

SOUTH DISTRICT • CHARLOTTE HARBOR BASIN

Final TMDL Report
Nutrient TMDLs for Sanibel Slough
(WBIDs 2092F1 and 2092F2)
and Documentation in Support of the
Development of
Site-Specific Numeric Interpretations
of the Narrative Nutrient Criterion

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Executive Summary

Sanibel Slough is located on Sanibel Island, Lee County, Florida. The waterbody was identified as impaired for nutrients based on elevated annual average Trophic State Index and was added to the 303(d) list by Secretarial Order on May 27, 2004, as the segment with **waterbody identification (WBID) number 2092F**. Subsequently, Sanibel Slough was reclassified as an estuarine system and then subdivided into two basins, Sanibel Slough West (WBID 2092F1) and Sanibel Slough East (2092F2). Individual total maximum daily loads (TMDLs) for total nitrogen (TN) and total phosphorus (TP) have been developed, and supporting information for the TMDLs is listed below in **Table EX-1**. These TMDLs were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the U.S. Environmental Protection Agency.

Table EX-1. Summary of TMDL supporting information for Sanibel Slough

| Type of Information | Description |
|--|---|
| Waterbody name/ WBID number | Sanibel Slough West/WBID 2092F1 Sanibel Slough East/WBID 2092F2 |
| Hydrologic Unit Code (HUC) 8 | 03100103 |
| Use classification/ Waterbody designation | Class III/Marine |
| Targeted beneficial uses | Fish consumption; recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife |
| 303(d) listing status | Verified List of Impaired Waters for the Group 2 basins (Charlotte Harbor) adopted via Secretarial Order dated May 27, 2004. |
| TMDL pollutants | TN and TP |
| TMDLs and site-specific interpretations of the narrative nutrient criterion | <p style="text-align: center;">WBID 2092F1:</p> <p>Chlorophyll a: 11 micrograms per liter ($\mu\text{g/L}$), expressed as an annual geometric mean (AGM) concentration not to be exceeded more than once in any consecutive 3-year period.</p> <p>TN: 1,903 kilograms per year (kg/yr), expressed as a rolling 3-year annual average load not to be exceeded.</p> <p>TP: 242 kg/yr, expressed as a rolling 3-year annual average load not to be exceeded.</p> <p style="text-align: center;">WBID 2092F2:</p> <p>Chlorophyll a: 21 $\mu\text{g/L}$, expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period.</p> <p>TN: 1,091 kg/yr, expressed as a rolling 3-year annual average load not to be exceeded.</p> <p>TP: 123 kg/yr, expressed as a rolling 3-year annual average load not to be exceeded.</p> |
| Load reductions required to meet the TMDLs | <p>WBID 2092F1: 26 % TN reduction and 34 % TP reduction to achieve a chlorophyll <i>a</i> target of 11 $\mu\text{g/L}$.</p> <p>WBID 2092F2: 54 % TN reduction and 74 % TP reduction to achieve a chlorophyll <i>a</i> target of 21 $\mu\text{g/L}$.</p> |

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Websites

Florida Department of Environmental Protection

[TMDL Program](#)

[Identification of Impaired Surface Waters Rule](#)

[Florida STORET Program](#)

[2016 Integrated Report](#)

[Criteria for Surface Water Quality Classifications](#)

[Surface Water Quality Standards](#)

[Basin Management Action Plans](#)

U.S. Environmental Protection Agency

[Region 4: TMDLs in Florida](#)

[National STORET Program](#)

Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairment of Sanibel Slough, located in the Charlotte Harbor Basin. The TMDLs will also constitute the site-specific numeric interpretation of the narrative nutrient criterion set forth in Paragraph 62-302.530(90)(b), Florida Administrative Code (F.A.C.), that will replace the otherwise applicable numeric nutrient criteria (NNC) in Subsection 62-302.531(2), F.A.C., for this particular waterbody, pursuant to Paragraph 62-302.531(2)(a), F.A.C. The waterbody was verified as impaired for nutrients using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.), and was included on the Verified List of Impaired Waters for the Charlotte Harbor Basin that was adopted by Secretarial Order on May 27, 2004.

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and provides water quality targets needed to achieve compliance with applicable water quality criteria based on the relationship between pollution sources and water quality in the receiving waterbody. The TMDLs establish the allowable loadings to Sanibel Slough that would restore the waterbody so that it meets its applicable water quality criteria for nutrients.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (DEP) divided the Charlotte Harbor Basin (Hydrologic Unit Code [HUC] 03100103) into watershed assessment polygons with a unique **waterbody identification (WBID)** number for each watershed or surface water segment. Sanibel Slough was originally assessed as the Sanibel River under WBID 2092F but was subsequently divided into two subbasins to acknowledge that the slough comprises two distinct systems separated by a water control structure. The Sanibel Slough West and Sanibel Slough East subbasins were assigned individual WBID numbers: 2092F1 and 2092F2, respectively.

In this report, discussions of the whole system will use the waterbody name Sanibel Slough. However, it will also be necessary to refer to the two subbasins individually, in which case they will be referred to as Sanibel Slough East (WBID 2092F2) and Sanibel Slough West (WBID 2092F1), or as the East and West Basins. **Figure 1.1** displays the location of the WBIDs in Lee County, along with the major geopolitical and hydrologic features in the area.

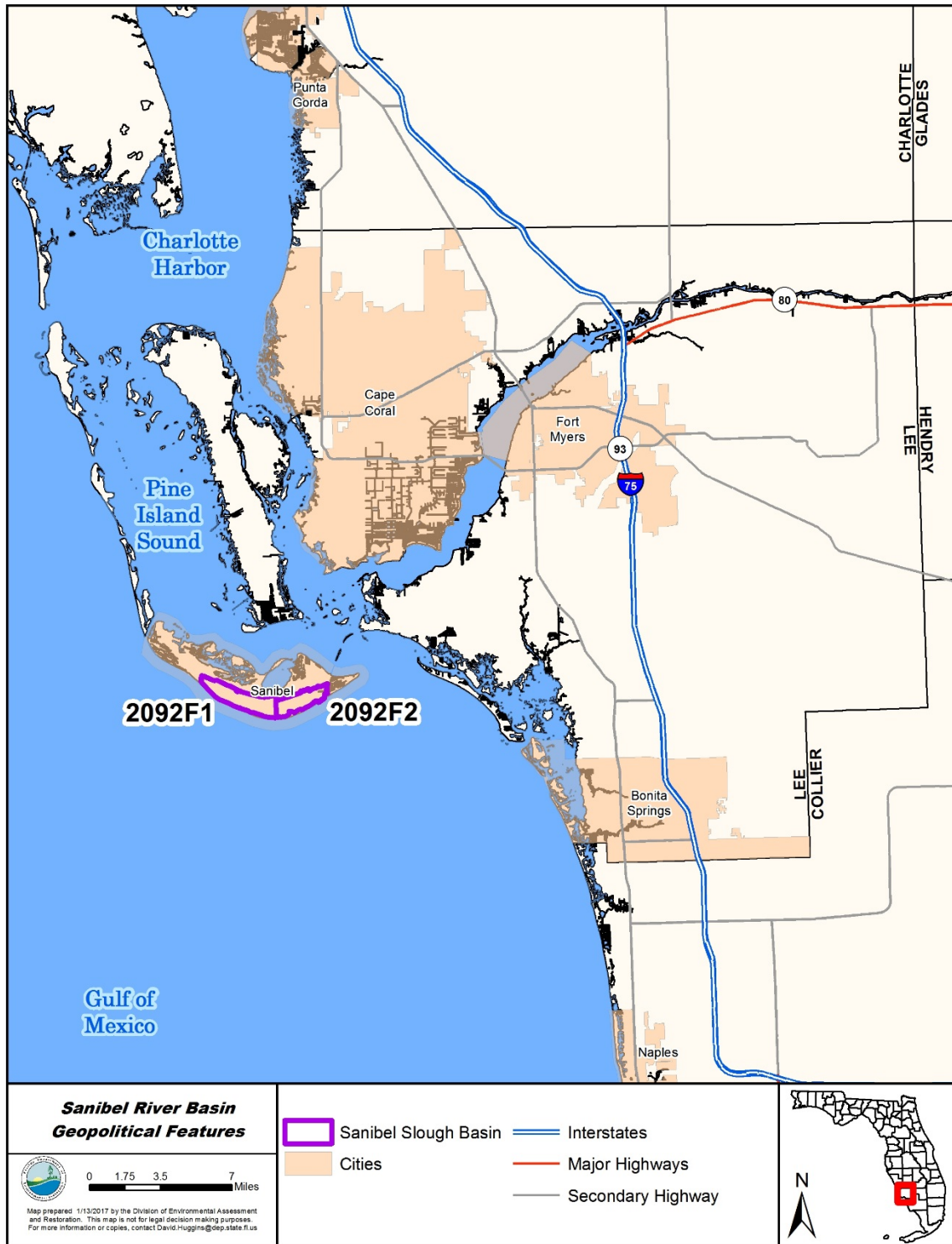


Figure 1.1. Location of Sanibel Slough (WBIDs 2092F1 and 2092F2) in Lee County and major hydrologic and geopolitical features in the area

1.3 Site-Specific Information

1.3.1 Population and Geopolitical Settings

Although the waterbody is known as the Sanibel River, per the Sanibel-Captiva Conservation Foundation (SCCF) the waterbody resembles a slough and will therefore be renamed by DEP and referred to as Sanibel Slough (Thompson and Milbrandt 2013). Sanibel Slough is located on Sanibel Island within the limits of the City of Sanibel in Lee County.

Sanibel and the adjacent island of Captiva are barrier islands separated from the mainland by San Carlos Bay and Pine Island Sound. The primary link to the mainland is a 3-part causeway and high-span bridge. The population of Sanibel Island was 6,469 in 2010, according to the U.S. Census. The population density at the time was estimated at 400 individuals per square mile.

The eastern portion of Sanibel Slough is more urbanized, and the western portion is in a somewhat less developed area adjacent to J.N. "Ding" Darling National Wildlife Refuge. Multiple tracts of preserved lands, primarily located near the western portion of Sanibel Slough, provide the slough with a vegetative buffer from developed land. Sanibel Island is also the home to the nonprofit research and conservation facility of the SCCF, and the organization has worked in partnership with the City of Sanibel on conservation issues on the island.

1.3.2 Topography

Sanibel Island is a long, low island with very little relief. The average elevation is slightly less than one meter above sea level, and elevation changes are gradual. The majority of the island is less than three meters in maximum elevation. **Figure 1.2** provides a light detection and ranging (LiDAR) topographic map of Sanibel Island showing a high-resolution elevation model for the island based on LiDAR data collected in 2007 by the Florida Division of Emergency Management. Sanibel Slough itself runs in a predominantly east-west orientation through the island's interior wetland system.

