3	2015-2017	20.9	7.3	6.7	77.3	5.2	0.028	0.281	0.61	0.015	4.0	
21FLPNS 3301A462A2	2015-2016	25.8	8.2	5.9	73.4	5.0	0.011	0.146	0.49	0.019	10.9	
21FLPNS G5NW0016	2017-2017	22.5	5.1	6.9	81.0	6.0	0.017	0.170	0.44	0.015	1.7	
21FLPNS G5NW0017	2017-2017	23.1	2.6	6.8	80.0	4.9	0.020	0.260	0.53	0.015	1.7	
21FLPNS G5NW0018	2017-2017	22.7	5.2	8.2	97.0	5.0	0.005	0.108	0.40	0.016	6.6	
21FLPNS G5NW0070	2015-2016	27.3	7.1	4.3	54.0	7.6	0.011	0.150	0.68	0.030	33.0	
21FLPNS 33010G10	2010-2017	21.4	15.9	7.1	84.9		0.021	0.022	0.36	0.019	4.8	22
21FLPNS G5NW0130	2019-2019	21.4	16.4	7.3	88.5	4.1	0.004	0.062	0.19	0.011	4.4	20

Table 5. Summary of Available Data for IP Pensacola Mill Effluent (2012-2020)

Parameter	Units	Min	Mean	Max
Flow	MGD	0.1	25.9	52
BOD5	mg/l	3.4	13.7	51
DO	mg/l	5.0	7.3	10
Temperature	deg F	60	84	97
Color	SCU	49	185	758
Ammonia	mg/l	0.02	1.30	4
Total Phosphorus	mg/l	0.16	0.59	1
Ortho Phosphorus	mg/l	0.01	0.18	1

4. Model Calibration Time-Period

Since the calibrated water quality model will be employed to support the NPDES permit renewal process for the IP Pensacola Mill after the effluent discharge relocation to the wetland treatment system, and given the available data for model calibration, it is recommended to calibrate the model against data collected during the January 2013 to December 2019 time-period. The available continuous data at stations TWT-01, TWT-02 and 11M for the period April 2014 to April 2015 will be very valuable in assessing the model performance.

Another important factor in the selection of the modeling time-period is the sufficiency of model results to address the applicable FDEP water quality standards. FDEP water quality standards are defined by a magnitude, a frequency and a duration (e.g., DO saturation from daily to 30-day average time-periods, 90^{th} percentile nutrient and chl-a compliance targets) and therefore require time-variable modeling results that are adequate for assessing compliance with such standards.

An additional consideration in the selection of a modeling time-period is the suitability of the selected modeling years in representing long term water body conditions; in the case of the Perdido Bay system, river flow, river temperature and tidal conditions. The selected modeling time-period should not be biased (e.g., including mostly low or high flow river conditions). To assess this requirement, Figures 10 and 11 which present probability plots of annual and summer (May-October) average Perdido River flows at Barrineau Park were used. On these figures, the circles represent average flows for the 1950 to 2019 period (long term). The selected modeling years (2013-2019) are labeled to easily compare these years versus long term conditions. These figures indicate that the selected modeling years encompass a range of hydrologic conditions comparable to long term conditions. A similar but more detailed analysis will be performed once the water quality model is ready for use in determining compliance of the applicable FDEP water quality standards.

5. Modeling Framework

A time-variable hydrodynamic and water quality model is recommended that is capable of appropriately representing the Perdido Bay system tidal circulation and nutrient/BOD impacts on DO and chl-a. The water quality model should also be able to evaluate the IP Pensacola mill discharge impacts on the main water bodies of interest (Elevenmile Creek and Upper Perdido Bay). An approximate spatial extent of the proposed model grid is presented in Figure 12. The model grid extends outside the bay into the Gulf of Mexico as it is necessary to define water column water quality concentrations that are independent on the bay water quality dynamics (e.g., bay nutrient and BOD loads).

5.1 Hydrodynamic Model

The transport and mixing of pollutant loads introduced to rivers, lakes, reservoirs and coastal environments are controlled by the circulation characteristics of the receiving water body. The fate of a pollutant is strongly influenced by turbulent mixing created by the surface wind stress, currents and tides (astronomical or meteorological). At the same time, turbulent mixing leads to horizontal dispersion in the longitudinal and lateral directions, and to vertical dispersion throughout the water column. Coupled with turbulent mixing due to wind and currents are heat exchange processes between the water column and the atmosphere. All these mechanisms determine the spatial extent and magnitude of the pollutant. The complexity of the physical processes governing the evolution of an introduced constituent, such as a pollutant load, suggests the use of sophisticated hydrodynamic models. For this study, HDR's state-of-the-art far-field hydrodynamic model, ECOMSED (Estuarine, Coastal and Ocean and Sediment Transport Model), will be applied to complete the assessment of the IP Pensacola mill discharge.

ECOMSED is a three-dimensional, time-dependent, estuarine and coastal circulation hydrodynamic model developed by Blumberg and Mellor (1987). The model incorporates the Mellor and Yamada (1982) level 2-½ turbulent closure scheme to provide a realistic parameterization of vertical mixing. A system of curvilinear coordinates is used in the horizontal direction, which allows for a smooth and accurate representation of variable shoreline geometry. In the vertical scale, the model uses a transformed coordinate system known as the σ-coordinate transformation to allow for a better representation of bottom topography. Water surface elevation, water velocity in three dimensions, temperature and salinity, and water turbulence are predicted in response to weather conditions (winds and incident solar radiation), tributary inflows, tides, temperature and salinity (if applicable) at open boundaries connected to the water body.

The model is widely accepted within the modeling community and regulatory agencies as indicated by the number of applications to important water bodies around the world. Among these applications are: Delaware River, Delaware Bay, and adjacent continental shelf, the South Atlantic Bight, the Hudson Raritan Estuary, the Gulf of Mexico, Chesapeake Bay, Massachusetts Bay, St. Andrew Bay, New York Harbor and Bight, Onondaga Lake, James River, Passaic River and Estuary, Columbia River and Estuary, Sabine River, Mobile Bay, Mississippi Sound and Dubai Coast. In addition, the model has been applied in Escambia/Pensacola Bay, Fenholloway River Estuary and Nearby Gulf of Mexico, Tampa Bay, St. Andrew Bay and Perdido Bay in Florida as part of the water quality projects in these systems. The model has also been applied in several lake environments such as Lake Michigan and Green Bay, Lake Pepin, and Milwaukee Harbor and near shore Lake Michigan. In all these studies, model performance was assessed by means of extensive comparisons between predicted and observed data. The predominant physics were realistically reproduced by the model for this wide range of applications. Figure 13 presents a simple schematic of the basic hydrodynamic mechanisms simulated by ECOMSED.

5.2 Water Quality Model

The water quality model to be employed in this study is RCA (Row-Column version of AESOP), models developed by HDR (previously HydroQual). RCA is an extension of the water quality model WASP, which was originally developed by HydroQual staff and later provided to USEPA. WASP is currently employed by USEPA and multiple state agencies for complex water quality applications. RCA in a eutrophication model that is directly coupled with the ECOMSED hydrodynamic model. In addition, a sediment flux submodel is also included in the eutrophication model to allow calculation of sediment oxygen demand (SOD) and sediment nutrient fluxes in response to settled organic matter and its subsequent decay in the sediment. The coupled hydrodynamic/water quality model (ECOMSED/RCA) has been successfully applied in numerous studies (e.g., Pensacola Bay System), including a number of the water bodies included in the hydrodynamic model summary.

The RCA eutrophication model includes the modeling of one phytoplankton group (although winter, summer, and fall groups are available), dissolved oxygen (DO), and the various organic and inorganic forms of nitrogen, phosphorus, silica and carbon or biochemical oxygen demand (BOD). The diagram presented in Figure 14 shows the various general kinetic pathways involved in the modeling framework.

6. Model Development

This task involves the gathering of data for the development of model inputs and the development of model inputs themselves. Some of the main model inputs that will be developed include:

- Configuration of model grid. This task will discretize the study area into numerous model segments in order to best represent the circulation dynamics in Perdido Bay. The model grid will be orthogonal and curvilinear (i.e., it will follow shoreline and bathymetric features) and will include increased resolution in areas of importance (e.g., upper Perdido Bay near the mouth of Elevenmile Creek and Perdido River). The appropriate model grid resolution for the Tee and Wicker Lakes and lower Elevenmile Creek will be determined once all available bathymetry data is gathered and also based on initial hydrodynamic model calibration runs (numerical model stability and runtime needs); sample initial grids for these waterbodies are presented on Figure 15. Model segment depths will be assigned based on NOAA bathymetry data and any other available sources.
- The hydrodynamic model is driven by freshwater flows and corresponding water temperature at the model upstream boundary locations. River flows and temperature from the Perdido, Blackwater and Styx Rivers, Elevenmile and Bayou Marcus Creeks and other inputs of freshwater flow to the Perdido Bay system will be obtained from USGS. A list of available flows gages relevant to this study is presented on Table 6.

Table 6. USGS Stations with Flow Data Available in the Study Area

USGS Number	Station Name	Latitude	Longitude	Drainage Area (sq mi.)	Flow Data Availability
02376100	BAYOU MARCUS CREEK NR PENSACOLA,FLA	30°26'53"	87°17'26"	10.8	1987-2020
02377570	STYX RIVER NEAR ELSANOR, AL.	30°36'20"	87°32'50"	192	1987-2020
02377750	STYX RIVER AT SEMINOLE, ALA260	30°31'05"	87°27'46"	260	-
02377960	BLACKWATER RIVER AT CO RD 87 NEAR ELSANOR, AL.	30°30'41"	87°34'54"	56.6	1987-1991
02376115	ELEVENMILE CREEK NR WEST PENSACOLA FL	30°29'53"	87°20'09"	27.8	1987-2020
02376500	PERDIDO RIVER AT BARRINEAU PARK, FL	30°41'25"	87°26'25"	394	1941-2020

- Figure 16 presents a map of the USGS gages included in Table 6. A starting point for the development of freshwater model boundary conditions will be the methodology implemented by HydroQual (now HDR) in the hydrodynamic/color study “Perdido Bay Time-Variable Color Modeling” in 2008. Briefly, in that study, measured flows were scaled up to the boundary condition locations based on drainage area increases as follows: Perdido River Boundary Flows = 1.44 x (QPR + QST + QBW); Elevenmile Creek Boundary Flow = 1.1 x (QEMC + Q8MC); and Bayou Marcus Boundary Flow = 1.1 x QBM; In these equations, QPR is the Perdido River flow, QST is the Styx River flow, QBW is the Blackwater River flow, QEMC is the Elevenmile Creek flow, Q8MC is the Eightmile Creek flow and QBM is the Bayou Marcus flow. The inflow to Tee and Wicker Lakes was based on the wetland project drainage area of 1,200 acres and a drainage area ratio to the Eightmile Creek flow gage of 0.17, which has a drainage area of 7,168 acres. This initial approach in developing freshwater model inputs will be refined based on available data and studies identified during the data review phase of this modeling study. In previous studies it was found that watershed areas adjacent to the shoreline reflect higher rainfall intensities than inland areas; this is a possible element to be considered if it can be justified by data (e.g., rainfall, land use type) and/or model calibration needs. Possible data sources for consideration in developing freshwater inputs to the model include: USGS, NOAA, local research institutions or university reports, FDEP and USEPA studies, etc. The modeling team will be in continuous communication with FDEP to evaluate the possible approaches in determining model freshwater inputs. Any dataset, study or technical recommendations provided by FDEP will be thoroughly considered in the development of this task. Because the salinity calibration dataset for the present study includes multiple years of data, this will make it possible to test the validity of the model freshwater inputs for a variety of weather conditions.
- An estimate of flows leaving the EDS will be made and specified in the hydrodynamic model. Currently, based on preliminary data observations and on the field experience by Nutter & Associates, it is believed that most of the flow leaving the EDS goes through the channel where station GS05 is located. Figure 17 presents a map of the area around this monitoring site. HDR and Nutter & Associates are currently developing a sampling strategy to estimate flows at station GS05. Stage has been monitored at this location for an extended period of time. Flow measurements to be performed with an ADCP will allow the development of a stage/flow relationship. Additionally, ADCP measurements are planned at other locations at Elevenmile Creek to perform an overall flow balance. Measured salinity at GS05 and other key locations at Elevenmile Creek will also be used to assess estimates of flow at the GS05 site. A review of LIDAR data at the EDS and surrounding areas will also be performed to identify other possible routes for flow to exit the EDS. It is also planned to perform bathymetric surveys and/or cross-sectional measurements at strategic locations, e.g., GS05 channel and confluence with Elevenmile Creek, to support the development of flow estimates at GS05. These bathymetric surveys will also allow a more accurate model simulation of salinity at lower

Elevenmile Creek; salinity model simulations will also be used to confirm the appropriateness of data-based estimates of flow leaving the EDS.