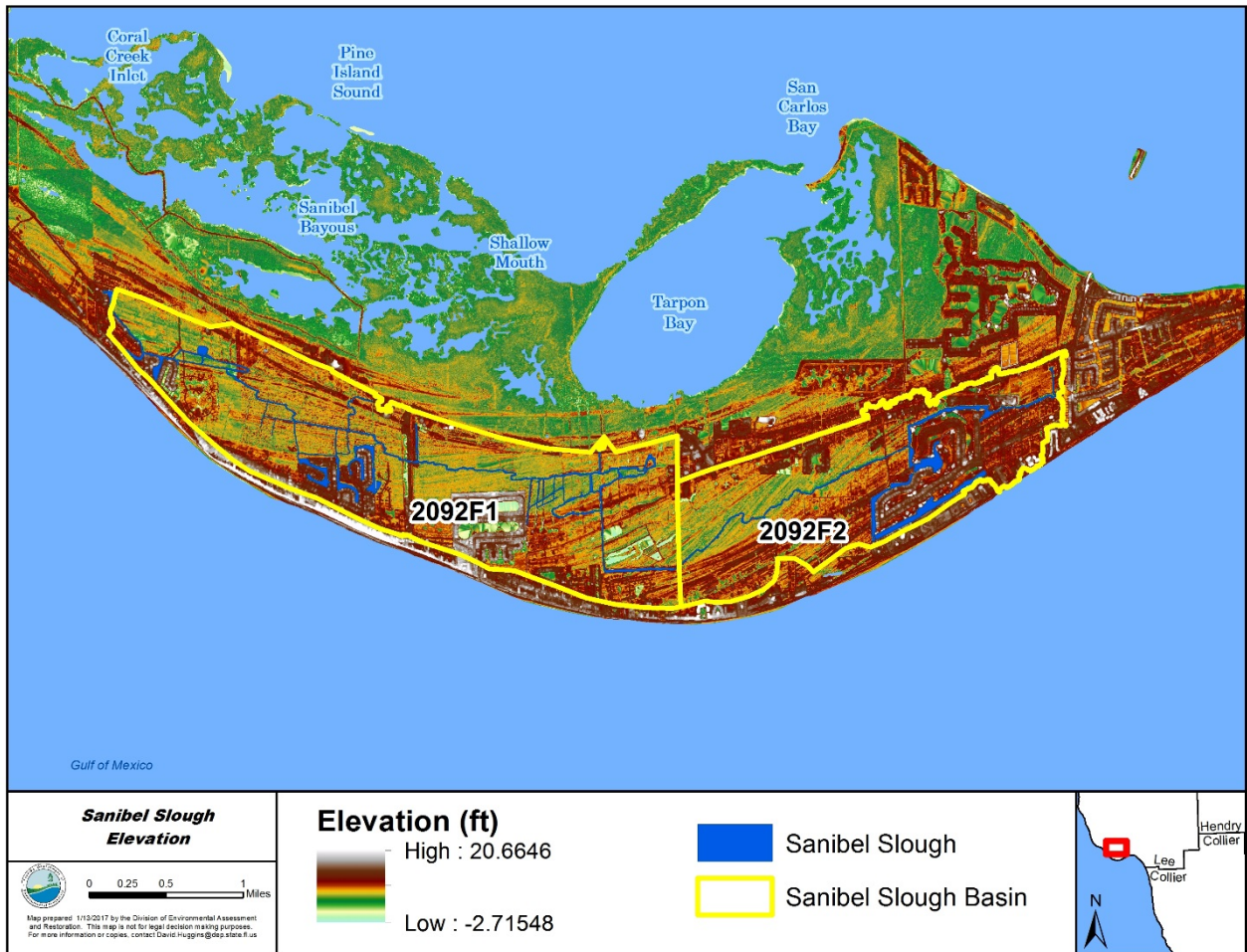


Figure 1.2. Topographic map of Sanibel Island using LiDAR-based elevation model

1.3.3 Hydrogeological Setting

The hydrogeological context of Sanibel Slough includes the topography discussed in the preceding section, along with soil geology, aquifer/groundwater interactions with surface water, and climate. Each of these factors helps to define the inflows and outflows that characterize the Sanibel Slough system.

The primary soils, based on the National Cooperative Soil Survey, belong in the Hydrologic Soil Groups C, B/D, and D. Group C soils are associated with urban land use resulting from the application of fill material. These moderately fine textured soils have low infiltration rates and impede the downward movement of water. Group D soils, found throughout the island, have a particularly low rate of water transmission and high runoff potential when thoroughly wet. The remaining Group B/D soils are better drained than the other soils on the island and have a moderate rate of water transmission. Groundwater interactions are through a surficial aquifer

consisting of an upper sequence of unconsolidated, unconfined sediments comprising a sand/shell composite substrate (Missimer and O'Donnell 1976). The mean thickness of the surficial aquifer is approximately 3.6 meters (Missimer and O'Donnell 1976). The aquifer level varies by season (being higher in the wet season) and can discharge directly into the Gulf and Sound ecosystems at high water levels.

The island's climate is humid subtropical with daily high temperatures ranging from approximately 24° to 32° C. The rainy season is from July to early October, with a long dry season from mid-October through June (Thompson and Milbrandt 2014). The island is subject to the periodic influence of tropical cyclones. In the model period, 2 tropical storms (Fay in 2008 and Bonnie in 2010) passed nearby Sanibel. Although the island was not on the direct path of either storm system, both tropical storms impacted Southwest Florida.

In the 1940s, Sanibel Slough was created by dredging channels between the interior wetlands of the island to serve as a mosquito control and drainage structure. The early stages of slough formation are seen in archived aerial photos of Sanibel Island collected by the U.S. Department of Agriculture in 1944 (**Figure 1.3**).



Figure 1.3. Aerial photographs of Lee County–U.S. Department of Agriculture Flight 2C-36 (1944) with red rectangles indicating dredging channels

The slough is severed from the surrounding estuarine areas of the Gulf of Mexico and San Carlos Bay by control weirs at Sanibel-Captiva Road (West Basin) and Beach Road (East Basin). The slough itself is further divided into eastern and western segments by another control weir located at Tarpon Bay Road. This divide is the basis for the division of the slough into the East and West Basins, because water does not normally pass from one basin into the other, and because water quality, land use, and development in the two basins differ. **Figure 1.4** shows the location of these outflow weirs, as well as the weir separating the East Basin from the West Basin.



Figure 1.4. East and West Basins and locations of the control weirs

The slough is managed to keep the interior wetlands hydrated while maintaining flood protection for developed areas in the island's interior. This strategy results in minimal discharges from the control weirs except in extreme storm events and has the added benefit of helping to prevent the spread of encroaching invasive hardwoods, especially Brazilian pepper (*Schinus terebinthifolius*). **Figure 1.5** shows the number of days with recorded flows over the control weirs for 2007 through 2013.

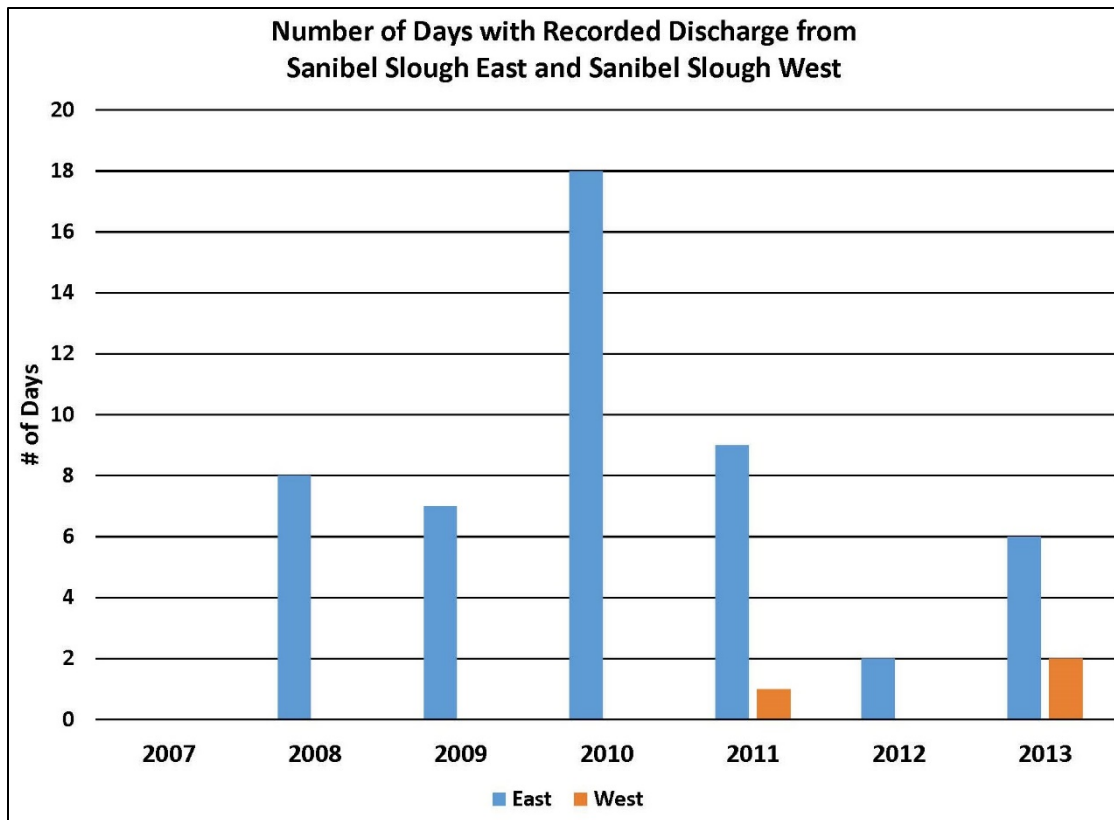


Figure 1.5. Number of days with recorded discharge from Sanibel Slough, 2007–13

1.4 Pollutant Sources and Waterbody Stressors

1.4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the target watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point sources or nonpoint sources. Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act (CWA) redefined certain nonpoint sources of pollution as point sources subject to regulation under the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as those from local

government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with CWA definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) **and** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 4.1 on Expression and Allocation of the TMDL**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

1.4.2 Point Sources

1.4.2.1 Wastewater Point Sources

There are two permitted WWTFs located in the Sanibel Slough Watershed. The Island Water Association Inc. (IWA) (NPDES FL0025593) is an existing 1.33-million-gallon-per-day (mgd) industrial wastewater facility that serves a reverse osmosis drinking water treatment plant. The IWA is permitted to discharge to an underground injection well, U-001, and has a permitted surface water discharge outfall to the Gulf of Mexico, D-001. The IWA has no direct surface water discharge to Sanibel Slough.

The Donax Water Reclamation Facility (WRF) (FLA014430) is an existing 2.375 mgd maximum monthly average daily flow (MMADF) domestic wastewater treatment plant that does not have a direct surface water discharge to Sanibel Slough. The City of Sanibel Service Area is identified as a Regional Reuse Service Area, which incorporates the entire island of Sanibel, for Part III public access reuse. The permitted reuse capacity of this facility is 2.375 mgd MMADF. The permitted reuse consists of the irrigation of grass at golf courses, athletic complexes and parks, other landscape irrigation areas, and residential areas.

Water from the IWA and Donax facilities is used for irrigation in the Sanibel Slough Watershed. The City of Sanibel determined that 0.044 pounds (lbs) of nitrogen and 0.018 lbs of phosphorus are applied to the land surface for every 1,000 gallons of reclaimed water used (Thompson and Milbrandt 2014). The use of reclaimed water for irrigation is suspected to be a major source of nutrient loading in the East and West Basins, and percolation from irrigation water could be a potential source of nutrient loads to groundwater (Thompson and Milbrandt 2016). **Figure 1.6** shows the location of the wastewater facilities in the Sanibel Slough Watershed.



Figure 1.6. Wastewater facilities in the Sanibel Slough Watershed

1.4.2.2 Municipal Separate Storm Sewer System (MS4) Permittees

MS4s may also discharge pollutants to waterbodies in response to storm events. To address stormwater discharges, the EPA developed the NPDES stormwater permitting program in 2 phases. Phase I, promulgated in 1990, addresses large and medium-size MS4s located in incorporated areas and counties with populations of 100,000 or more. Phase 2 permitting began in 2003. Regulated Phase II MS4s are defined in Rule 62-624.800, F.A.C., and typically cover urbanized areas serving jurisdictions with a population of at least 1,000 or discharging into Class I or Class II waters, or into Outstanding Florida Waters (OFWs). The NPDES Phase I MS4 permit (FLS000035) covers the entire extent of Sanibel Island, and the co-permittees are Lee County and the City of Sanibel. The stormwater collection systems in the Sanibel Slough Watershed are owned and operated by the City of Sanibel.

1.4.3 Nonpoint Sources

1.4.3.1 Land Use and Land Use Practices

Land use classification for the Sanibel Slough Basin was identified using the 2008–09 South Florida Water Management District (SFWMD) land use geographic information system (GIS) coverage. A combination of Florida Land Use, Cover and Forms Classification System (FLUCCS) Level 1/Level 3 land use categories, summarized in **Table 1.1** and **Figure 1.7**, was used to classify the contributing area. Wetlands covered 40 % of the East Basin and 55 % of the West Basin. The East Basin had a slightly higher rate of residential development per subbasin acreage, with a total of 34 % of the East basin being low-, medium-, and high-density residential, compared with approximately 29 % in the West Basin. Medium density made up most of the residential land types in the East Basin, while low density was the primary residential type in the West Basin. The East Basin also had more commercial development, with a total of 103 acres in the East compared with 16 acres in the West.