- The water quality model requires the specification of water quality corresponding to the freshwater flows included in the hydrodynamic model. Data collected by Nutter & Associates will be used to define Elevenmile Creek background water quality. Additionally, other sources of data will be examined to support the development of Elevenmile Creek background loads; data collected at historical monitoring sites will also be employed if necessary. The current (as of this document preparation date) IWR data retrieval was limited to a couple of miles upstream of the Perdido River. A second IWR data retrieval will be performed including the upstream freshwater portion of the Perdido River to obtain any available data to define Perdido River background water quality. Additionally, a data retrieval from the USGS Water Quality Portal (WQP) will be performed for the whole study area (including freshwater flows) to find additional data for the definition of model freshwater water quality inputs. Based on the amount of river/creek water quality data gathered during the data retrievals, possible methodologies for developing daily water quality (e.g., TN and TP) associated with model freshwater inputs are: simple seasonal averages, linear interpolations, regressions as a function of flow and LOADEST simulations. The appropriate approach will be selected in coordination with FDEP. If no water quality data is available for a given tributary, data from nearby comparable (basin size, land use, slope, etc.) river/creeks will be used. For example, for discussion purposes only, if Eightmile Creek had no available measured water quality then the upstream monitoring stations (background concentrations) at Elevenmile Creek could be used for Eightmile Creek; this approach would be justifiable provided these two watersheds are similar enough in terms of catchment characteristics. Additional adjustments to the selected methodology for developing freshwater water quality loads may be made based on model calibration needs.
- Meteorological parameters (wind speed and direction, air temperature, relative humidity, atmospheric pressure and solar radiation/cloud coverage) are another set of forcing terms for the hydrodynamic model. Data will be obtained from the National Climate Data Center's (NCDC) for the closest meteorological stations and/or airports to the study area.
- Oceanic tidal water surface elevations, salinity and temperature levels will be assigned for the model open boundary locations. Water surface elevations will be obtained from NOAA sources. Oceanic salinity and temperature levels will be obtained from local measurements (if available), the NOAA National Oceanographic Data Center (NODC), larger scale oceanic models (if available) or estimated based on internal Perdido Bay calibration needs. Similarly, oceanic water quality concentrations will be based on available local data, NODC data, comparable/nearby estuarine systems, literature values or a combination of these approaches for calibration needs.
- Atmospheric deposition loads and groundwater flow and loads (to the shoreline) could be considered if, after a review of local studies and literature, it is deemed necessary to

do so. Atmospheric deposition could be estimated from the National Atmospheric Deposition Program (NADP) data and other Florida studies. Groundwater flows and water quality concentrations could be estimated from USGS and other Florida studies. In previous modeling studies the representation of groundwater flows entering the shoreline was a key factor in replicating the measured salinity; particularly at water quality monitoring stations located in shallow areas nearby the shoreline. For example, in the Fenholloway River and Estuary Modeling Study, groundwater flows entering the shoreline were considered in the model by assigning a shoreline flow (cfs/mi) modified temporally by flow measured at a local river.

7. Model Calibration Approach and Model Performance Assessment

Calibration of any hydrodynamic/water quality model requires the adjustment of certain parameters for site-specific conditions based on comparisons between observed data and model output. The method of calibrating the model begins with the selection of a set of parameters (kinetic constants) based on other modeling studies. The remainder of the calibration phase involves the adjustment of key parameters, both individually and in conjunction with other parameters, to obtain a reasonable representation of the hydrodynamics and water quality kinetics observed in the system. Adjustment of the model parameters is tightly constrained by typical ranges as determined from the literature and other modeling studies. It is likely that numerous model runs will be performed to arrive at the final calibration.

Based on the nature of the calibration process, this involves many sensitivities to key model parameters. These sensitivities differ from those involving variation of individual parameters with subsequent observation of the effect on model results; instead, they involve the simultaneous adjustment of linked parameters within typical ranges to assess their effects. For instance, model sensitivities will be performed involving phytoplankton growth and respiration rates to assess the effects on calculated phytoplankton (chl-a) and nutrient levels with the set of parameters that best reproduces the observed data chosen for the final calibration. Therefore, the method of calibrating the hydrodynamic/water quality model includes many iterations involving the adjustment of individual parameters and many sensitivities to coupled parameters.

The hydrodynamic model will be calibrated to available water elevation data in Perdido Bay, and salinity and temperature data collected by Nutter & Associates and the data retrieved from the FDEP IWR database. The water quality model will be calibrated to available chl-a, DO, and nutrients from both datasets. The model calibration will focus not only on reproducing the temporal variation in these parameters but also on reproducing the observed vertical stratification levels. The results of the model calibration will be a presentation of the model output versus observed data at the numerous monitoring stations located throughout the Perdido Bay system. Typically, three different graph formats are employed for assessing the model performance: temporal plots; probability distribution plots; and spatial distribution maps. When appropriate, goodness of fit statistics will also be developed; such statistics will consider the limited frequency of the data when compared to model results and will be interpreted within the scope of the modeling project. A detailed analysis of model assessment figures and goodness of fit statistics will ensure that the final calibrated model is technically defensible and acceptable to all parties for use in the NPDES permit renewal process of the IP Pensacola Mill.

8. Evaluation of FDEP Water Quality Standards

HDR and IP will discuss with FDEP the applicable DO, nutrient and chl-a standards for the Perdido Bay System WBIDs (water body identification numbers). For example, in the case of DO, it is HDR's understanding that currently a few WBIDs are categorized as Class III predominantly freshwaters and others are categorized as Class III predominantly marine waters.

For the Panhandle West bioregion Class III predominantly freshwaters, the DO standard specifies that no more than 10 percent of the daily average percent DO saturation values shall be below 67 percent. In the case of Class III predominantly marine waters, the DO criteria specifies that minimum DO saturation levels shall be as follows: a) the daily average percent DO saturation shall not be below 42 percent saturation in more than 10 percent of the values; b) the seven-day average DO percent saturation shall not be below 51 percent more than once in any twelve week period; and, c) the 30-day average DO percent saturation shall not be below 56 percent more than once per year. Hereinafter, for the purposes of this study, these DO criteria will be referred as the absolute DO criteria.

Additionally the DO criteria specifies that if it is determined that the natural background DO saturation in the water body (including values that are naturally low due to vertical stratification) is less than the applicable standards, the applicable standard shall be 0.1 mg/l below the DO concentration associated with the natural background DO saturation level. Also, for predominately marine waters, a decrease in magnitude of up to 10 percent from the natural background condition is allowed if it is demonstrated that sensitive resident aquatic species will not be adversely affected using the procedure described in the DEP document titled Appendix H of the "Technical Support Document for the Derivation of Dissolved Oxygen Criteria to Protect Aquatic Life in Florida's Fresh and Marine Waters: Determination of Acceptable Deviation from Natural Background Dissolved Oxygen Levels in Fresh and Marine Waters" (DEP-SAS-001/13), dated March 2013. Hereinafter, whichever DO criterion is eventually applicable to this study, that is, either the 0.1 mg/L below or the 10 percent from the natural background DO, will be referred as the delta DO criterion. To determine if the delta DO criterion is applicable to this study, a natural background scenario will be required. This scenario will define DO concentrations associated with the natural background DO saturation levels, that is, the condition of a water body in the absence of man-induced alterations.

After the water quality model is sufficiently calibrated, it will be determined what water quality model projections are required to meet the FDEP Water Quality Based Effluent Limitation (WQBEL) Level II process. As noted in FDEP Chapter 62-650.500, "the WQBEL Level II Process is a means of determining the available assimilative capacity of a water body and setting WQBELs utilizing appropriate procedures for simulation and prediction of water quality impacts which may include computer modeling and other scientific methodology" and "have the capability to predict impacts from stormwater contributions." Although not a comprehensive or final list of model runs, as modeling results may dictate the need for additional model runs, the following water quality model runs are proposed for the WQBEL evaluation:

For the evaluation of DO standards:

- "Natural Background Condition" model run: To determine the available assimilative capacity of the Perdido Bay system, the calibrated water quality model will be used to complete a model run without man-induced, non-abatable sources. An assessment of upstream watersheds (upstream Perdido River, Styx/Blackwater River, Bayou Marcus Creek, Wolf Creek and Elevenmile Creek) will be performed by evaluating land use in these watersheds to determine whether they reflect relatively unimpacted watersheds and whether any significant point sources exist in these watersheds. For any upstream watershed that is not representative of background conditions, watershed water quality concentrations will be replaced by values representative of land uses not associated with anthropogenic activities, e.g., urban and agricultural. Such water quality representative values will be obtained from nearby watershed studies (either data or model-based) and any available literature applicable to the study area. The availability of data or studies for the definition of natural background concentrations is currently unknown, such information will be gathered during the data review phase of this modeling study. It is proposed to perform a series of model sensitivity runs for a reasonable range of possible natural background concentrations to assess the effect of this model input. Additionally, the IP and ECUA Bayou Marcus WRF loads will be removed from the model. The resulting water quality model concentrations for nutrients, chl-a and DO will represent natural background conditions. The difference between the applicable water quality standards and the model background condition results will represent the available assimilative capacity of the Perdido Bay system. These results will be time-varying and spatially variable. If model results for this run don't meet the absolute DO criteria for specific areas of the water bodies of interest, then the delta DO criterion will be used for such areas (model segments) for the assessment of model projection runs with point sources assigned. It is anticipated that bottom layer DO for the natural background condition model projection run will be less than the absolute DO criteria in lower Elevenmile Creek, lower Perdido River and Perdido Bay based on past water quality modeling.

  - Evaluation of IP's Current BOD_5 Permit Load with the Traditional Permitting Approach: A model projection run with the IP wetland treatment system and ECUA Bayou Marcus WRF at current permit loads will be completed. Model inputs (other than point sources) will be the same as the calibration scenario. Two modeling features define the traditional permitting approach when deriving dischargers permit loads using a calibrated time-variable model: a) the specification of discharger loads at monthly BOD_5 limit levels every day of the model simulation and b) the use of one hydrodynamic year (generally a critical one) or all hydrodynamic years included in the calibration period. This traditional permitting approach is rather unsound as: a) a discharger treatment system doesn't operate in such manner (at monthly limit levels every day), b) the use of a critical year is typically excessively conservative, c) an analysis of which hydrodynamic years to use (from the calibration period) for model projections to appropriately represent long term weather and hydrodynamic conditions is typically not performed and d) the combination of items a) to c) produce a frequency of criteria violations that is not explicitly quantified with the traditional permitting approach. Specification of the permit loads will be discussed with FDEP and IP as to whether additional removal through the wetland treatment system is assigned or if the permit effluent loads are used. The same decision will be required for the ECUA Bayou Marcus WRF discharge as such discharger has a wetland treatment system in use as well. The results of this model projection run will be used to assess compliance with the applicable DO standard. As per the results of the natural background condition model run, certain model areas will be assessed against the absolute DO criteria and other ones against the delta DO criterion (as is anticipated for bottom layer DO in certain model sections). Permit loads that meet the applicable DO criteria (the generally applicable criteria in areas that attain the criteria under natural background conditions and the delta DO in areas where natural background levels are below the generally applicable criteria) would be the WQBEL loads to be used for the NPDES permit renewal. The traditional permitting approach is the standard approach used by federal and state regulatory agencies in developing monthly point source BOD_5 permit limits. However, this approach is generally overly conservative. HDR proposes to evaluate IP permit load under these assumptions for comparison only against the more realistic approach described in the following section.

- Evaluation of IP's Current BOD_5 Permit Load with a Time-Variable Permitting Approach: A model projection run similar to the projection run described in the previous section will be completed but with explicit consideration of both time-variable hydrodynamic conditions (river flows, river/bay temperature, tides, etc.) and time-variable IP BOD_5 loading (day to day). This modeling approach intends to a) represent true water body long-term conditions as opposed to, for example, a conservative combination of point source loads, freshwater flows, water temperature and tidal conditions, b) represent the day to day variation of effluent loading, and c) explicitly quantify the frequency of criteria violations for a particular effluent permit load. There are many possible combinations of daily hydrodynamic conditions and point source loading patterns that can occur when day to day variation is accounted for when using this permit load derivation approach. If necessary, representative hydrodynamic years and/or BOD_5 effluent loading years will be appropriately selected to reduce model runtimes. Multiple statistical analyses will be performed for the selection of representative hydrodynamic years and/or BOD_5 effluent loading years that represent long term conditions. If the DO criteria is not met under IP's current BOD_5 permit load, design model runs will be performed. The model will be executed iteratively to determine the IP BOD_5 load that attains the criteria. In a time-variable modeling analysis a time-variable effluent load is associated with a monthly average permit limit; the design model runs would be configured to represent progressively lower monthly average permit limits until the DO criteria is met. Permit loads that meet the applicable DO criteria (the generally applicable criteria in areas that attain the criteria under natural background conditions and the delta DO in areas where natural background levels are below the generally applicable criteria) would be the WQBEL loads to be used for the NPDES permit renewal.