Table 1.1. 2008–09 land use in the Sanibel Slough Watershed

| Land Use | East Basin (acres) | East Basin % of Contributing Area | West Basin (acres) | West Basin % of Contributing Area |
|----------------------------------|--------------------|-----------------------------------|--------------------|-----------------------------------|
| Low-Density Residential | 113 | 9 | 347 | 18 |
| Medium-Density Residential | 235 | 19 | 214 | 11 |
| High-Density Residential | 79 | 6 | 2 | 0 |
| Commercial | 103 | 8 | 16 | 1 |
| Institutional | 2 | 0 | 12 | 1 |
| Recreational | 100 | 8 | 0 | 0 |
| Rangeland | 30 | 2 | 150 | 8 |
| Forest/Rural Open | 25 | 2 | 45 | 2 |
| Water | 56 | 4 | 104 | 5 |
| Wetlands | 503 | 40 | 1,081 | 55 |
| Communication and Transportation | 8 | 1 | 7 | 0 |
| Total | 1,255 | 100 | 1,978 | 100 |

Nutrient loading from urban areas is most often attributed to multiple sources, including stormwater runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from the improper disposal of waste materials, leaking septic systems, and domestic animals. The largest anthropogenic land use in the Sanibel Slough Watershed consists of residential areas. These areas, as well as golf courses, which are classified under "recreational" land use, can contribute nutrients from fertilizer application. The City of Sanibel proactively implemented a fertilizer ordinance (Sanibel 2007) on the island in 2007 to reduce the potential runoff contribution to Sanibel Slough (Thompson and Milbrandt 2014).

The largest land use category in the Sanibel Slough watershed consists of wetlands. A majority of the total island, 51 %, is held in conservation through the SCCF, the J.N. "Ding" Darling

National Wildlife Refuge, or various city parks. Approximately 46 % of the West Basin and 26 % of the East Basin are preserved lands (**Figure 1.8**). The refuge is home to over 245 species of birds and provides feeding, nesting, and roosting areas for migratory birds (J.N. "Ding" Darling National Wildlife Refuge website 2014).

In addition to the nutrient sources associated with anthropogenic activities, birds and other wildlife can also contribute considerable amounts of nutrients to waterbodies through their feces, particularly in areas with bird rookeries. While detailed source information is not always available to accurately quantify the loadings from wildlife sources, land use information can be used to help identify areas with the potential for wildlife to congregate. It is not DEP's intent to mitigate natural conditions, but it is necessary to understand the various potential sources in the watershed.

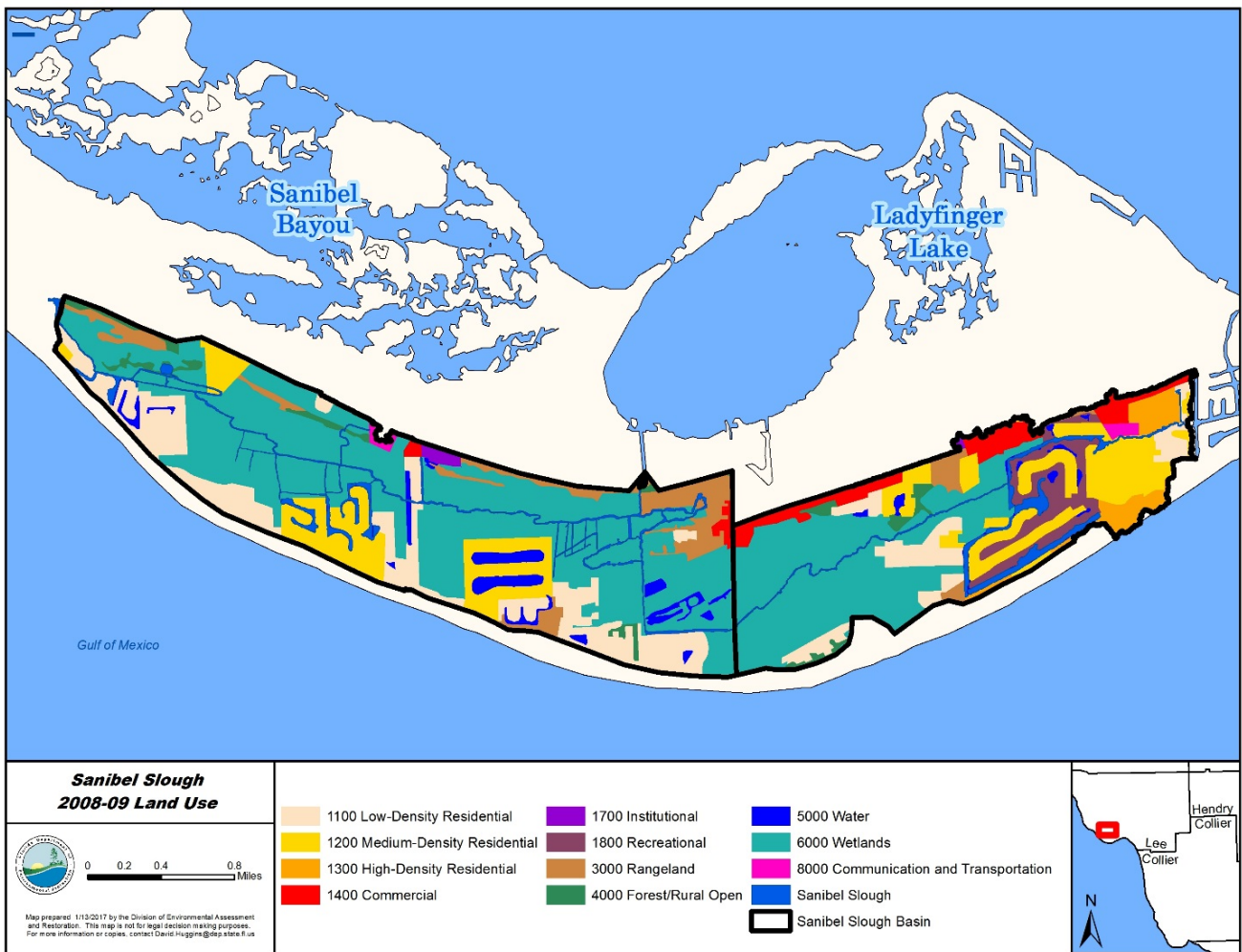


Figure 1.7. 2008–09 land use in the Sanibel Slough Watershed

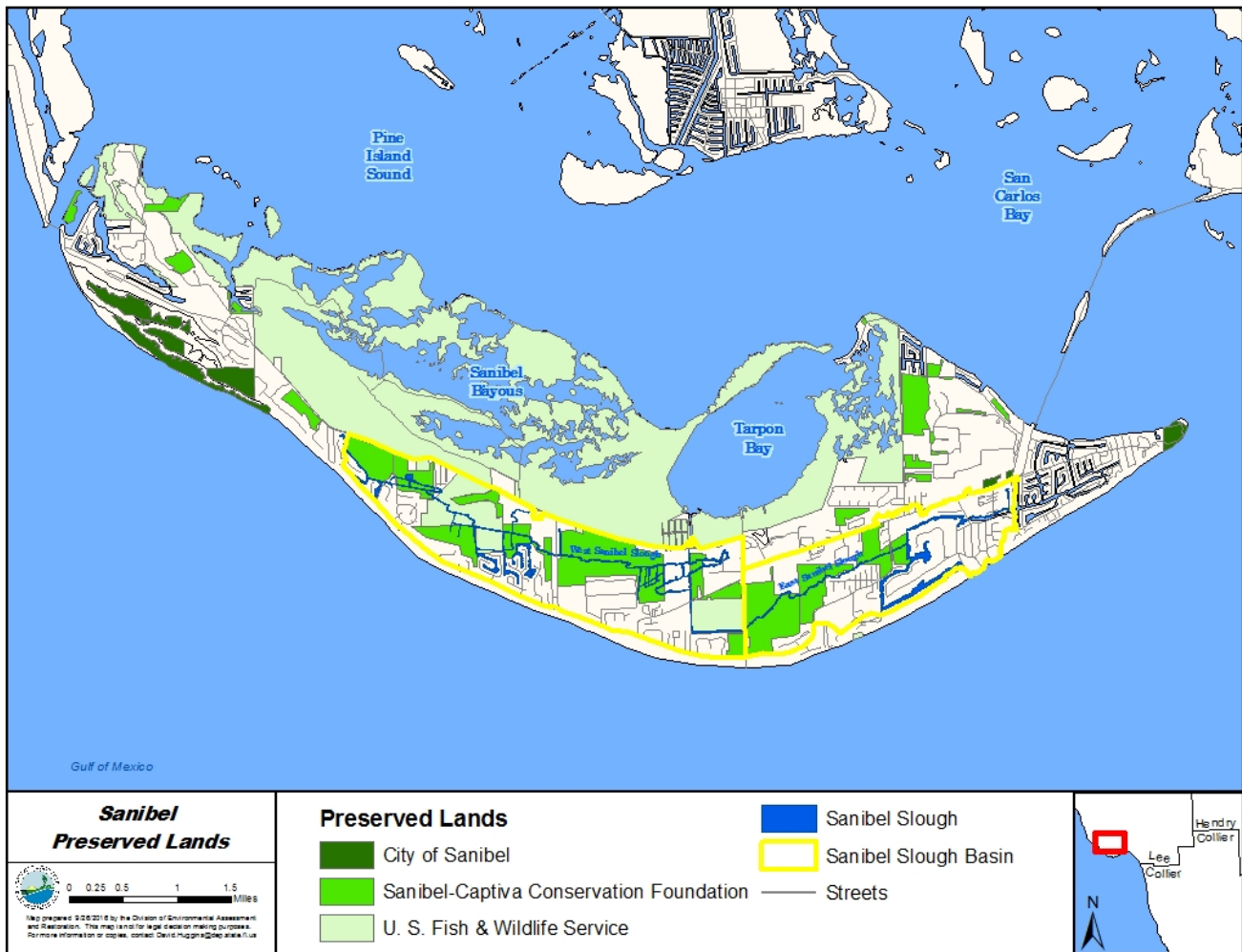


Figure 1.8. Preserved lands in the Sanibel Slough Watershed

1.4.3.2 Onsite Sewage Treatment and Disposal Systems (OSTDS)

OSTDS, including septic tanks, are commonly used where providing central sewer service is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDS are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, however, OSTDS can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both groundwater and surface water.

The City of Sanibel has made great efforts to convert most of the island to the centralized sewer and treatment system. In total, only 69 OSTDS are still in operation on the entire island, with only 30 left in the Sanibel Slough Watershed: 11 in the West Basin and 19 in the East Basin (**Figure 1.9**). Information on the location of septic systems was obtained from the City of Sanibel Utilities Department in September 2016. Nutrient loads from the remaining OSTDS in

the Sanibel Slough Watershed are expected to be minimal because of the low number of systems, and any OSTDS loads, both from legacy contamination and from active sites, would be factored into the overall groundwater loading concentrations discussed in **Section 1.4.4**.