For the evaluation of numeric nutrient criterion:

- In the context of this study (WQBEL), it is HDR's understanding that FDEP has requested IP to demonstrate that IP's discharge does not cause or contribute to exceedances of Upper Perdido Bay's new estuary specific NNC. A model projection run will be completed with IP at current nutrient permit levels; the base case for this projection run will be the model calibration scenario. Results of this model projection run will be evaluated to demonstrate attainment of the TN, TP, and chl-a NNC for Upper Perdido Bay and to compare/contrast the model results with the current IWR 303(d) assessment results for the bay. Specification of IP's nutrient permit load will be discussed with FDEP and IP as to whether additional removal through the wetland treatment system is assigned or if the permit effluent loads are used.

As part of the evaluation of IP's permit loads and compliance for DO and nutrient criteria, to the extent there is some uncertainty in key model coefficients, it is proposed to perform multiple model sensitivity runs to evaluate the implications of such uncertainty in the WQBEL study conclusions. The selection of sets or combinations of model coefficients to be included in the uncertainty analysis will be selected in a manner that is technically appropriate; for example, there are model coefficients that are related to each other by a common physical variable (wind, temperature) and therefore their ranges are limited by such variable, also the selection of coefficient combinations and ranges is dictated by a proper model calibration level being achieved with such coefficients.

A clarification provided by FDEP is the issue of how to evaluate the tidally influenced WBIDs that fluctuate between predominantly fresh and marine. FDEP stated that a) the assessment for a WQBEL is not based on WBID averages, but instead is typically based on the output from key "worst case" model segment/cells, b) for assessing DO, the assessment should look at results for individual model layers, and c) each model result should be compared to the criterion that applies based on the modeled salinity for the same time period for that cell. HDR will consult with FDEP about criteria evaluation approaches as model results for model projections become available.

We appreciate the opportunity to further support IP at the Pensacola Mill and look forward to working together.

Sincerely,

HDR Engineering, Inc.

Cristhian Mancilla
Sr. Water Quality Modeler

Sincerely,

HDR Engineering, Inc.

Andrew J. Thuman, P.E. (NJ)
Vice President

cc: Namita Joshua (HDR)
Thomas Gallagher (HDR)