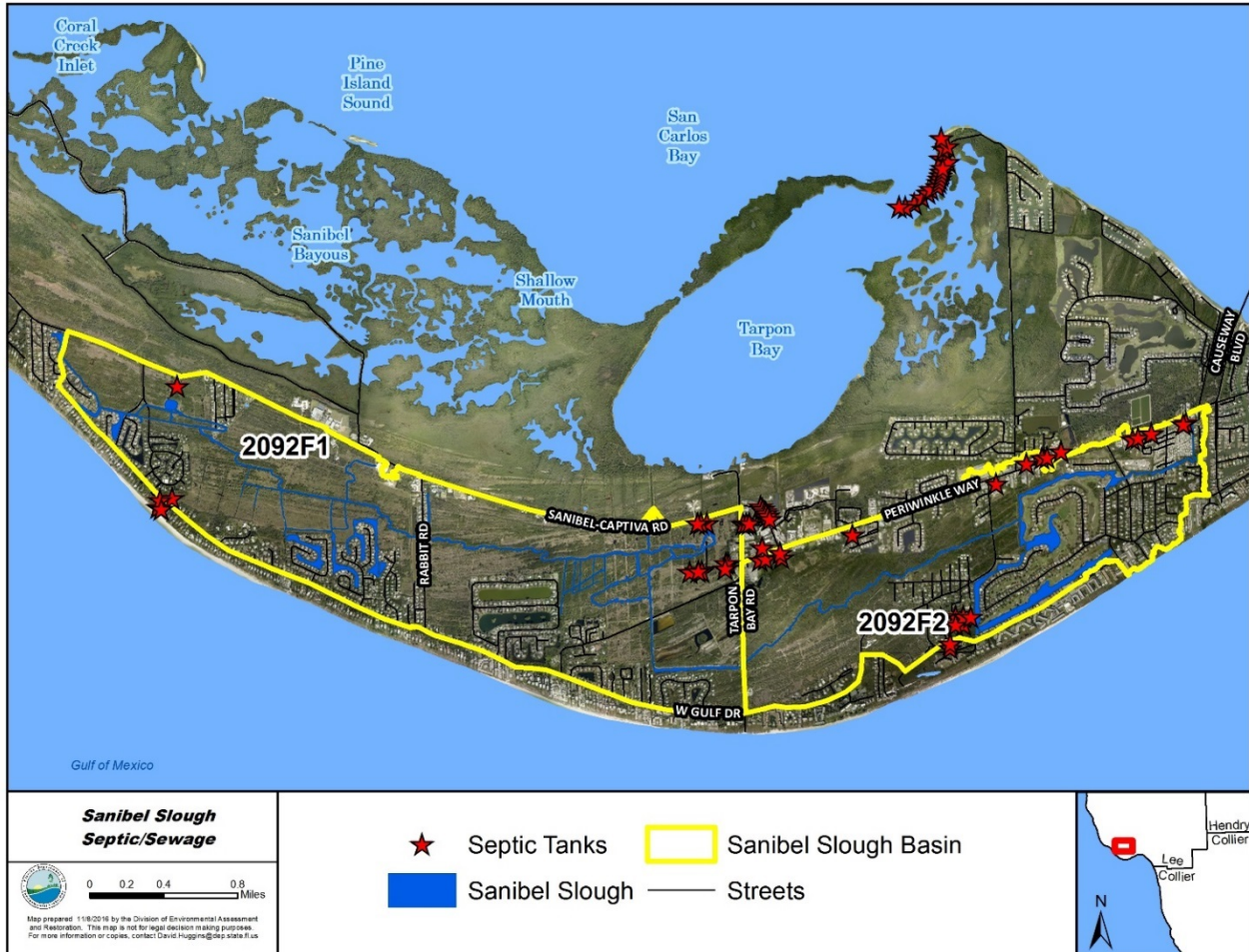


Figure 1.9. Remaining OSTDS (septic tanks) in the Sanibel Slough Watershed

1.4.4 Groundwater

The SCCF Marine Lab conducted an intensive study of potential nutrient loadings from the surficial aquifer to the surface waters of Sanibel Island and determined that the surficial aquifer discharges a significant volume and nutrient load to Sanibel Slough (Thompson and Milbrandt 2016). The study indicated that a steady exchange of groundwater and surface water occurs along Sanibel Slough, and that this groundwater discharge controls the surface water level in the slough.

The SCCF report indicates that irrigation with reclaimed water, fertilizer leaching through the well-drained sandy soils, and legacy nutrient enrichment from the soils near prior OSTDS or

wastewater sites could be sources of higher nutrient concentrations in water infiltrating to the surficial aquifer.

1.4.5 Atmospheric Deposition

Nutrient loadings from the atmosphere are an important component of the nutrient budget in many Florida lakes and marine waters. Nutrient delivery comes through two pathways: wet atmospheric deposition with precipitation and dry particulate-driven deposition. Atmospheric deposition to terrestrial portions of the Sanibel Slough Watershed is assumed to be accounted for in the Sanibel-specific event mean concentrations (EMCs) used to estimate the watershed loading in **Section 3.1.1**. Loading from atmospheric deposition directly onto the water surface was also considered in the loading estimation. **Chapter 3** details how the atmospheric loads were used in the receiving water model.

Chapter 2: Applicable Water Quality Standards, Pollutants of Concern, and Site-Specific Targets

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the EPA lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. DEP has developed such lists, commonly referred to as 303(d) lists, since 1992.

The Florida Watershed Restoration Act (FWRA) (Section 403.067, Florida Statutes [F.S.]) directed DEP to develop, and adopt by rule, a new science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the new methodology as Chapter 62-303, F.A.C. (IWR), in April 2001. The rule was amended in 2006, 2007, 2012, 2013 and 2016.

The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], F.S.). The state's 303(d) list is amended annually to include basin updates.

2.2 Classification and Numeric Interpretation of the Narrative Nutrient Criterion

Sanibel Slough East (WBID 2092F2) and Sanibel Slough West (WBID 2092F1) are Class III marine waterbodies, with a designated use of fish consumption, recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the verified impairment (nutrients) for this water is Florida's nutrient criterion in Paragraph 62-302.530(90)(b), F.A.C.

Florida incrementally adopted NNC for most estuaries and other marine waters during the period from 2011 to 2014. As part of the analyses conducted to derive nutrient criteria for predominately marine waters, DEP evaluated the available water quality data for individual estuary systems and further subdivided the estuaries into homogeneous segments, or estuary nutrient regions (ENRs). These ENRs represent water segments over which the estuary-specific numeric interpretations of the narrative nutrient criterion (Subsection 62-302.531[1], F.A.C.) apply. NNC do not apply to wetlands, tidal tributaries, or non-ENR estuaries (those not expressly listed by name in Subsection 62-302.532[1], F.A.C., or delineated in the maps of the Florida ENRs incorporated by reference in Subsection 62-302.532[3], F.A.C.), unless a site-specific numeric interpretation of the narrative criterion has been adopted through some other mechanism (e.g., a TMDL, a site-specific alternative criterion [SSAC], a Level II water quality-based effluent limitation [WQBEL], or a Reasonable Assurance Plan [RAP]), as specified in Paragraph 62-302.531(2)(a), F.A.C.

Sanibel Slough East and Sanibel Slough West are classified as non-ENR estuaries and therefore are subject to the narrative nutrient criterion, which states that nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna (Subsection 62-302.531[1], F.A.C.). For non-ENR estuaries, a chlorophyll *a* target of 11 micrograms per liter ($\mu\text{g/L}$), expressed as an annual geometric mean (AGM) not to be exceeded more than once in any consecutive 3-year period, is used to assess nutrient response. The 11 $\mu\text{g/L}$ chlorophyll *a* target represents the level below which a nutrient-related imbalance in flora or fauna is not expected to occur (Subsection 62-303.353[2], F.A.C.). The nutrient TMDLs discussed in this report will also serve as the site-specific numeric interpretation of the narrative nutrient criterion, as specified in Paragraph 62-302.531(2)(a), F.A.C.

2.3 Determination of the Pollutant of Concern

2.3.1 Monitoring Results

Data providers for Sanibel Slough include DEP and the City of Sanibel (Natural Resources and Public Works Departments), with the majority of the available data coming from the monitoring conducted by the City of Sanibel. The city sampled quarterly at six stations (21FLSBL...) in Sanibel Slough from 2007 through 2014. DEP sampled quarterly at four stations (21FLFTM...) in Sanibel Slough in 2007. **Figure 2.1** shows the sampling locations.

To ensure that the nutrient TMDL was developed based on current conditions and that recent trends in water quality were adequately captured, monitoring data were compiled for 2007 through 2013, which includes seven complete years of the Cycle 3 verified period (January 1, 2007–June 30, 2014).

The individual water quality measurements used in this analysis are available in the IWR Database (Run 52), and are available on request. Water quality results for the period of record for variables relevant to this TMDL analysis, which were collected by all sampling entities, are also available on request.



Figure 2.1. Sanibel Slough water quality sampling stations

2.3.2 Information on Verified Impairment

When DEP used the IWR Database to assess water quality impairments in the original WBID (2092F), the waterbody was verified as impaired for nutrients based on an elevated annual average Trophic State Index (TSI) during the Cycle 1 verified period for the Group 2 basins (January 1, 1996–June 30, 2003). When the Cycle 1 assessment was performed, WBID 2092F was classified as a high-color lake (color higher than 40 platinum cobalt units [PCU]), and the IWR methodology used the water quality variables TN, TP, and chlorophyll *a* in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. The TSI threshold (60 for high-color lakes) was exceeded in multiple years during the verified period and was sufficient to identify the waterbody as impaired for nutrients.

During the Cycle 2 assessment, WBID 2092F was reclassified as a stream, and the IWR methodology used an annual average corrected chlorophyll *a* threshold of 20 µg/L in interpreting Florida's narrative nutrient threshold. In the Cycle 2 verified period (January 2001–June 2008),

annual mean chlorophyll *a* values exceeded the threshold of 20 µg/L in 2007, and the waterbody remained on the Verified List.

The waterbody was again reclassified as an estuary in 2010 based on long-term specific conductance. The long-term average specific conductance at the time of the reclassification was 4,968 micromhos per centimeter (µmhos/cm) during the years 2002 through 2009, and the prevailing plant community included halophytes such as red mangrove (*Rhizophora mangle*) and sea grape (*Coccoloba uvifera*), which are indicative of estuarine systems. As such, the waterbody was assessed as an estuary in the more recent Cycle 3 assessment. The IWR methodology used an AGM corrected chlorophyll *a* threshold of 11 µg/L to assess the waterbody during the verified period (January 1, 2007–June 30, 2014). The chlorophyll *a* values exceeded the threshold of 11 µg/L during every year of the verified period, and the waterbody remained on the Verified List.

Following the most recent assessment, WBID 2092F was split into WBID 2092F1 (Sanibel Slough West) and 2092F2 (Sanibel Slough East), and the changes were apparent in IWR Run 53, as explained in **Section 1.3.3**. This division more accurately reflects the condition of the slough as 2 separate and distinct systems and will result in more accurate assessments in the future. Data from IWR Run 52 indicated that the 2 new WBIDs were still impaired for nutrients based on chlorophyll *a* concentrations that exceeded the 11 µg/L threshold for non-ENR estuaries during most years. **Table 2.1** lists the AGM values for chlorophyll *a* during the 2007 to 2014 verified period.

Table 2.1. Sanibel Slough AGM values for the 2007–14 verified period

Note: Values shown in bold italic type and shaded are greater than the narrative nutrient threshold for non-ENR estuaries. Rule 62-302.531, F.A.C., states that the threshold for chlorophyll *a* shall not be exceeded more than once in any consecutive 3-year period.

| Year | Sanibel Slough East (WBID 2092F2) chlorophyll <i>a</i> (µg/L) | Sanibel Slough West (WBID 2092F1) chlorophyll <i>a</i> (µg/L) |
|------|---|---|
| 2007 | <i>42</i> | <i>15</i> |
| 2008 | <i>62</i> | <i>16</i> |
| 2009 | <i>50</i> | <i>25</i> |
| 2010 | <i>16</i> | 10 |
| 2011 | <i>21</i> | <i>12</i> |
| 2012 | <i>39</i> | <i>13</i> |
| 2013 | <i>26</i> | <i>15</i> |
| 2014 | <i>32</i> | 5 |

2.4 Site-Specific Target

The nutrient TMDLs presented in this report constitute the site-specific numeric interpretation of the narrative nutrient criterion set forth in Paragraph 62-302.530(90)(b), F.A.C., that will replace the otherwise applicable NNC in Subsection 62-302.531(2), F.A.C., for this particular

waterbody, pursuant to Paragraph 62-302.531(2)(a), F.A.C. It is important to note that as non-ENR estuaries, Sanibel Slough East and West have no generally applicable NNC for TN and TP. **Appendix B** summarizes the relevant supporting information for using the TMDL nutrient targets as the site-specific numeric interpretations of the narrative nutrient criterion, including why the TMDLs provide for the protection of Sanibel Slough and for the attainment and maintenance of water quality standards in downstream waters (pursuant to Subsection 62-302.531[4], F.A.C.).

Targets used in TMDL development are designed to restore surface water quality to meet a waterbody's designated use. Similarly, water quality criteria are based on scientific information used to establish specific levels of water quality constituents that protect aquatic life and human health for particular designated use classifications. Thus, TMDL targets and water quality criteria serve the same purpose, as both are designed to protect surface water designated uses.

2.4.1 Target Selection

The development of the site-specific nutrient criteria is based on the evaluation of a response variable (chlorophyll *a*) and stressor variables (TN and TP) to develop water quality thresholds that are protective of designated uses. As described in further detail in **Chapter 3**, modeling was done to estimate the natural background condition of the East and West Basins that would be expected if all anthropogenic land uses were removed. The natural background chlorophyll *a* was selected as the target for the TMDL because natural background conditions are inherently protective of designated uses. To acknowledge their variability, the natural background conditions were expressed as the 80th percentile of the natural background values plus the percent difference between the means of the measured and model-predicted chlorophyll *a* concentrations. Because the BATHTUB model outputs are expressed as whole integer values, all concentrations were rounded to the nearest whole number value.

The yearly natural background values and the calculated 80th percentile of those concentrations over the model period can be found in **Table 2.2**. Based on the properties of the 80th percentile and a 3-year assessment period, it is expected that the resulting concentration will not be exceeded more than once in a 3-year period (DEP 2012). The calibration of the model and resulting analysis between the model simulated concentrations and the measured data can be found in Section **3.1.2.3**. The percent differences between observed and simulated means indicated that the central tendency of the model was underpredicting the central tendency of the measured values (**Table 3.12**).