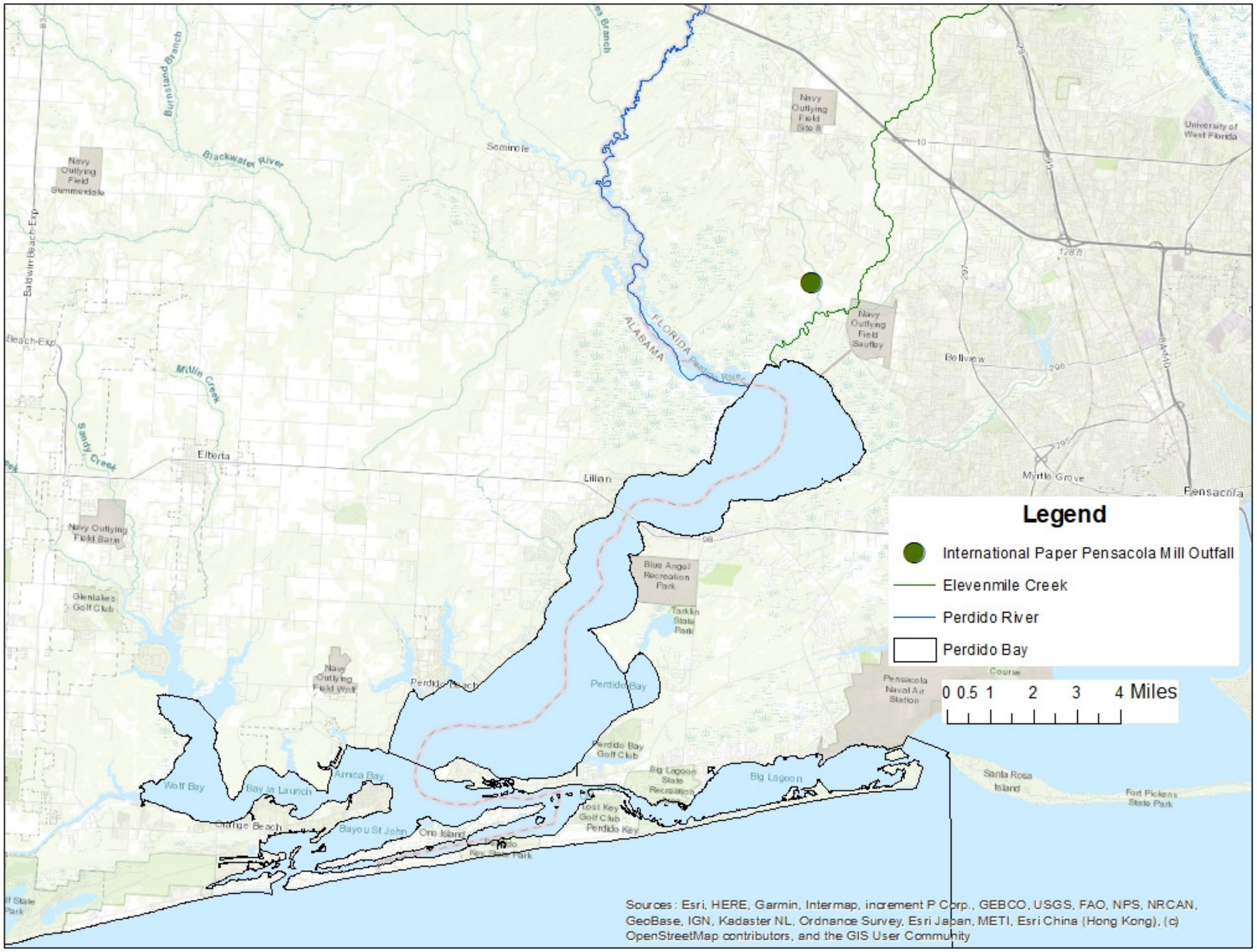

Figure 1. Map of Study Area

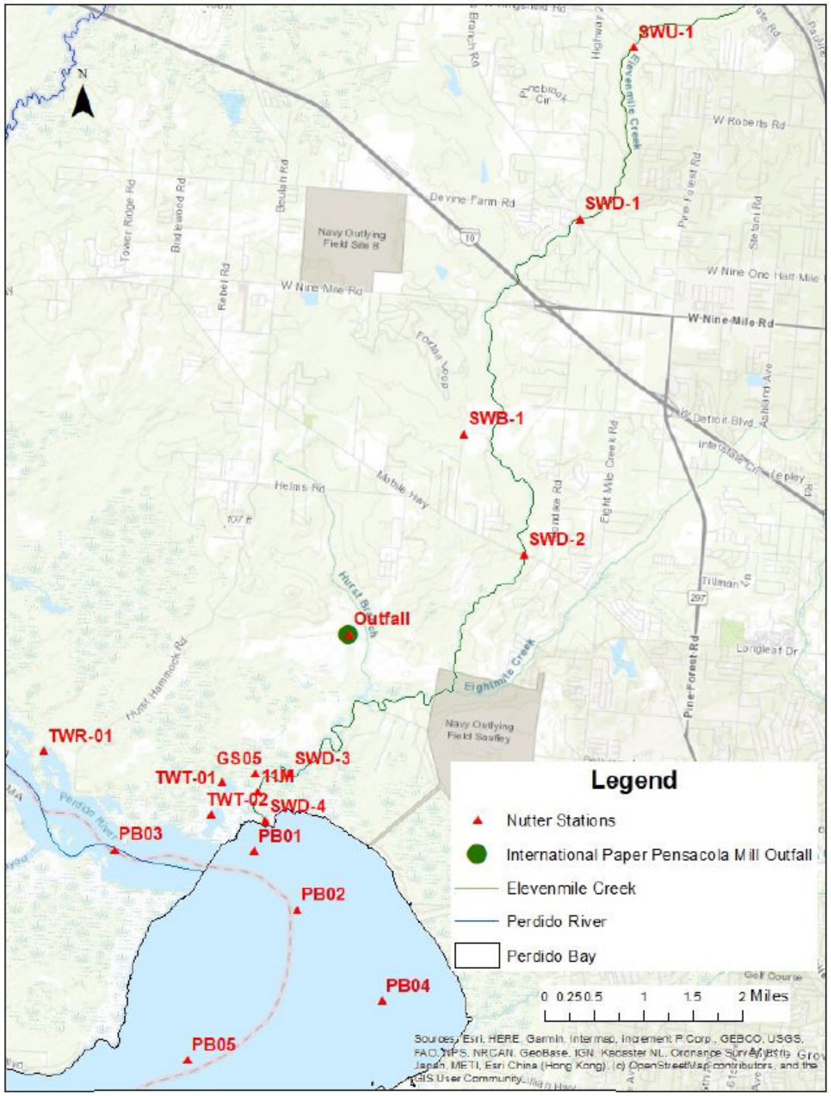

Figure 2. Map of Nutter Sampling Stations

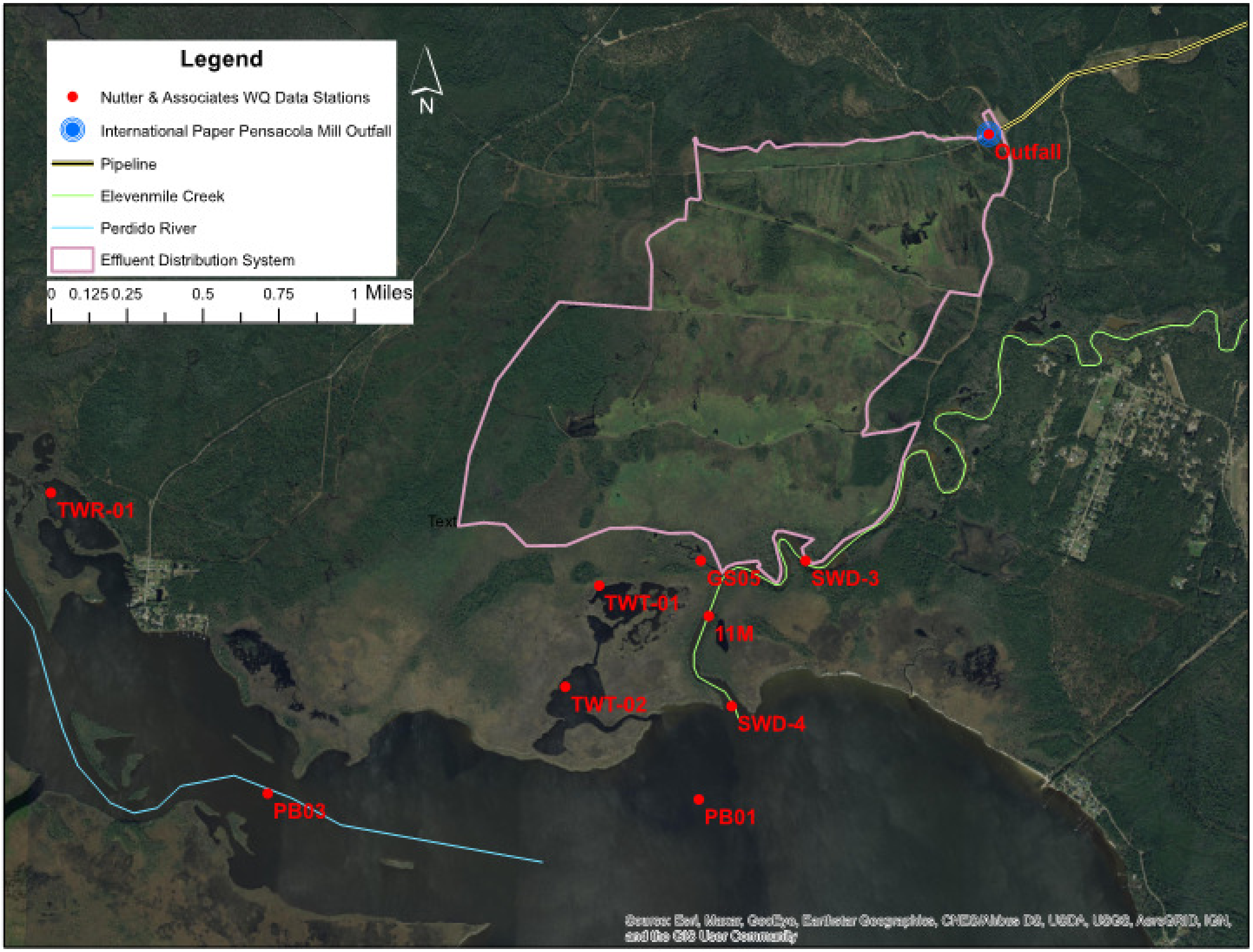

Figure 3. Close-up Map of Nutter Sampling Stations

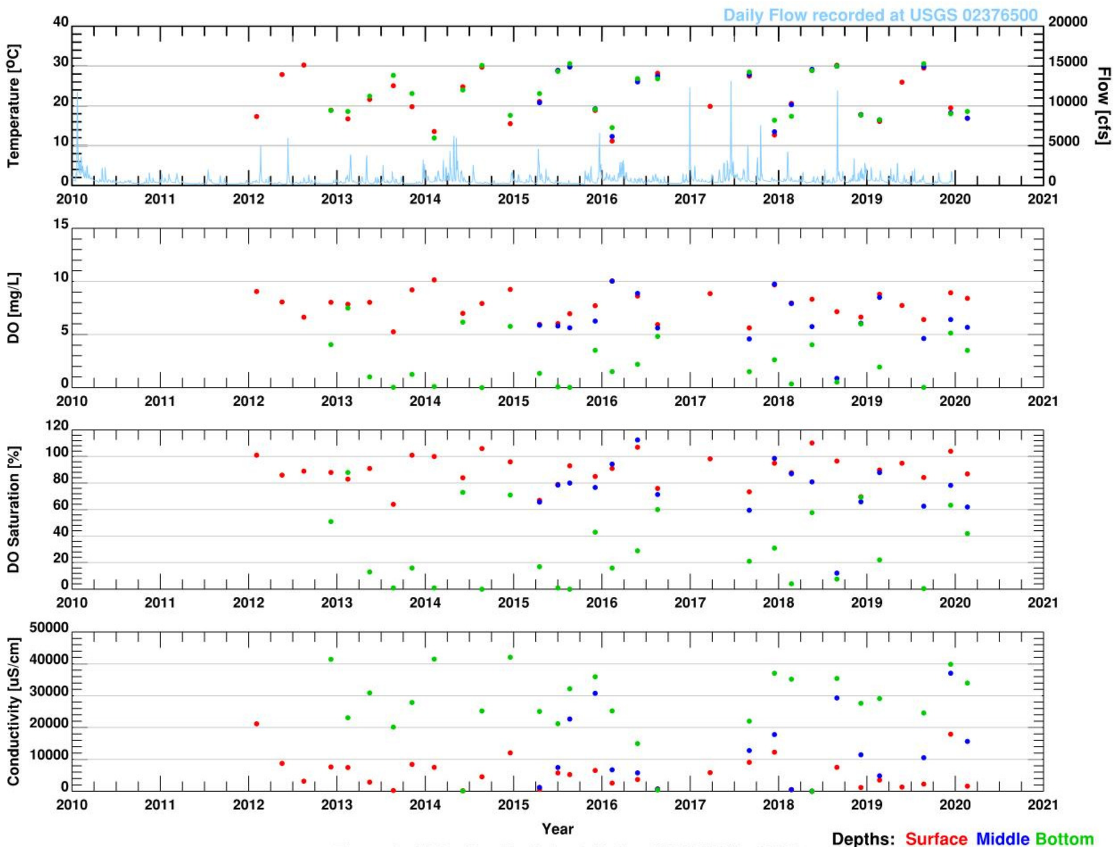

Figure 4a. Water Quality Data at Station PB03

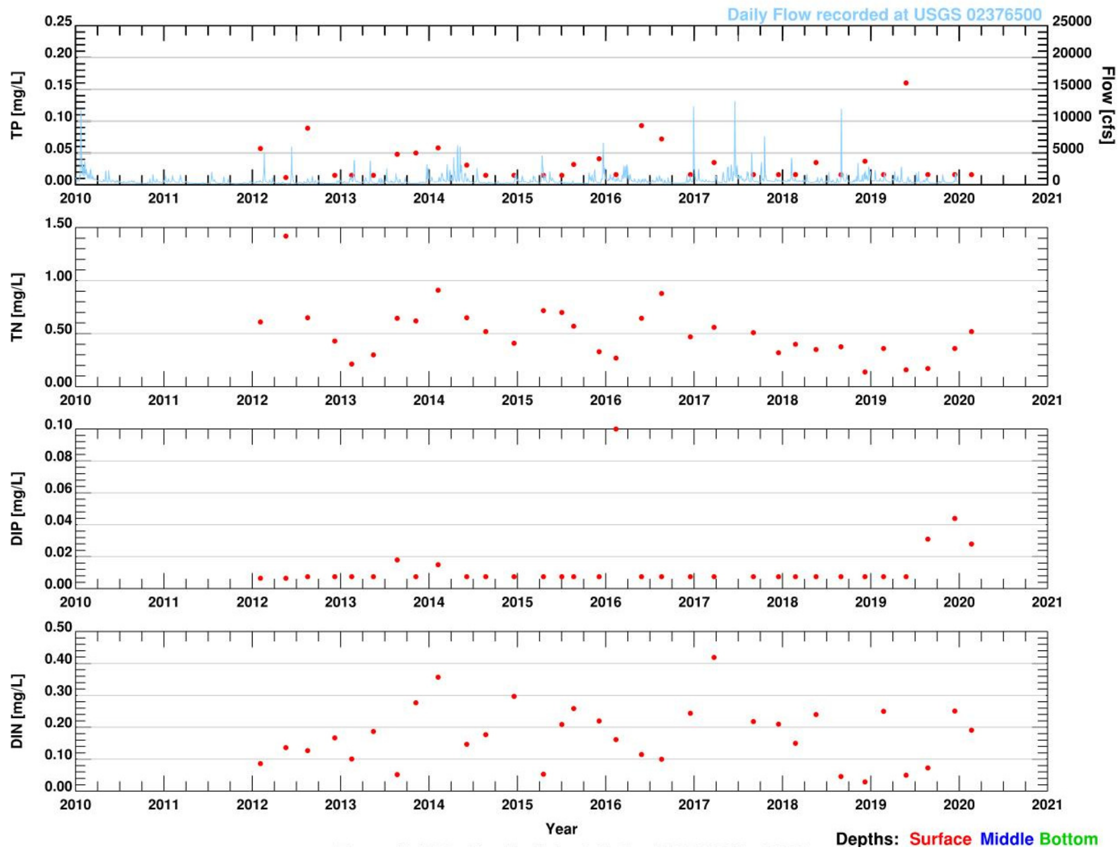

Figure 4b. Water Quality Data at Station PB03

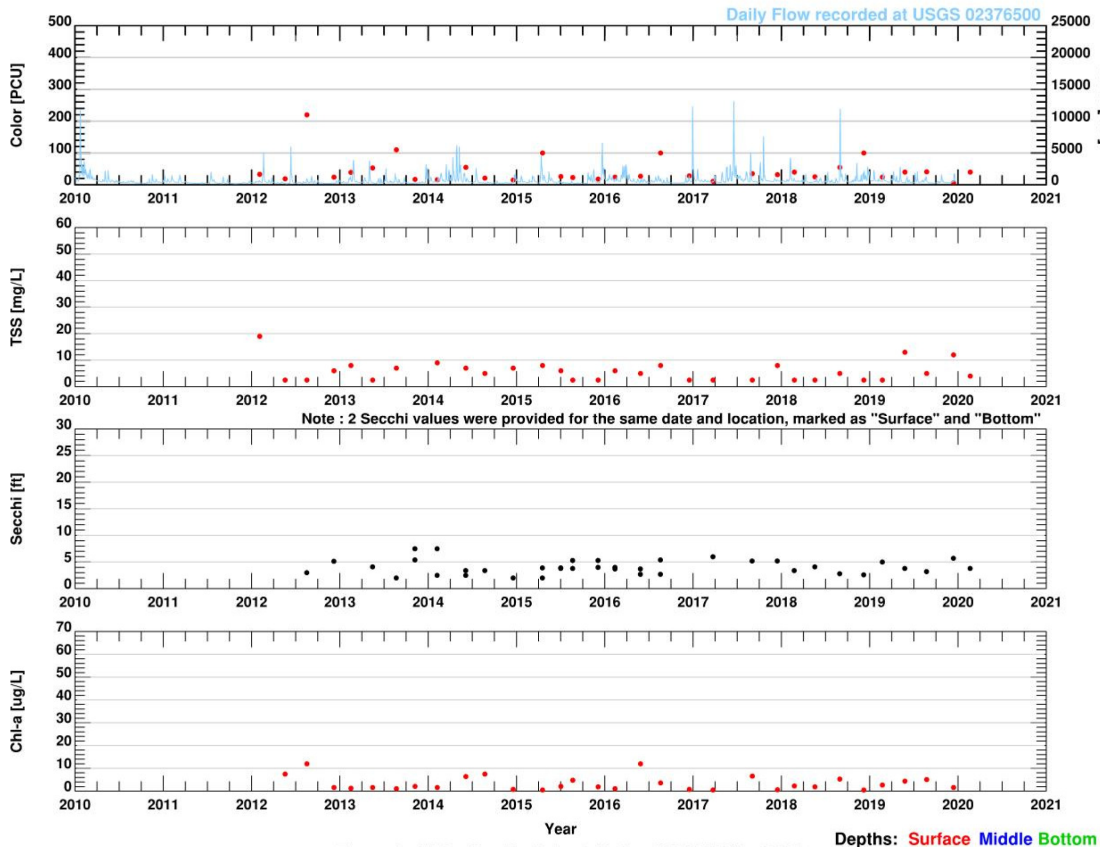