Table 2.2. Sanibel Slough Natural Background chlorophyll *a* values

Note: Values shown in bold italic type and shaded are the 80th percentiles of the natural background values.

| Year | Sanibel Slough East Natural Background chlorophyll <i>a</i> (µg/L) | Sanibel Slough West Natural Background chlorophyll <i>a</i> (µg/L) |
|----------------------------|---|---|
| 2007 | 20 | 10 |
| 2008 | 17 | 10 |
| 2009 | 20 | 10 |
| 2010 | 12 | 9 |
| 2011 | 12 | 10 |
| 2012 | 16 | 10 |
| 2013 | 12 | 9 |
| 80th Percentile | <i>19</i> | <i>10</i> |

Adding the percent difference of the predicted and measured means to the 80th percentile of the background distribution ensures that the full range of naturally occurring chlorophyll *a* concentrations is used to establish the site-specific target for the waterbody, and that natural conditions are not unintentionally abated due to model uncertainty.

The equation used to calculate the chlorophyll *a* target is:

$$T = p(1 + d)$$

Where:

T is chlorophyll *a* target.

p is the 80th percentile of the natural background values.

d is the percent difference of the predicted and measured means.

For the West Basin, the 80th percentile chlorophyll *a* concentration is 10 µg/L and the percent difference is 7%, $10(1+0.07) = 10.7$, which was then rounded to 11. Following this approach, the site-specific expression of the narrative nutrient criteria for the West Basin is an AGM chlorophyll *a* concentration of 11 µg/L, with no more than one exceedance in a 3-year period. For the East Basin, the 80th percentile chlorophyll *a* concentration is 19 µg/L and the percent difference is 8%, $19(1+0.08) = 20.5$, which rounds to 21. The site-specific expression of the narrative nutrient criteria for the East Basin is an AGM chlorophyll *a* concentration of 21 µg/L, with no more than one exceedance in a 3-year period. Establishing TMDL targets at the natural background ensures that the designated uses that were protected originally in a natural condition will continue to be protected once the TMDL condition is achieved.

2.4.2 Selected Water Quality Indicators and Pollutant Interactions

In attempting to establish a nutrient TMDL for any system, it is important to determine the degree to which stressor and response variables are related to appropriately model the impact of nutrients on algal growth and anthropogenic eutrophication, as measured by chlorophyll *a* response. As discussed previously, Sanibel Slough was verified impaired for nutrients in each assessment cycle using different nutrient assessment criteria applied to the slough as a lake, a stream, and an estuary. The current assessment is based on a chlorophyll *a* AGM concentration of 11 µg/L, which is the threshold established for estuarine systems.

In Florida waterbodies, nitrogen and phosphorus are most often the limiting nutrients. A limiting nutrient is defined as the nutrient(s) that limits plant growth (both macrophytes and algae) when it is not available in sufficient quantities. In the past, management activities to control eutrophication focused on phosphorus reduction, as phosphorus was generally considered the limiting nutrient in freshwater systems. Recent studies, however, support the reduction of both nitrogen and phosphorus to control algal growth in aquatic systems (Conley 2009; Paerl 2009; Paerl and Otten 2013).

DEP notes that there is a DO impairment for Sanibel Slough East and West and will be working to ascertain whether the current standard is appropriate or whether site-specific criteria will need to be developed. The system was impaired for DO based on the Cycle 3 assessment, and data from IWR Run 52 indicate that WBIDs 2092F1 and 2092F2 would still be impaired for DO based on the DO percent saturation standard of 42 % for predominately marine waters, per Section 62-302.533(2), F.A.C. Analyses showed no significant relationship between nutrients and DO. Because of the nature of the slough system, the existing DO criterion for the system may not be achievable. It is likely that the lower DO in this system is a result of physical alteration and therefore is not directly being addressed in this TMDL analysis. Reducing the nutrient loads entering the waterbody will likely have some positive effect on DO levels while not negatively impacting other water quality parameters in the estuary.

Simple linear regression analyses were performed to detect relationships between the nutrient inputs of TN and TP and the response variable of chlorophyll *a*. **Table 2.3** lists the results of these regression analyses, with the relevant r^2 for each parameter pair provided for both the East and West Sloughs. Additionally, simple linear regression analyses were performed to detect relationships between the nutrient inputs and DO (**Table 2.4**). Monthly average concentrations were used in the analyses between nutrients and DO because of the availability of only 1 year of DO data, in 2007. A screening value of r^2 of ≥ 0.5 and p-values of ≤ 0.05 were used to determine statistically significant relationships between the pairs of parameters of interest.

Correlations between TN and chlorophyll *a* were not detected in the East Slough, but a significant relationship between these parameters was found in the West Slough with an r^2 of 0.61 at a p-value of 0.02. The only other variables that showed strong significant relationships were TN and TP, with the East Slough having an r^2 of 0.72 at a p-value of 0.01. None of the other parameters were found to have statistically significant relationships.

Table 2.3. R² and P-values from simple linear regressions of nutrient AGMs

Note: Shaded cells and bold type indicate ave statistically significant p-values at the 95 % confidence level. Shaded cells and bold italic indicate r² values above 0.5.

| Basin | TN vs. chlorophyll <i>a</i> | TP vs. chlorophyll <i>a</i> | TN vs. TP |
|-------|--|------------------------------------|--|
| East | r ² = 0.05, p = 0.59 | r ² = 0.08, p = 0.49 | <i>r² = 0.72,</i> p = 0.01 |
| West | <i>r² = 0.61,</i> p = 0.02 | r ² = 0.02, p = 0.75 | r ² = 0.25, p = 0.21 |

Table 2.4. R² and P-values from simple linear regressions of monthly average nutrient and DO pairs

Note: The shaded cell and bold type indicate statistically significant p-values at the 95 % confidence level.

| Basin | DO vs. TN | DO vs. TP | DO vs. chlorophyll <i>a</i> |
|-------|--|-------------------------------------|------------------------------------|
| East | r ² = 0.01, p = 0.28 | r ² = 0.003, p = 0.48 | r ² = 0.01, p = 0.32 |
| West | <i>r² = 0.14,</i> p = 0.03 | r ² = 0.07, p = 0.13 | r ² = 0.01, p = 0.56 |

Two weather stations were used to estimate rainfall in the Sanibel Slough system. The first is located in the J.N. "Ding" Darling National Wildlife Refuge on Sanibel Island, although it lacked data from 2007 and the record from 2008 was incomplete. The second station is in St. James City, a little more than 7 kilometers north of Sanibel Island. This station has a complete data record over the entire model period. Data from the St. James City station were used for the missing period in 2008 in the "Ding" Darling Refuge record.

Sanibel Slough is a highly managed system, with weir structures controlling both the outflow into San Carlos Bay at 2 points and the flow between the eastern and western portions of the slough. The City of Sanibel owns and operates the 3 weirs. Discharges are infrequent, with 53 days of recorded discharges in 7 years, and are confined to rare high-rainfall events (**Figure 1.5**). Water levels in both the eastern and western systems generally track precipitation (**Figure 2.2**).

TN and TP concentrations were found to be inversely correlated with rainfall amounts in both segments of Sanibel Slough. In the East Slough the r² value for TN was 0.11 with a r² for TP of 0.47, and in the West Slough the r² values for TN and TP were both 0.31 (**Table 2.5**). These inverse relationships suggest that factors in addition to external nutrient loadings, such as residence time and internal cycling of nutrients, may have some influence on nutrient levels, since during periods with presumably higher watershed nutrient loadings (i.e., higher precipitation), there is no associated increase in TN and TP results. A regression analysis of chlorophyll *a* for precipitation explained very little of the variation in those parameters, with the West and East both showing an r² of less than 0.10.

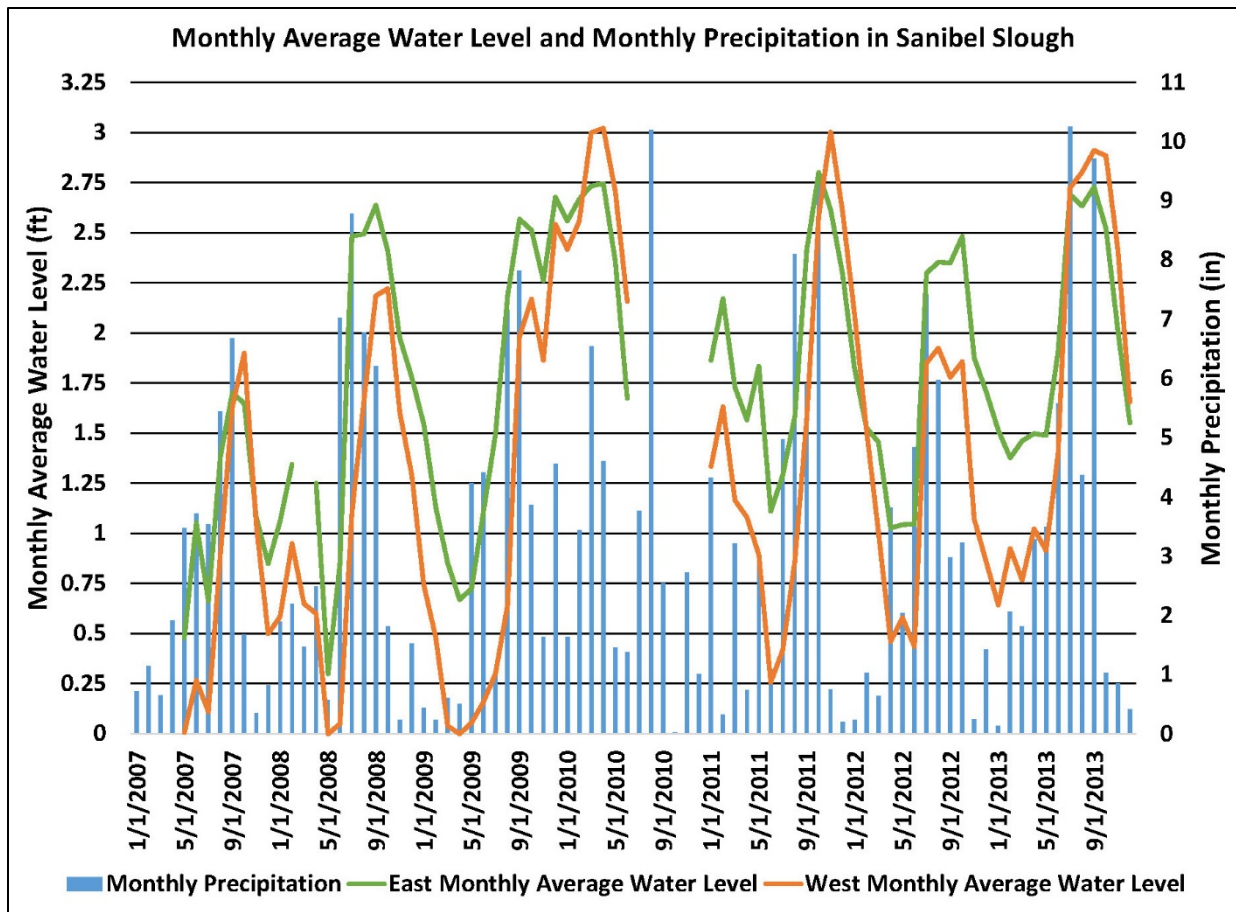


Figure 2.2. Monthly average water level and monthly precipitation in Sanibel Slough

Table 2.5. R² and P-values from simple linear regressions of AGM nutrient parameters on precipitation annual sums

Note: Shaded cells and bold italic type indicate statistically significant p-values at the 95 % confidence level.

| Basin | TN vs. Precipitation | TP vs. Precipitation | chlorophyll <i>a</i> vs. Precipitation |
|-------|--|--|--|
| East | <i>r</i> ² = 0.11, <i>p</i> = 0.01 | <i>r</i> ² = 0.47, <i>p</i> = 0.01 | <i>r</i> ² = 0.09, <i>p</i> = 0.49 |
| West | <i>r</i> ² = 0.31, <i>p</i> = 0.25 | <i>r</i> ² = 0.31, <i>p</i> = 0.25 | <i>r</i> ² = 0.0002, <i>p</i> = 0.98 |

2.4.3 Numeric Expression of Target

Because of the distinct nature of the two basins, as discussed in Section 1.3.3, individual targets were selected for each basin. The TN and TP targets for the East and West Basins were established using the modeling approach discussed in detail in Chapter 3 of this TMDL analysis. This approach links the yearly watershed TN and TP loading simulation to the estuary chlorophyll *a*, TN, and TP concentration simulation for 2007 through 2013.