Figure 4c. Water Quality Data at Station PB03

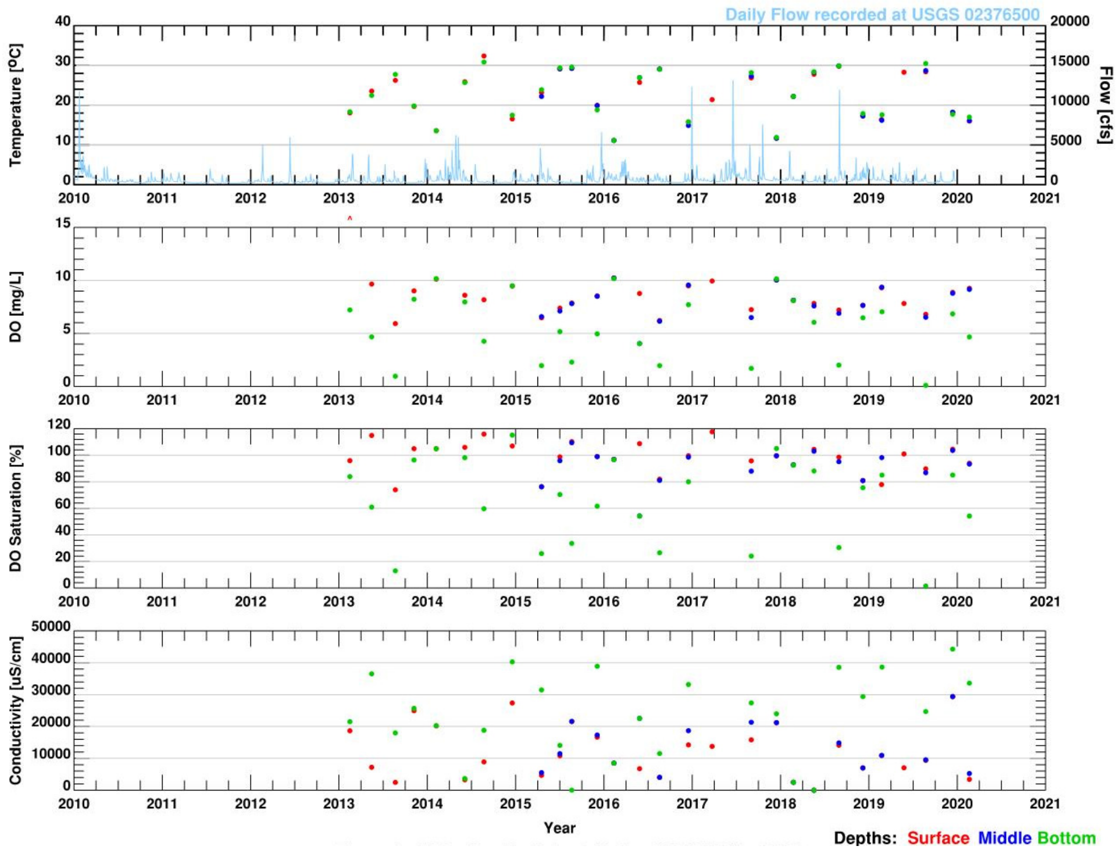

Figure 5a. Water Quality Data at Station PB05

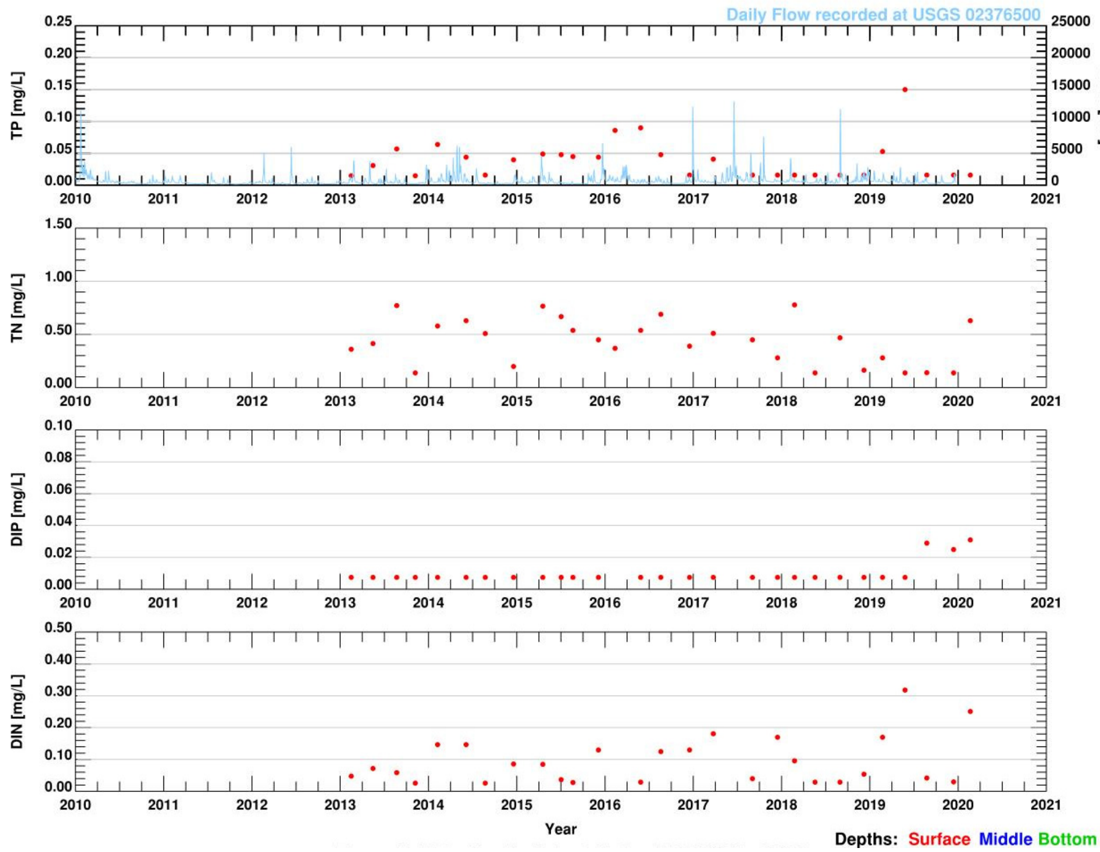

Figure 5b. Water Quality Data at Station PB05

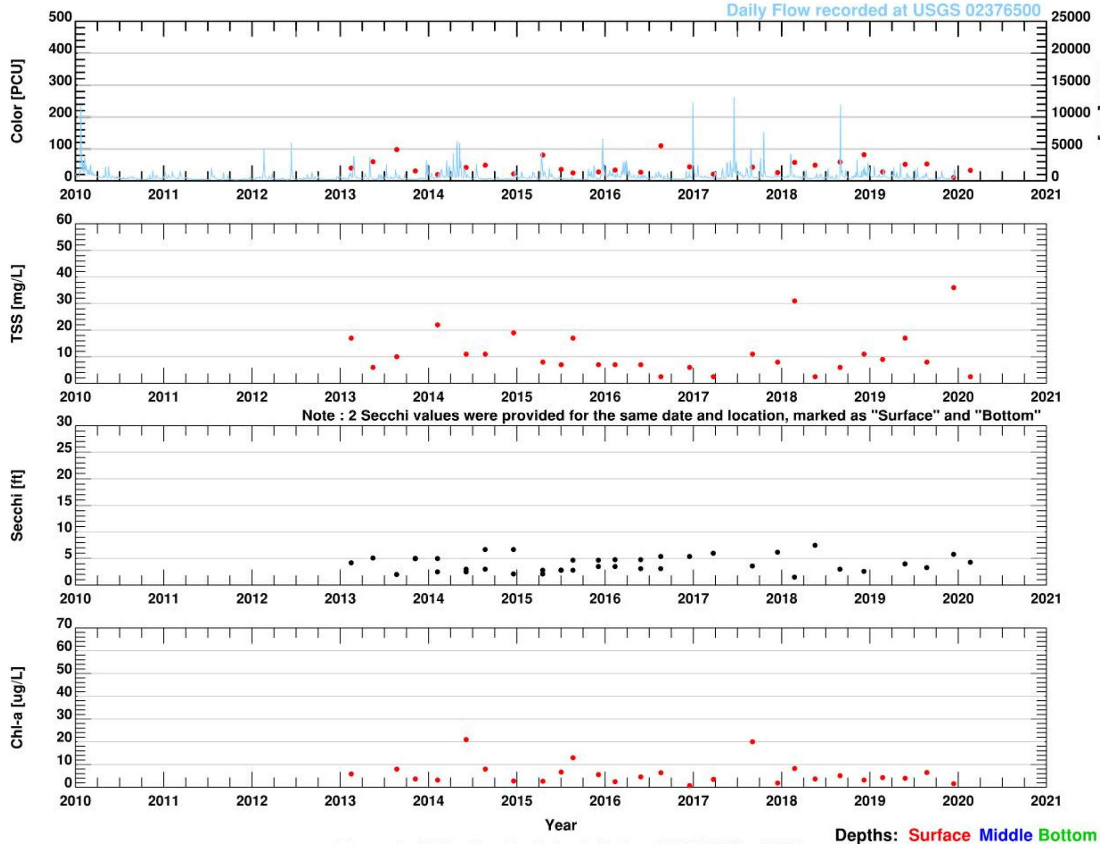

Figure 5c. Water Quality Data at Station PB05

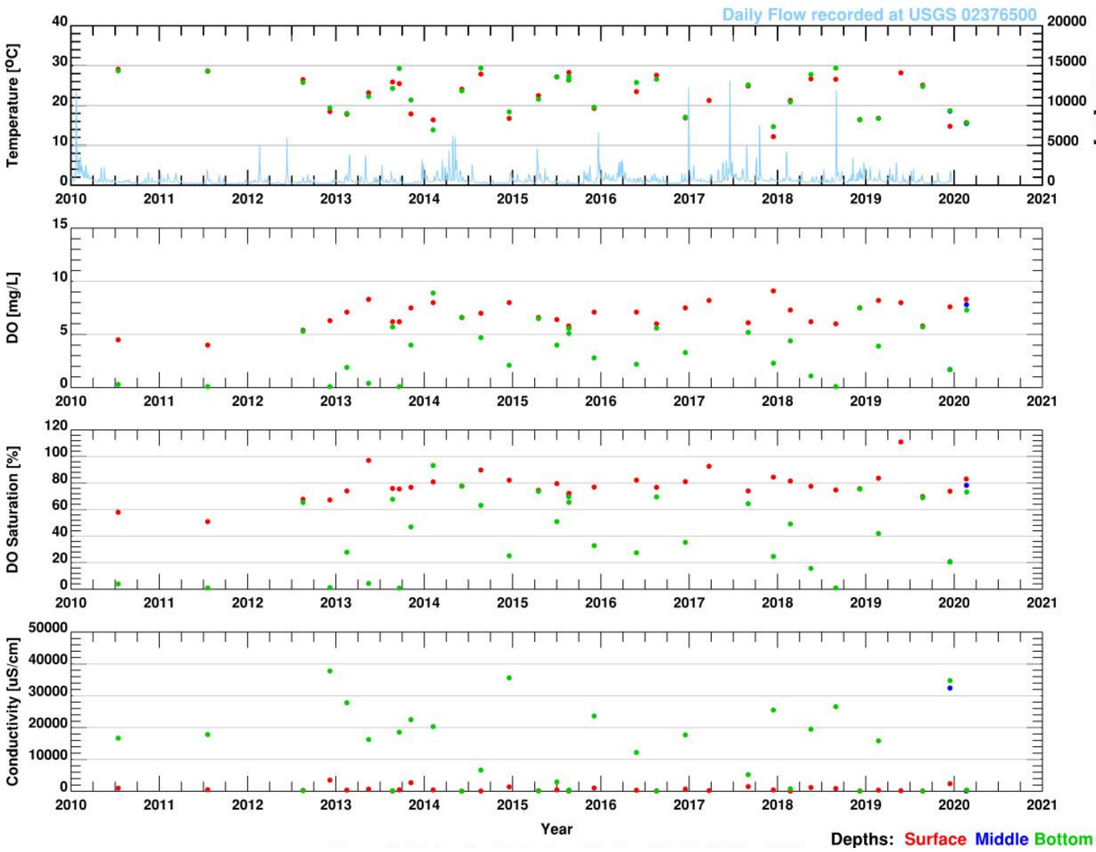

Figure 6a. Water Quality Data at Station SWD3

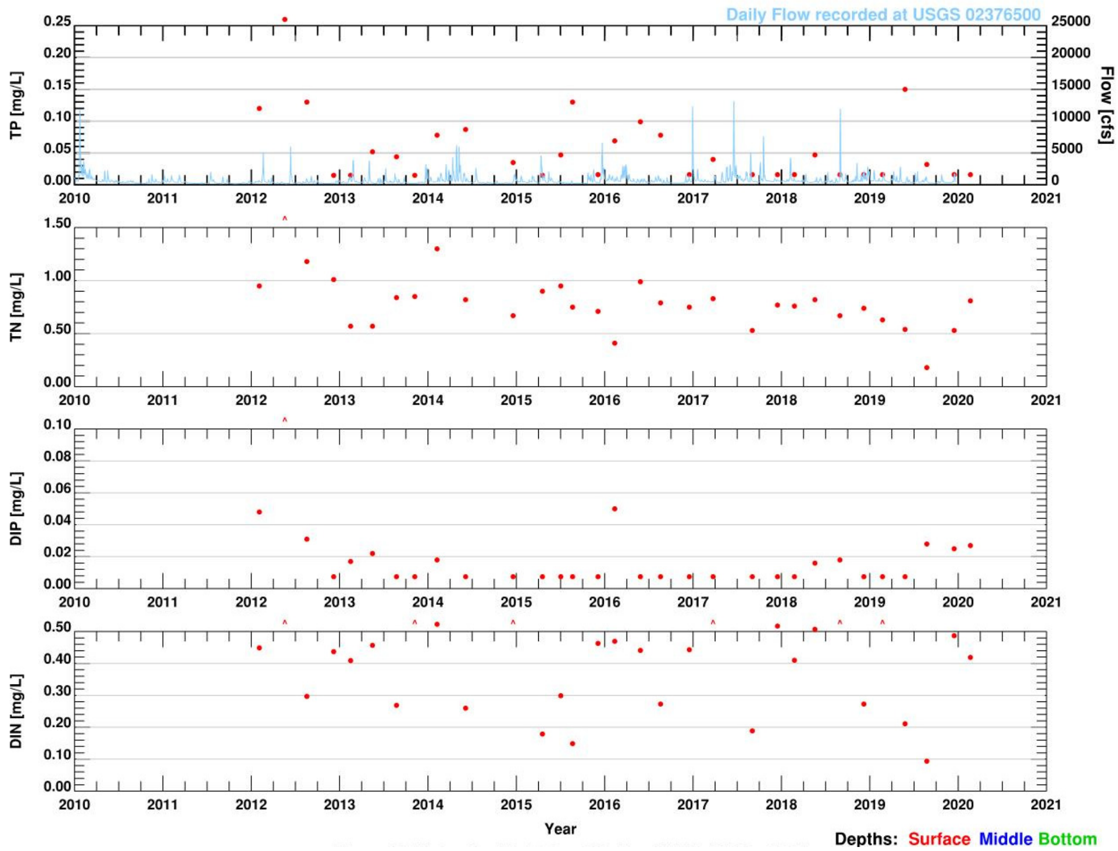

Figure 6b. Water Quality Data at Station SWD3