The simulated relationship between estuary AGM concentrations of chlorophyll *a*, TN, and TP and incoming TN and TP loads was used to derive a distribution of yearly TN and TP loads necessary to meet the chlorophyll *a* target of 11 µg/L in the West Slough and 21 µg/L in the East Slough. The modeling used to derive these loading values is discussed in more detail in **Section 3.4**.

For both basins, a lagged 3-year rolling average was applied to the distribution of yearly nutrient loads, and the maximum of the resulting 3-year averages was chosen as the respective target TN and TP loads. The 3-year average TN and TP target loads necessary to meet the chlorophyll *a* target of 11 µg/L (TMDL condition) in the West Basin are 1,903 and 241 kilograms per year (kg/yr), respectively (**Table 2.6**). The 3-year average TN and TP target loads necessary to meet the chlorophyll *a* target of 21 µg/L (TMDL condition) in the East Basin are 1,091 and 123 kg/yr, respectively (**Table 2.7**).

Table 2.6. Sanibel Slough West TMDL condition nutrient loads

Note: Shaded cells and bold italic type indicate the maximum of the 3-year rolling averages and the three annual loads corresponding to the maximum 3-year rolling average.

| Year | TMDL Condition TN Loads (kg/yr) | Lagging 3-Year Rolling Average TN Loads (kg/yr) | TMDL Condition TP Loads (kg/yr) | Lagging 3-Year Rolling Average TP Loads (kg/yr) |
|------|---------------------------------|---|---------------------------------|---|
| 2007 | 1,357 | | 237 | |
| 2008 | 1,932 | | 337 | |
| 2009 | 1,631 | 1,640 | 301 | 201 |
| 2010 | 1,975 | 1,846 | 333 | 238 |
| 2011 | 1,974 | 1,856 | 334 | 241 |
| 2012 | 1,620 | 1,903 | 284 | 240 |
| 2013 | 2,115 | 1,903 | 363 | 241 |

Table 2.7. Sanibel Slough East TMDL condition nutrient loads

Note: Shaded cells and bold italic type indicate the maximum of the 3-year rolling averages and the three annual loads corresponding to the maximum 3-year rolling average.

| Year | TMDL Condition TN Loads (kg/yr) | Lagging 3-Year Rolling Average TN Loads (kg/yr) | TMDL Condition TP Loads (kg/yr) | Lagging 3-Year Rolling Average TP Loads (kg/yr) |
|------|---------------------------------|---|---------------------------------|---|
| 2007 | 1,090 | | 90 | |
| 2008 | 1,131 | | 128 | |
| 2009 | 944 | 1,055 | 112 | 110 |
| 2010 | 1,088 | 1,054 | 121 | 120 |
| 2011 | 1,152 | 1,061 | 129 | 121 |
| 2012 | 943 | 1,061 | 106 | 119 |
| 2013 | 1,179 | 1,091 | 134 | 123 |

Table 2.8 summarizes the chlorophyll *a* target concentration for each WBID as well as the TMDL target loads for TN and TP. The chlorophyll *a* target and the associated TN and TP target loads will serve as the site-specific interpretations of the narrative nutrient criterion pursuant to Paragraph 62-302.530(90)(b), F.A.C. These nutrient loads shall be expressed as a rolling 3-year annual average load not to be exceeded, and the chlorophyll *a* concentration shall be expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period.

Table 2.8. Site-specific interpretations of the narrative nutrient criterion

Note: Chlorophyll *a* shall not be exceeded more than once in any consecutive 3-year period. TN and TP are not to be exceeded.

| WBID | AGM chlorophyll <i>a</i> (µg/L) | Rolling 3-Year Annual Average TN (kg/yr) | Rolling 3-Year Annual Average TP (kg/yr) |
|--------|---------------------------------|--|--|
| 2092F1 | 11 | 1,903 | 241 |
| 2092F2 | 21 | 1,091 | 123 |

The TN and TP reference concentrations represent the simulated estuary TN and TP concentrations corresponding to the estuary chlorophyll *a* concentrations. A distribution of the yearly simulated nutrient concentrations corresponding to the target chlorophyll *a* condition was derived in the modeling approach, and the 80th percentile of this distribution was selected as the reference TN and TP concentrations. The statistical derivation of the 80th percentile is consistent with a 1-in-3-year exceedance rate, as documented in the report, *Overview of Approaches for Numeric Nutrient Criteria Development in Marine Waters* (DEP 2012).

The TN and TP reference concentrations for the West Basin are 1.60 and 0.06 mg/L, respectively, and for the East Basin, 1.00 and 0.04 mg/L, respectively. **Table 2.9** lists the yearly distribution of simulated nutrient concentrations and the resulting 80th percentile reference TN and TP concentrations for the East and West Basins. The TMDL loads will be considered the site-specific interpretation of the narrative criterion. Nutrient concentrations are provided for comparative purposes only.

Table 2.9. Sanibel Slough simulated nutrient AGM concentrations

| Year | West Basin AGM TN Concentrations (mg/L) | West Basin AGM TP Concentrations (mg/L) | East Basin AGM TN Concentrations (mg/L) | East Basin AGM TP Concentrations (mg/L) |
|------------------------|---|---|---|---|
| 2007 | 1.62 | 0.05 | 1.36 | 0.04 |
| 2008 | 1.44 | 0.06 | 0.96 | 0.04 |
| 2009 | 1.47 | 0.06 | 0.93 | 0.04 |
| 2010 | 1.69 | 0.06 | 1.01 | 0.04 |
| 2011 | 1.45 | 0.06 | 0.97 | 0.04 |
| 2012 | 1.54 | 0.06 | 0.98 | 0.04 |
| 2013 | 1.47 | 0.06 | 0.93 | 0.04 |
| 80th Percentile | 1.60 | 0.06 | 1.00 | 0.04 |

2.5 Critical Conditions and Seasonal Variation

The estimated assimilative capacity is based on annual conditions, rather than critical/seasonal conditions because (1) the methodology used to determine assimilative capacity does not lend itself very well to short-term assessments, (2) DEP is generally more concerned with the net change in overall primary productivity in the segment, which is better addressed on an annual basis, and (3) the methodology used to determine impairment is based on annual conditions (AGMs or arithmetic means).

2.6 Downstream Protection

As discussed in **Section 1.3.3** and shown in **Figure 1.4**, Sanibel Slough West has a weir control structure at Sanibel-Captiva Road on the northern side of the island that discharges into Tarpon Bay, which eventually flows into San Carlos Bay. Sanibel Slough East has a weir control structure at Beach Road on the eastern side of the island, which drains to a system of canals that eventually mixes with San Carlos Bay.

San Carlos Bay (including Tarpon Bay, WBID 2065H1) is a Class II estuary with estuary-specific numeric interpretations of the NNC for chlorophyll *a*, TN, and TP. There is no history of nutrient impairments in WBID 2065H1, and, based on the most recent assessment results, San Carlos Bay is not currently impaired for nutrients. **Table 2.10** lists the applicable NNC values, current assessment data, and assessment status of San Carlos Bay for the most recent assessment period, Cycle 3, which was completed on April 27, 2016, for the Group 2 basins.

Table 2.10. Cycle 3 assessment status for San Carlos Bay

Note: The estuary nutrient criteria for San Carlos Bay (ENRD6) are a long-term average.

| Parameters Assessed | NNC Expressed as a Long-Term Average | Long-Term Average of Measured Data Used for Cycle 3 Assessment | Assessment Category | Summary Status |
|----------------------|--------------------------------------|--|---------------------|----------------|
| chlorophyll <i>a</i> | 3.7 µg/L | 2.7 µg/L | 2 | Not Impaired |
| TN | 0.44 mg/L | 0.42 mg/L | 2 | Not Impaired |
| TP | 0.045 mg/L | 0.037 mg/L | 2 | Not Impaired |

As evidenced by the healthy existing conditions in San Carlos Bay, the existing loads from Sanibel Slough to San Carlos Bay have not led to an impairment of the downstream water and are not preventing San Carlos Bay from attaining its designated uses. The reductions in nutrient loads prescribed in this TMDL are not expected to cause nutrient impairments downstream but will result in water quality improvements to downstream waters.

Chapter 3: Determination of the TMDL

3.1 Selection of Appropriate Tool

For this TMDL, a calibrated model-based prediction was used to estimate the nutrient loads necessary to achieve an AGM chlorophyll *a* concentration of 11 µg/L in Sanibel Slough West and 21 µg/L in Sanibel Slough East. The model period used was 2007 through 2013, in order to encompass the years with complete calendar years' worth of data in the most recent Cycle 3 assessment period (January 1, 2007–June 30, 2014).

3.1.1 Watershed Loading Models

The SCCF Marine Laboratory developed Sanibel Island–specific runoff coefficients using a modified Soil Conservation Service (SCS) curve number (CN) method. The key function of this spreadsheet model is to estimate the annual average runoff coefficient for each land use–soil type combination for each year. The full method and results of the Sanibel CN modeling are available in Thompson and Milbrandt (2014). Once the runoff coefficient is decided, the runoff volume can be calculated as the product of rainfall, runoff coefficient, and acreage of the land use–soil type combination.

The equation used to calculate the land use specific runoff volume is as follows:

$$Q_{W/D} = A \times RC_{W/D} \times P_{W/D}$$

Where:

$Q_{W/D}$ is the wet or dry season runoff volume.

A is the area per land use type.

$RC_{W/D}$ is the land use specific runoff coefficient for the wet or dry season.

$P_{W/D}$ is the annual precipitation for the wet or dry season.

Additionally, Sanibel-specific EMCs were developed to present the most accurate nutrient loading rates from the watershed stormwater runoff. The EMCs used for calculating the stormwater loads are taken from the report on the development of Sanibel-specific runoff coefficients, EMCs, and loads (Thompson and Milbrandt 2014), with the exception of the runoff coefficients and EMCs for upland hardwood forests and wetlands. These were calculated using the CN Model, as was done in the SCCF report. The EMCs for upland hardwood forests and wetlands on Sanibel were estimated using the relationship between the Sanibel-specific EMCs for urban land uses and the EMCs for those same land uses in Dr. Harvey Harper's Florida EMC Database and stormwater review report (2003). That relationship was reversed to estimate the EMCs for upland hardwood forests and wetlands based on the Harper values for those land uses.

Tables 3.1 and 3.2 summarize the dry and wet season runoff coefficients and nutrient EMCs, respectively, used in the watershed loading calculations.

Table 3.1. Sanibel-specific dry season runoff coefficients and EMCs

| Land Use Type | West Basin Dry Season Runoff Coefficient | East Basin Dry Season Runoff Coefficient | Dry Season TN (mg/L) | Dry Season TP (mg/L) |
|----------------------------|--|--|----------------------|----------------------|
| Low-Density Residential | 0.13 | 0.12 | 1.61 | 0.24 |
| Medium-Density Residential | 0.19 | 0.18 | 1.22 | 0.27 |
| High-Density Residential | 0.28 | 0.26 | 1.04 | 0.22 |
| Commercial and Services | 0.49 | 0.43 | 0.66 | 0.15 |
| Institutional (School) | 0.20 | 0.19 | 1.18 | 0.15 |
| Recreational (Golf Course) | | 0.04 | 4.32 | 1.21 |
| Utilities | 0.78 | 0.78 | 1.82 | 0.27 |
| Shrub and Brushland | 0.14 | 0.14 | 1.20 | 0.07 |
| Upland Hardwood Forests | 0.10 | 0.10 | 0.58 | 0.20 |
| Wetlands | 0.35 | 0.35 | 0.66 | 0.07 |

Table 3.2. Sanibel-specific wet season runoff coefficients and EMCs

| Land Use Type | West Basin Wet Season Runoff Coefficient | East Basin Wet Season Runoff Coefficient | Wet Season TN (mg/L) | Wet Season TP (mg/L) |
|----------------------------|--|--|----------------------|----------------------|
| Low-Density Residential | 0.33 | 0.33 | 0.71 | 0.32 |
| Medium-Density Residential | 0.38 | 0.39 | 1.13 | 0.36 |
| High-Density Residential | 0.42 | 0.45 | 1.33 | 0.31 |
| Commercial and Services | 0.62 | 0.58 | 0.51 | 0.15 |
| Institutional (School) | 0.43 | 0.60 | 1.18 | 0.15 |
| Recreational (Golf Course) | | 0.25 | 2.28 | 1.69 |
| Utilities | 0.97 | 0.97 | 1.82 | 0.27 |
| Shrub and Brushland | 0.30 | 0.30 | 1.20 | 0.07 |
| Upland Hardwood Forests | 0.14 | 0.14 | 0.58 | 0.20 |
| Wetlands | 0.38 | 0.38 | 0.66 | 0.07 |

The Sanibel-specific runoff coefficients and EMCs were used in a modified Pollutant Load Simulation Model (PLSM) spreadsheet to calculate the nutrient loadings for the West and East Basins by wet and dry season. Nutrient loads were calculated for each basin, per season, by multiplying the land use-specific runoff volume and EMCs.