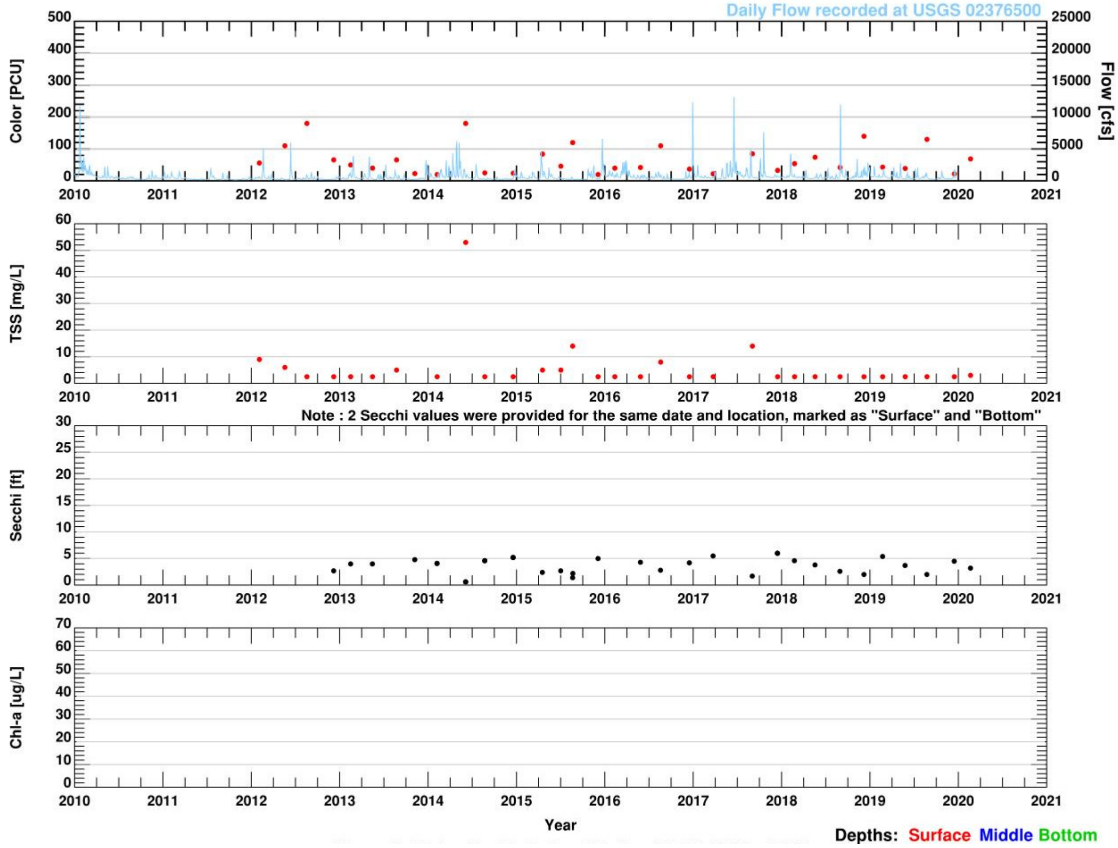

Figure 6c. Water Quality Data at Station SWD3

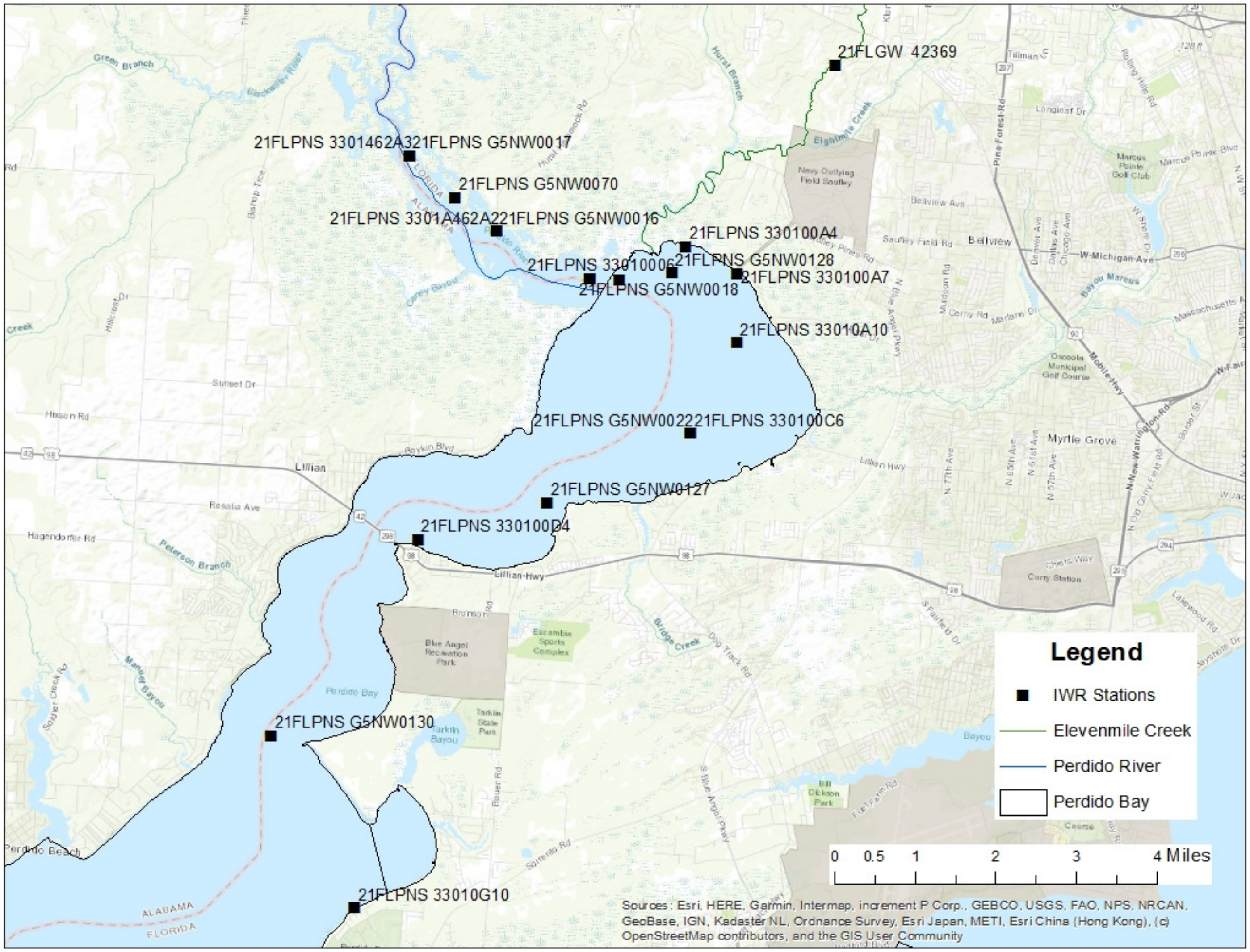

Figure 7. Map of IWR Stations in Perdido Bay, Perdido River and Elevenmile Creek

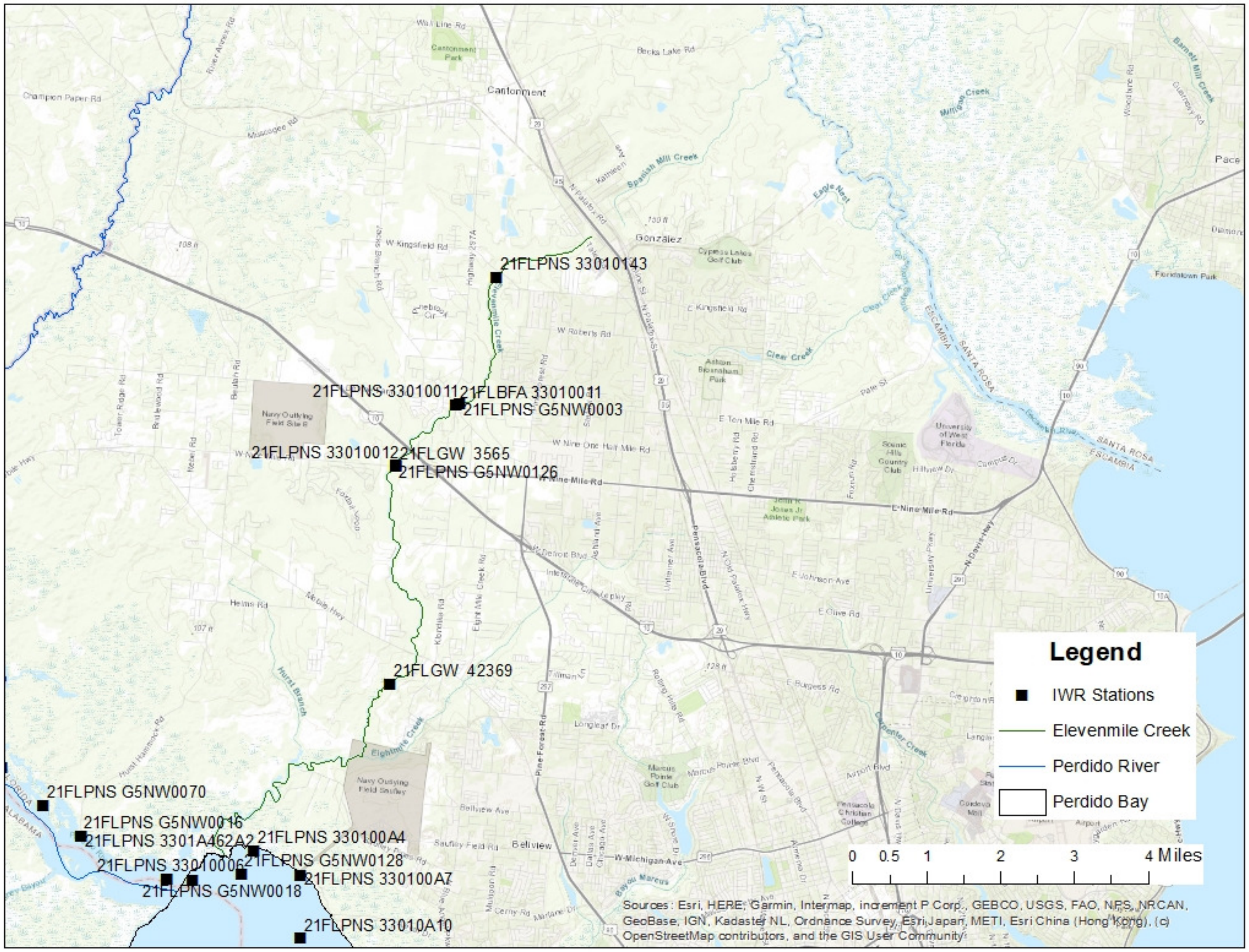

Figure 8. Map of IWR Stations in Perdido Bay, Perdido River and Elevenmile Creek

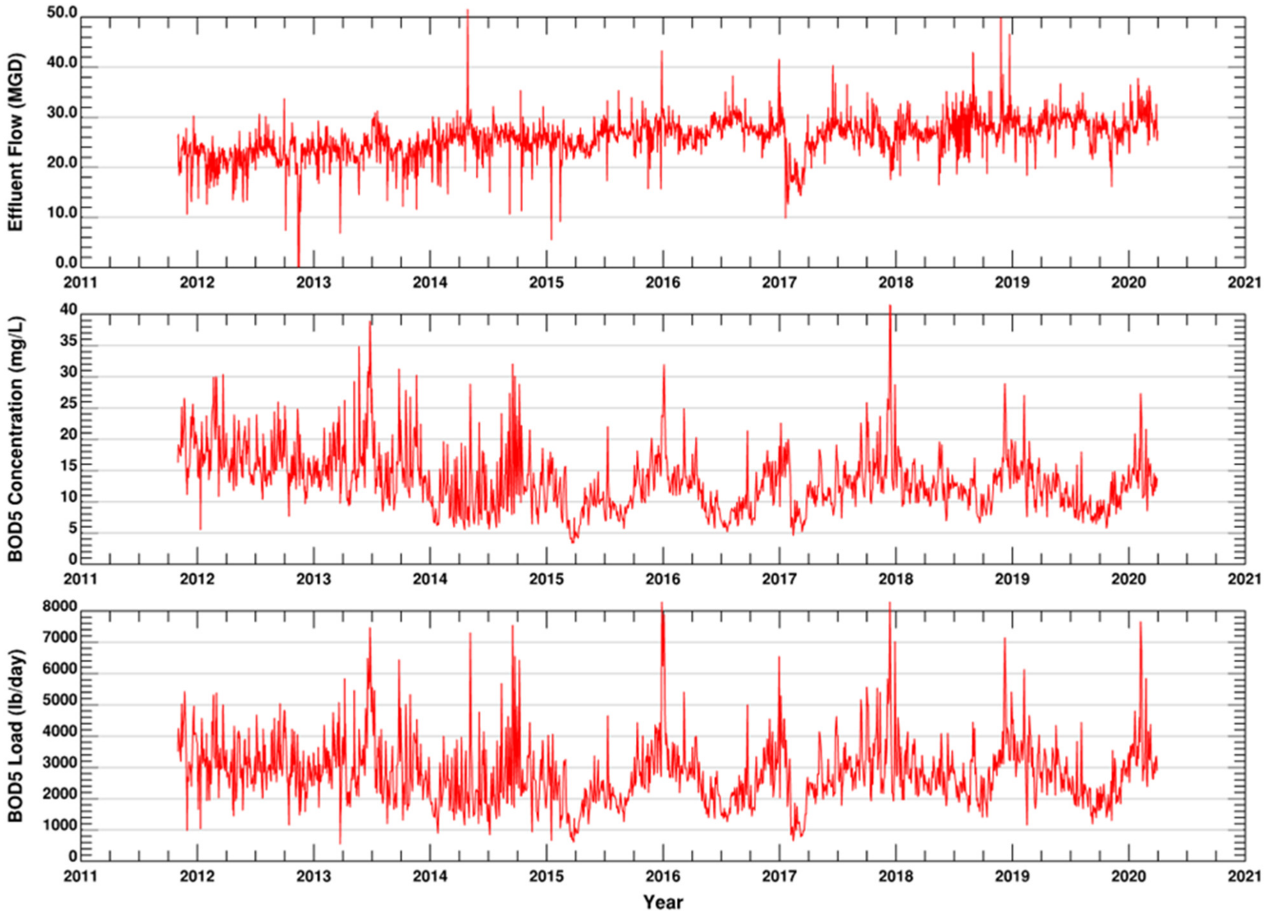

Figure 9. IP Pensacola Mill Daily Effluent Flow and BOD5 (2011-2020)