Finally, the wet and dry season loads were summed to provide the annual TN and TP loadings for each basin per year in the modeling period. The resulting annual nutrient runoff loads are summarized in **Table 3.3** and were used as the stormwater inputs for the receiving water model discussed in **Section 3.1.2**.

Table 3.3. Summary of annual watershed loads for Sanibel Slough

| Year | West Basin TN Loads (kg/yr) | West Basin TP Loads (kg/yr) | East Basin TN Loads (kg/yr) | East Basin TP Loads (kg/yr) |
|------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| 2007 | 1,372 | 233 | 1,036 | 260 |
| 2008 | 1,962 | 331 | 1,480 | 368 |
| 2009 | 1,750 | 296 | 1,258 | 296 |
| 2010 | 1,827 | 292 | 1,341 | 312 |
| 2011 | 1,985 | 327 | 1,477 | 357 |
| 2012 | 1,633 | 279 | 1,235 | 312 |
| 2013 | 2,078 | 357 | 1,575 | 400 |

3.1.2 Receiving Water Model

The BATHTUB model was chosen for Sanibel Slough because of the reservoir-like nature of the system, caused by the weir-controlled water levels (Thompson and Milbrandt 2013). As discussed in **Section 1.3.3**, BATHTUB was set up to simulate estuary TN, TP, and chlorophyll *a* concentrations each year from 2007 to 2013 based on simulated TN and TP loads.

3.1.2.1 BATHTUB Overview

The BATHTUB eutrophication model is a suite of empirically derived steady-state models developed by the U.S. Army Corps of Engineers (ACOE) Waterways Experimental Station. The primary function of these models is to estimate nutrient concentrations and algal biomass resulting from different patterns of nutrient loadings. The procedures for selecting the appropriate model for a particular waterbody are described in the *User's Manual* (Walker 2004). The empirical prediction of eutrophication with this approach is typically a two-stage procedure using the following two categories of models (Walker 1987):

- The **nutrient balance model** relates the nutrient concentration to the external nutrient loadings, morphometrics, and hydraulics of the waterbody.
- The **eutrophication response model** describes the relationships among eutrophication indicators in the waterbody, including nutrient levels, chlorophyll *a*, transparency, and hypolimnetic oxygen depletion.

Figure 3.1 shows the scheme used by BATHTUB to relate the external loading of nutrients to the waterbody nutrient concentrations and the physical, chemical, and biological response of the waterbody to the level of nutrients.

The BATHTUB model includes a suite of phosphorus and nitrogen sedimentation models along with a set of chlorophyll and Secchi depth models. The nutrient balance models assume that the net accumulation of nutrients in a waterbody is the difference between nutrient loadings into the waterbody from various sources and the nutrients carried out through outflow and the losses of nutrients through decay processes inside the waterbody. Different limiting factors such as nitrogen, phosphorus, light, or flushing are considered in the selection of an appropriate chlorophyll *a* model. The variety of models available in BATHTUB allows the user to choose specific models based on a waterbody's particular condition.

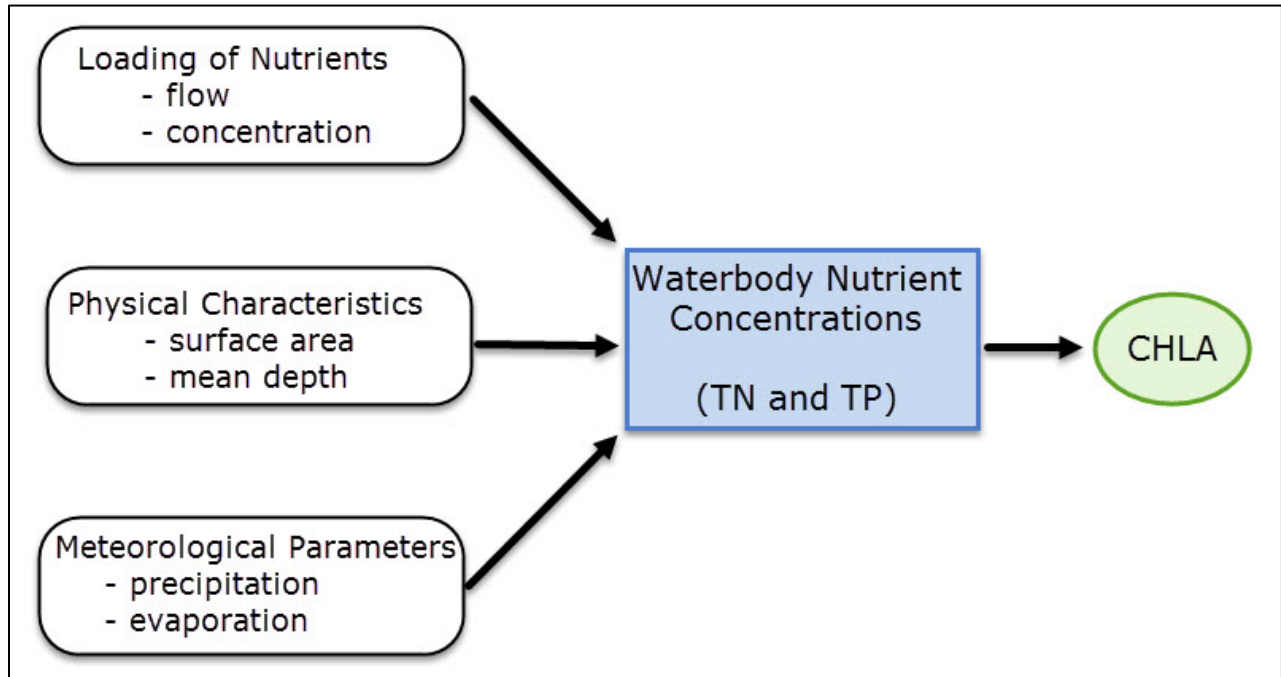


Figure 3.1. BATHTUB concept scheme

3.1.2.2 *BATHTUB Inputs*

MORPHOLOGICAL

The morphological measurements of Sanibel Slough were estimated based on cross-sectional analysis performed by Johnson Engineering, Inc. on behalf of the City of Sanibel, measured water level recordings taken by the city, and the GIS coverage of the slough. The average widths were derived based on the cross-section survey, and the average widths for Sanibel Slough West and Sanibel Slough East were 0.03 and 0.02 kilometers (km), respectively. The lengths of the West and East Slough were measured in ArcGIS with the Measure tool. The lengths of Sanibel Slough West and Sanibel Slough East were 18.1 and 6.6 km, respectively. The cross-sectional widths were used with the measured lengths to estimate the surface area of the waterbody. The average surface area for Sanibel Slough West was 0.58 square kilometers (km²), and the surface area for Sanibel Slough East was 0.14 km².

The cross-sectional analysis provided slough depths relative to the North American Vertical Datum of 1988 (NAVD 88), and the average of the cross-section depths was used to determine the estimated average bottom depth of the slough. The average bottom depths for Sanibel Slough West and Sanibel Slough East were 1.29 and 1.22 meters (m) below NAVD 88, respectively. Records of the water levels taken by City of Sanibel employees at several staff gauges along the slough in each basin were used to estimate water surface elevation above the NAVD 88 datum. The water level readings were averaged for each year from 2007 to 2013, and the yearly average water surface elevations were added to the averaged bottom depth of the slough to calculate the annual average water depths. **Table 3.4** summarizes the annual average water depths.

Table 3.4. Mean depths for Sanibel Slough, 2007–13

| Year | Sanibel Slough West Mean Depth (m) | Sanibel Slough East Mean Depth (m) |
|------|--|--|
| 2007 | 1.55 | 1.57 |
| 2008 | 1.62 | 1.73 |
| 2009 | 1.57 | 1.72 |
| 2010 | 2.10 | 1.97 |
| 2011 | 1.73 | 1.81 |
| 2012 | 1.68 | 1.75 |
| 2013 | 1.83 | 1.81 |

METEOROLOGICAL

Daily rainfall data collected at MesoWest Station TS755 (University of Utah), located at the J.N. "Ding" Darling National Wildlife Refuge, was used to calculate the seasonal precipitation measurements per year for May 2008 through December 2013. Data for 2007 and the first four months of 2008 were missing in the MesoWest rainfall dataset. To complete the dataset, the rainfall data from the closest station, located at Ruby Ave. and Henley Canal in St. James, Florida, were used to fill the gaps. The wet season on Sanibel Island is July 1 through October 15, with the remainder of the year being described as the dry season (Thompson and Milbrandt 2014). **Table 3.5** summarizes wet and dry season precipitation per year.

Evaporation from the surface of Sanibel Slough was predicted using measurements of water surface evaporation, which were based on cumulative literature and lysimeter studies and evaporation and evapotranspiration measurements and estimations. Estimations from the SFWMD suggest an open water evaporation rate of 1.35 m/yr (53 in/yr) for the southern portion of Florida (Abteu et al. 2003). This evaporation rate was used as an input to the BATHTUB receiving waterbody model.

Table 3.5. Annual rainfall in the Sanibel Slough Watershed, 2007–13

| Year | Dry Season (m) | Wet Season (m) | Yearly Total (m) |
|------|----------------|----------------|------------------|
| 2007 | 0.31 | 0.41 | 0.72 |
| 2008 | 0.48 | 0.57 | 1.05 |
| 2009 | 0.52 | 0.41 | 0.93 |
| 2010 | 0.58 | 0.42 | 1.00 |
| 2011 | 0.54 | 0.52 | 1.07 |
| 2012 | 0.36 | 0.50 | 0.86 |
| 2013 | 0.45 | 0.64 | 1.09 |

NUTRIENT LOADS

Nutrient loading inputs into the BATHTUB model were added through three pathways: atmospheric deposition loads, groundwater loads, and stormwater runoff loads from the watershed model discussed in **Section 3.1.1**.

The estimated total atmospheric nutrient loading directly to the slough in the West Basin is 63 kg/yr for TN and 1 kg/yr for TP, and for the East Basin it is 50 kg/yr and 1 kg/yr for TN and TP, respectively (Thompson and Milbrandt 2013). The atmospheric deposition loads of TN and TP were entered as global variables in the BATHTUB model inputs, expressed as a per area loading rate on an annual scale, as listed in **Table 3.6**.

Table 3.6. Sanibel Slough atmospheric deposition loads

| Basin | TN (mg/m ² /yr) | TP (mg/m ² /yr) |
|-------|----------------------------|----------------------------|
| West | 217 | 3 |
| East | 228 | 4 |

The SCCF Maine lab conducted a groundwater study from 2015 to 2016 and estimated that the annual groundwater discharge to the East Basin during the study period was 174,373 cubic meters (m³), and the annual discharge for the West Basin was approximately 74,026 m³ (Thompson and Milbrandt 2016). The discharge was determined to be proportional to the amount of rainfall during the study period, and this relationship was used to extrapolate the estimated annual groundwater discharge during the model time frame by deriving the relationship between the study period seasonal rainfall and seasonal discharge and applying the relationship to the seasonal rainfall during the model years to estimate the seasonal discharge for each year in the model domain (**Table 3.7**).

Table 3.7. Sanibel Slough seasonal groundwater discharge

| Year | West Basin Wet Season Groundwater Discharge (m ³ /yr) | West Basin Dry Season Groundwater Discharge (m ³ /yr) | East Basin Wet Season Groundwater Discharge (m ³ /yr) | East Basin Dry Season Groundwater Discharge (m ³ /yr) |
|------|--|--|--|--|
| 2007 | 25,502 | 10,612 | 29,467 | 46,444 |
| 2008 | 35,381 | 16,069 | 40,882 | 70,323 |
| 2009 | 25,613 | 17,716 | 29,595 | 77,532 |
| 2010 | 26,039 | 19,569 | 30,087 | 85,641 |
| 2011 | 32,540 | 18,334 | 37,599 | 80,235 |
| 2012 | 30,915 | 12,251 | 35,721 | 53,615 |
| 2013 | 39,989 | 15,468 | 46,206 | 67,695 |

Additionally, groundwater nutrient concentrations were measured at several well stations along the slough. The mean groundwater concentration in the West Basin was 3.31 milligrams per liter (mg/L) for TN and 0.09 mg/L for TP, and the mean TN and TP concentrations in the East Basin were 7.06 and 0.76 mg/L, respectively. The extrapolated annual discharges and the mean nutrient concentrations were used to determine the annual groundwater nutrient loads in the East and West Basins (**Table 3.8**) for each year of the modeling period.