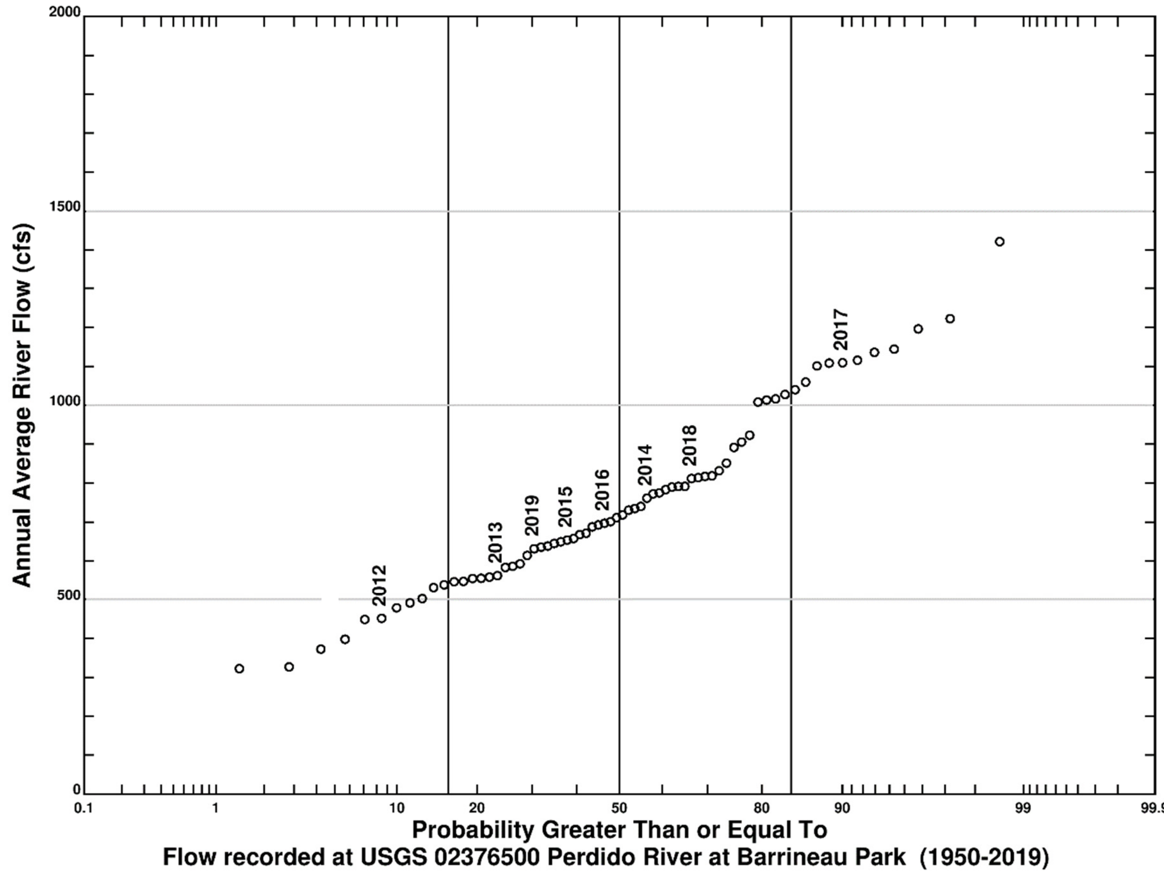

Figure 10. Annual Average Perdido River Flows at USGS 02376500 at Barrineau Park

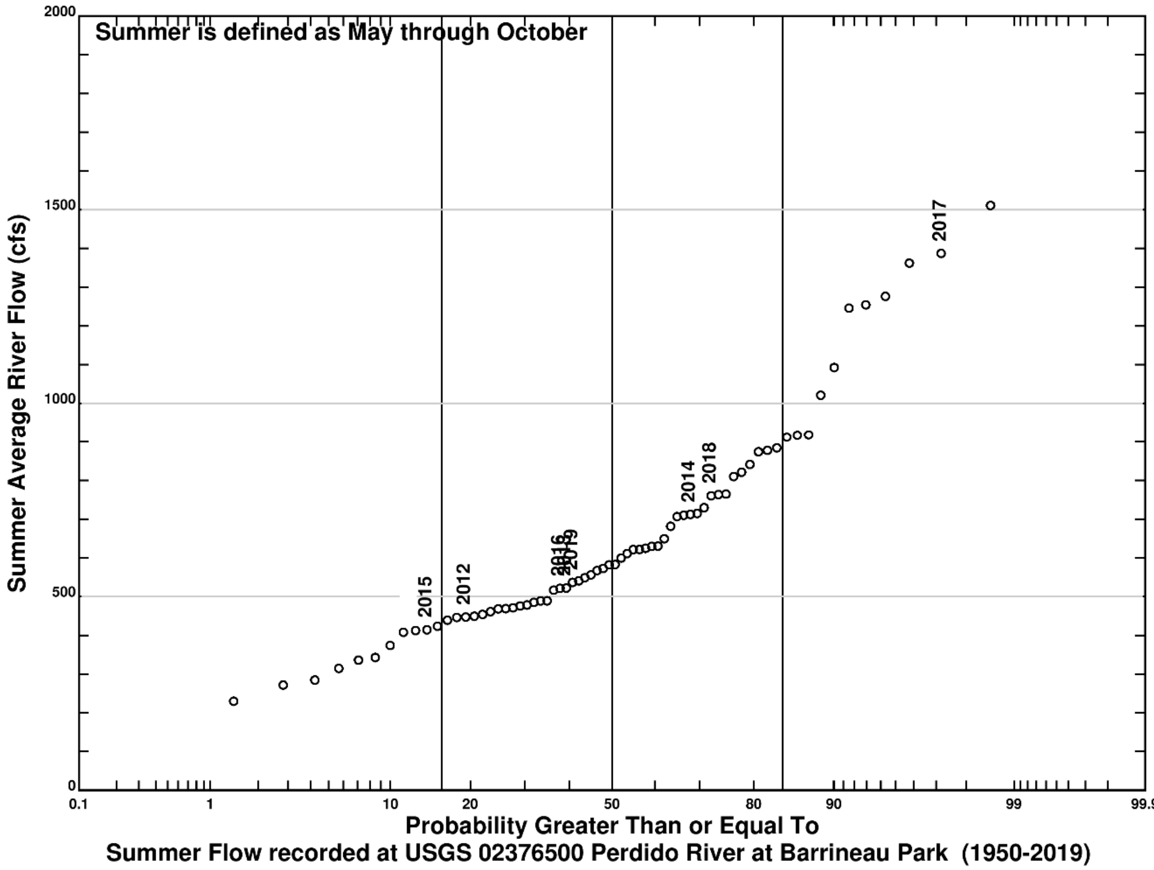

Figure 11. Summer Average Perdido River Flows at USGS 02376500 at Barrineau Park

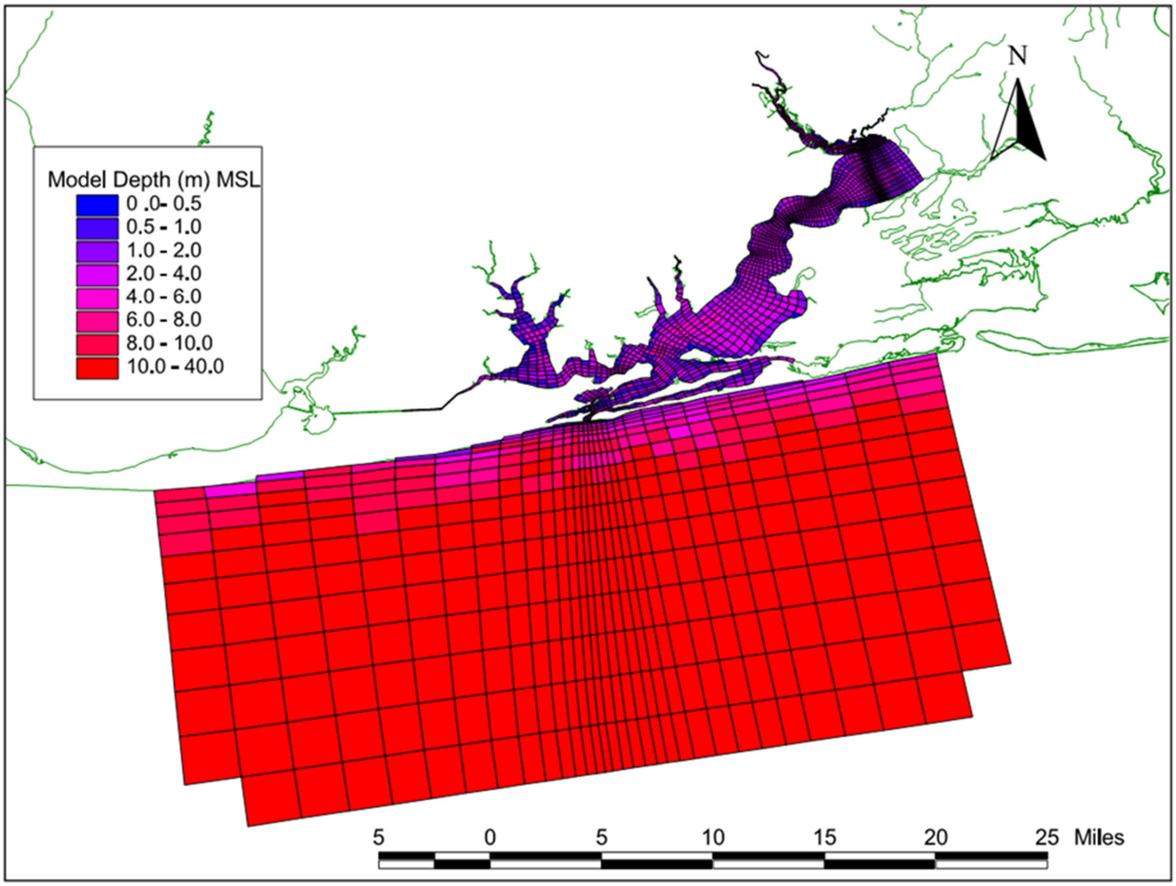

Figure 12. Sample Model Grid for the Perdido Bay System

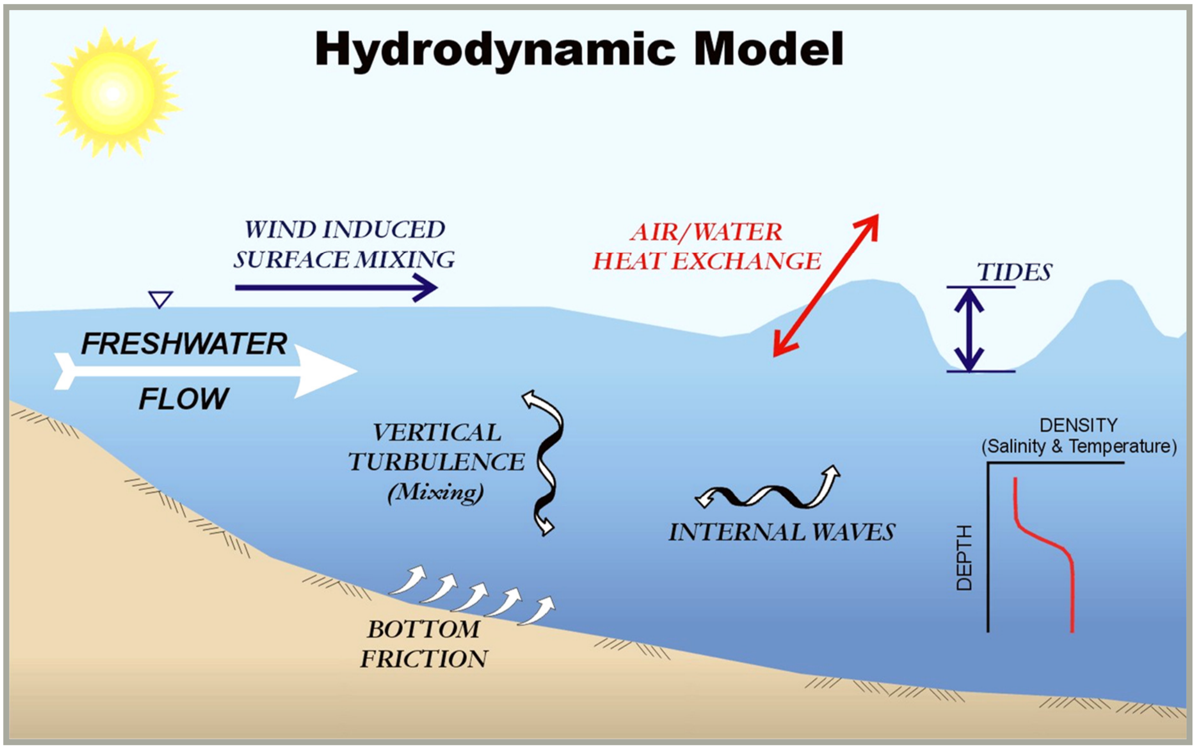

Figure 13. Schematic of Hydrodynamic Mechanisms Simulated by ECOMSED.

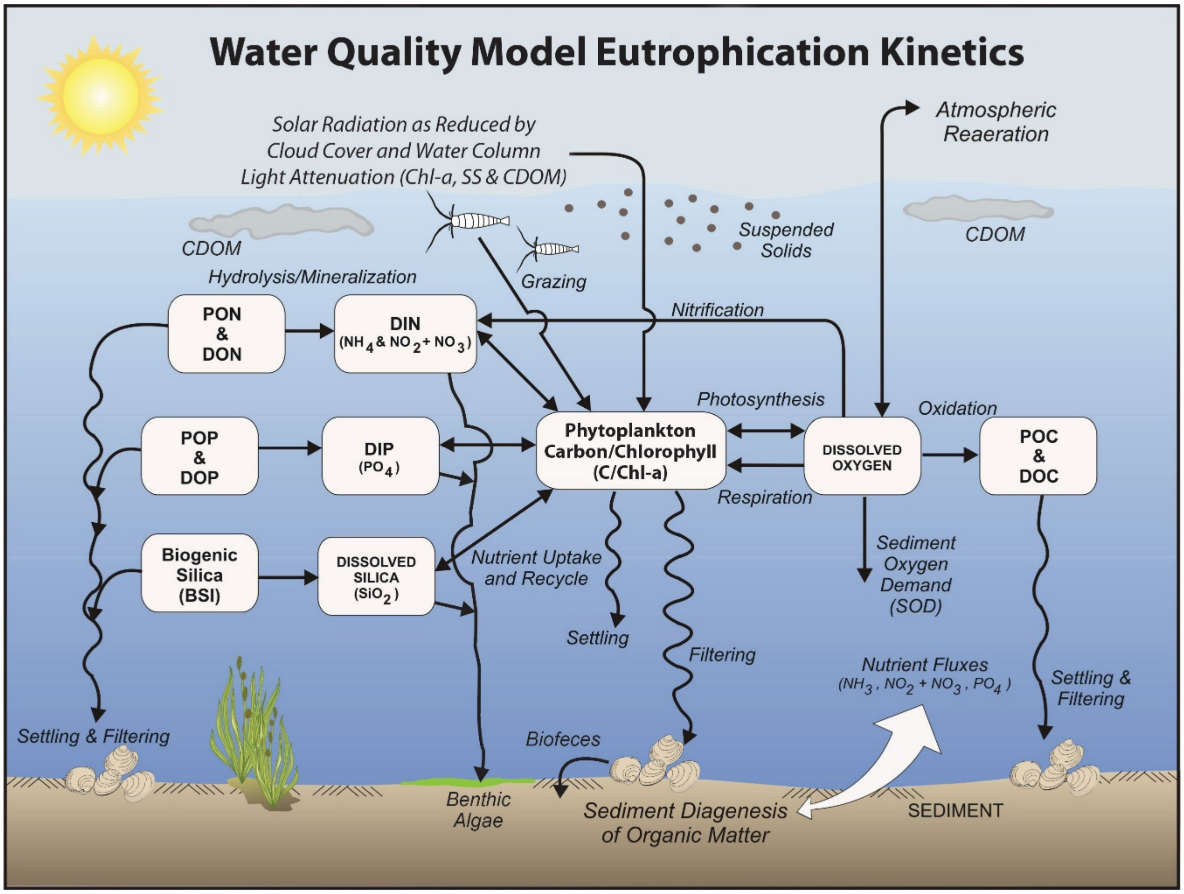

Figure 14. RCA Model Eutrophication Kinetics.

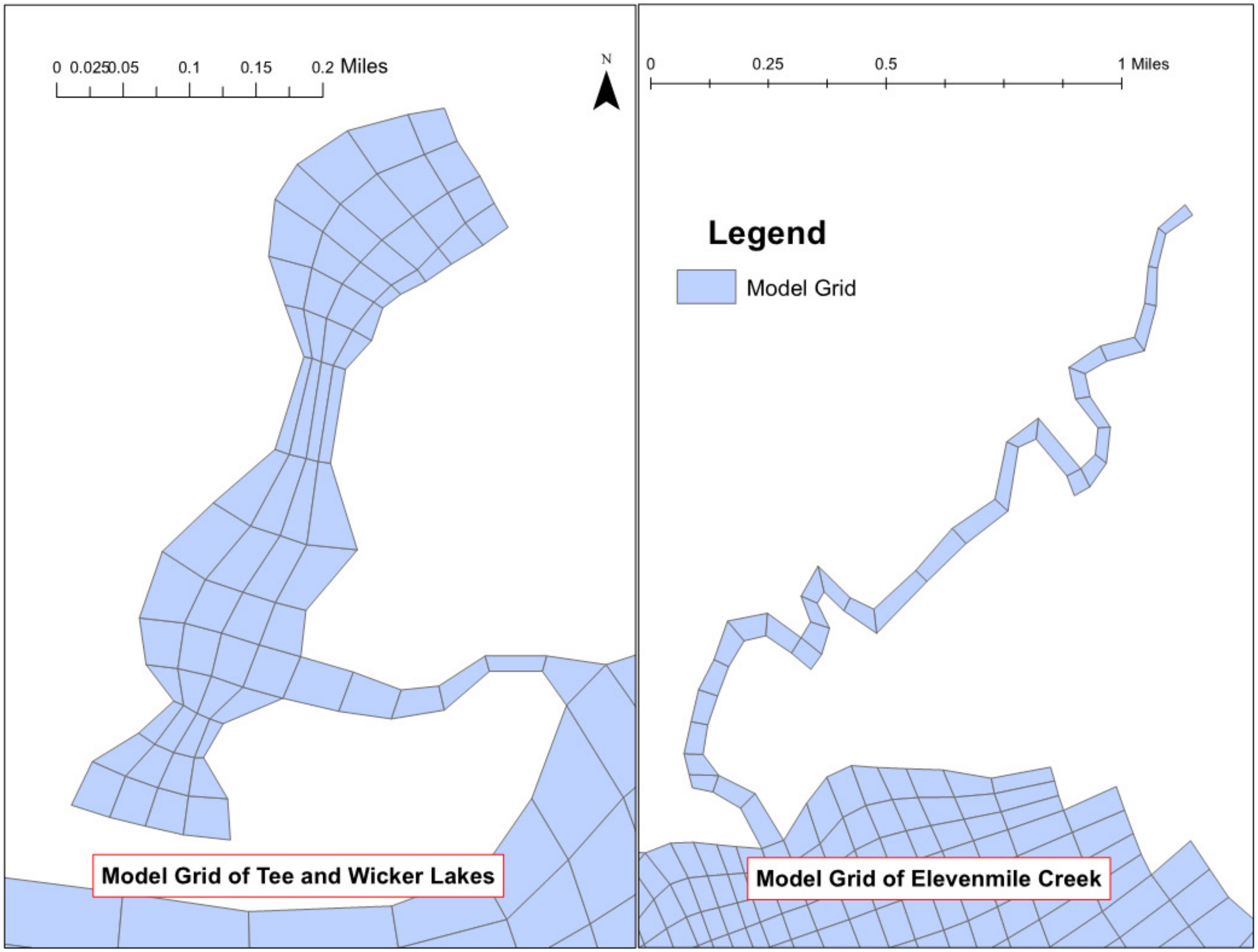

Figure 15. Model Grid in Tee and Wicker Lakes and Elevenmile Creek

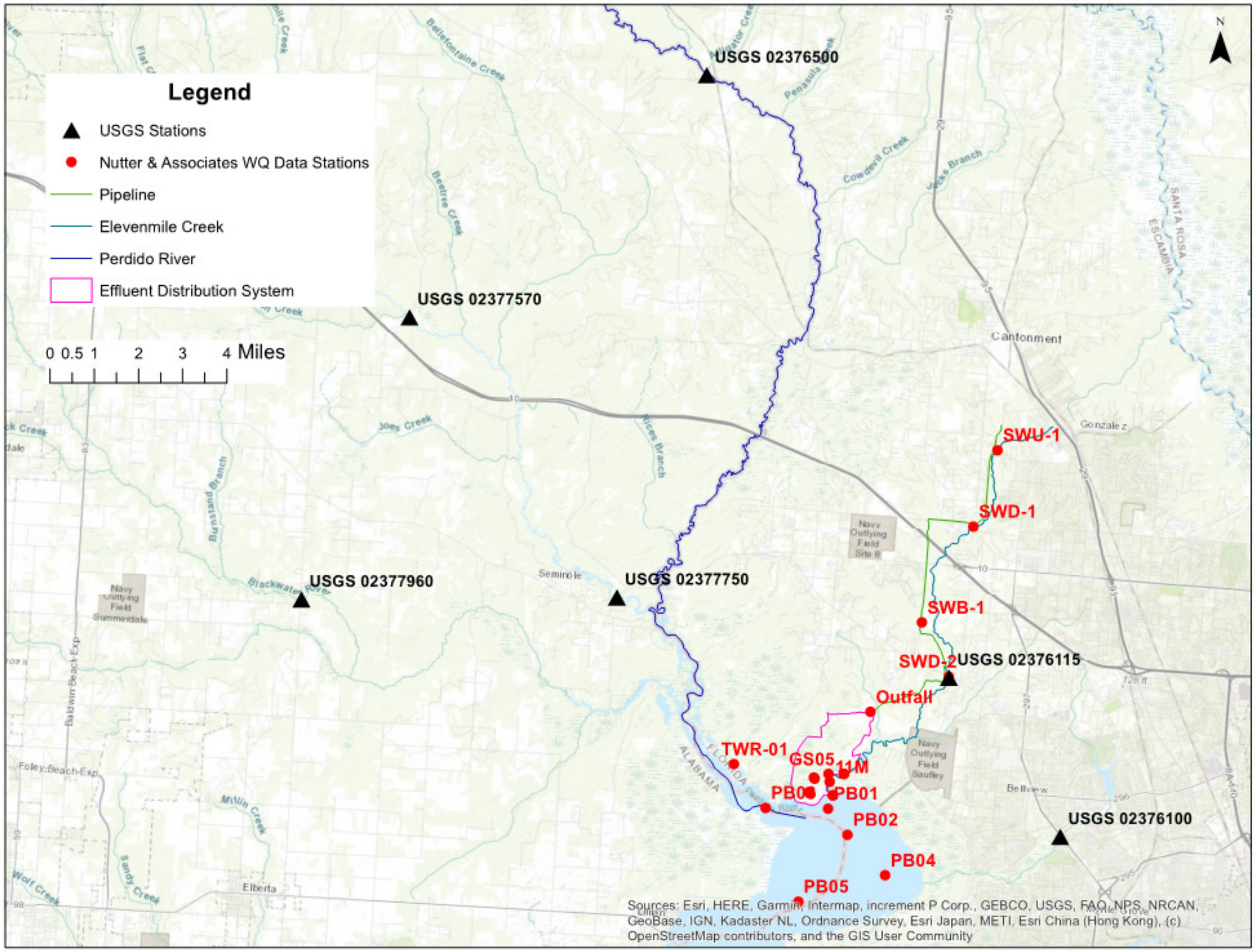

Figure 16. Map of USGS Stations in Study Area

Figure 17. Map of Water Quality Station GS05