Table 3.8. Sanibel Slough groundwater nutrient loads

| Year | West Basin TN Loads (kg/yr) | West Basin TP Loads (kg/yr) | East Basin TN Loads (kg/yr) | East Basin TP Loads (kg/yr) |
|------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| 2007 | 121 | 3 | 520 | 56 |
| 2008 | 172 | 5 | 768 | 83 |
| 2009 | 142 | 4 | 766 | 82 |
| 2010 | 149 | 4 | 832 | 89 |
| 2011 | 169 | 5 | 829 | 89 |
| 2012 | 145 | 4 | 609 | 66 |
| 2013 | 187 | 5 | 775 | 84 |

Groundwater loads and stormwater loads were added as individual tributaries to the receiving water segments in the BATHTUB model inputs. **Table 3.9** summarizes simulated total nutrient loadings from all sources for the West and East Basins and highlights the values that represent the maximum loads for the model period for each basin. **Figure 3.2** and **Figure 3.3** illustrate the average percent contribution of all sources for the West and East Basins, respectively.

Table 3.9. Sanibel Slough simulated existing condition nutrient loads

Note: Shaded cells and bold italic type indicate maximum loads for the model period.

| Year | West Basin Existing Condition TN Loads (kg/yr) | West Basin Existing Condition TP Loads (kg/yr) | East Basin Existing Condition TN Loads (kg/yr) | East Basin Existing Condition TP Loads (kg/yr) |
|------|--|--|--|--|
| 2007 | 1,562 | 237 | 1,638 | 321 |
| 2008 | 2,195 | 337 | 2,288 | 450 |
| 2009 | 1,943 | 301 | 2,092 | 382 |
| 2010 | 2,568 | 333 | 2,251 | 405 |
| 2011 | 2,216 | 334 | 2,370 | 448 |
| 2012 | 1,833 | 284 | 1,901 | 379 |
| 2013 | <i>2,343</i> | <i>363</i> | <i>2,377</i> | <i>482</i> |

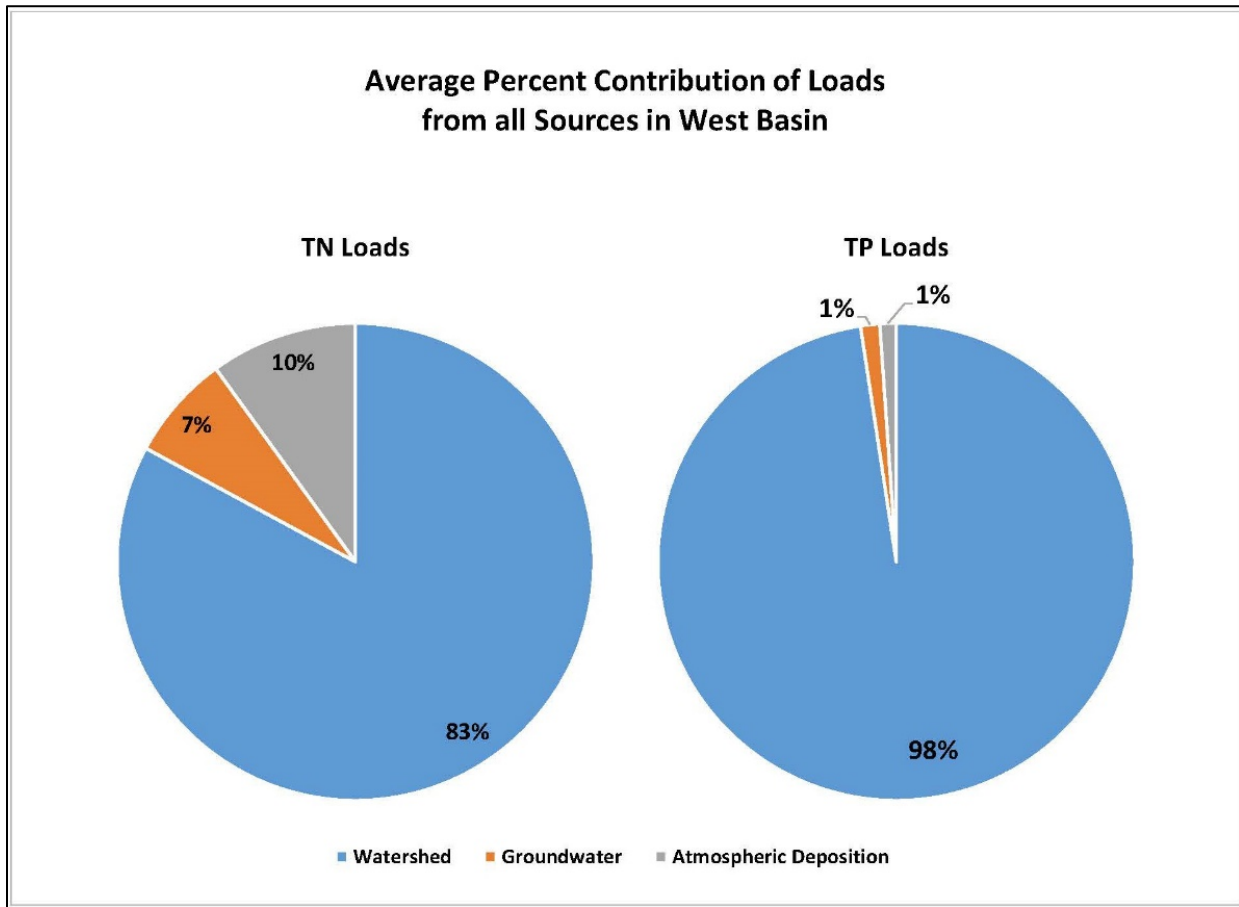


Figure 3.2. Average percent contribution of loads from all sources in the West Basin

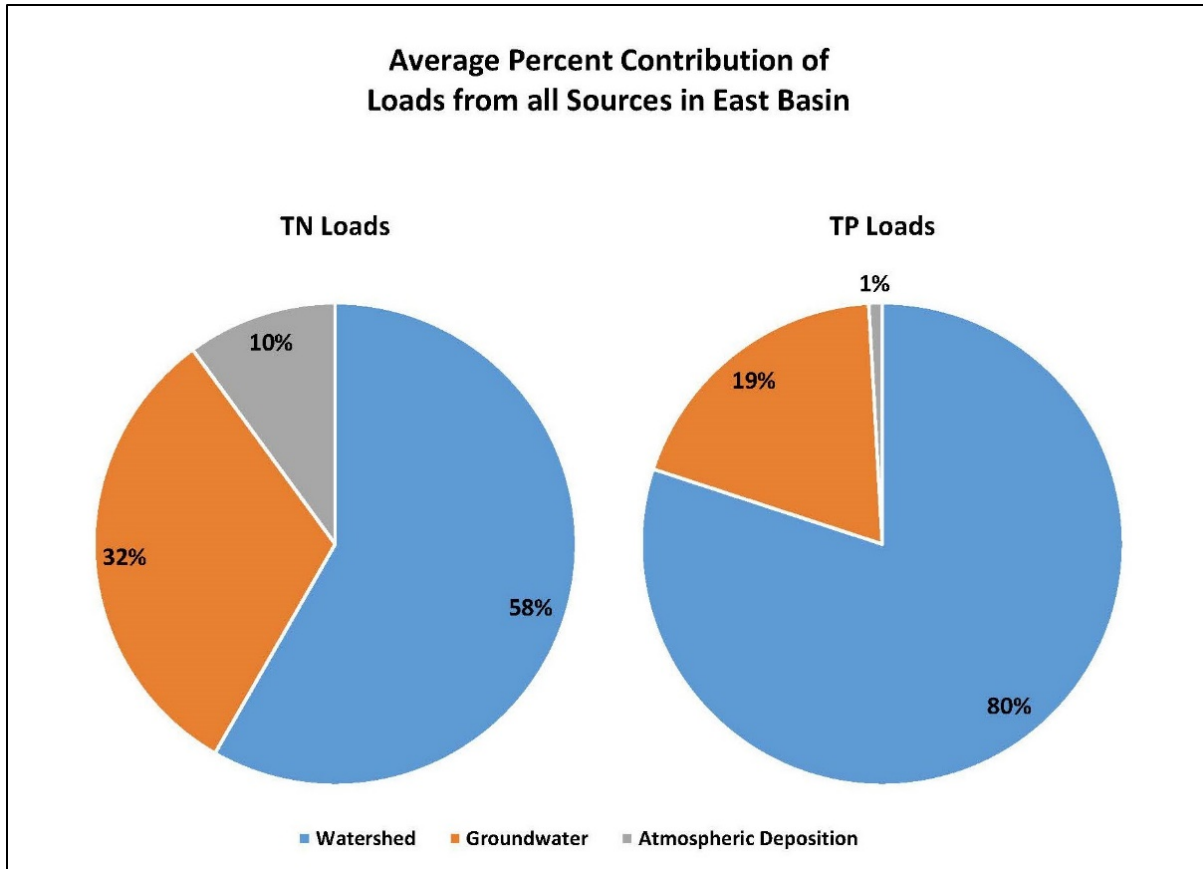


Figure 3.3. Average percent contribution of loads from all sources in the East Basin

NUTRIENT BALANCE MODEL SELECTION

The BATHTUB model package can use a range of model equations to predict a waterbody's responses to long-term physical and chemical factors. The model equations are chosen based on the model's ability to predict the measured nutrient concentrations. For the West Slough, the phosphorus Model Option 4, based on the mass balance phosphorus loading model developed by Canfield and Bachmann for reservoirs (1981), and nitrogen Model Option 6, based on a simple first-order decay rate, were chosen to represent the nutrient dynamics of the waterbody. For the chlorophyll *a* simulation, chlorophyll *a* Model Option 4 was chosen. This model is based on the assumption of a simple linear relationship between chlorophyll *a* and TP. Despite linear regression analysis finding only a weak relationship between the empirical chlorophyll *a* and TP AGMs, it was found that using Model 4 provided the best fit between simulated and measured TP results.

The phosphorus Model Option 4, based on the Canfield and Bachmann (1981) equation for phosphorus sedimentation rates in reservoirs, and nitrogen Model Option 6, based on a simple first-order decay rate, were used to simulate both nitrogen and phosphorus sedimentation in Sanibel Slough East. Model Option 2, which includes phosphorus, light/transparency, and

flushing as potential limiting factors to algal production, was selected for the simulation of chlorophyll *a* in the East Slough.

3.1.2.3 BATHTUB Calibration

The BATHTUB model includes calibration factors as a means for adjusting model predictions to account for site-specific conditions. Calibration variables include TP, TN, and chlorophyll *a*, and calibration factors apply to sedimentation rates (default) or predicted concentrations. Once the BATHTUB models are calibrated, they can be used to evaluate different scenarios by changing the incoming nutrient loads. The measured AGM concentrations for TN, TP, and chlorophyll *a* were calculated from available water quality data and used to calibrate the BATHTUB model by adjusting the simulated concentrations until they were within an acceptable range of the measured values. To calibrate the West Basin, a calibration factor of 1.75 was applied to TN, a calibration factor of 0.75 was applied to TP, and a calibration factor of 0.75 was used for chlorophyll *a*. A calibration factor of 1.45 was applied to the TN predicted concentrations in the East Basin and a factor of 0.9 was used for TP, but no calibration factor was applied to chlorophyll *a*.

Tables 3.10 through 3.12 present the results of the model calibration using the percent difference between the simulated and measured values as the measure of model performance. Overall, the percent differences were generally within a range that is described as "good" to "very good," according to generally accepted model calibration tolerances (Donigian 2000). The chlorophyll *a* concentrations were poorly predicted in the BATHTUB model for the East Basin in 2008 and 2010 and in the West Basin in 2009. However, the remaining years were closely predicted. The means of the simulated and measured values were calculated, and the percent difference of the means were used to compare the central tendencies. The percent differences between the mean chlorophyll *a* values were 8 % for the East and 7 % for the West. Figures 3.4 through 3.9 present the visual interpretation of the calibration results, with error bars representing +/- 35 % difference in the simulated values.

Table 3.10. BATHTUB calibration for TN, average AGM 2007–13

Note: Shaded cells and bold italic type indicate the means of the simulated and measured values and the percent difference between those means.
ppb = Parts per billion

| Year | West Basin Simulated TN (ppb) | West Basin Measured TN (ppb) | West Basin TN % Difference | East Basin Simulated TN (ppb) | East Basin Measured TN (ppb) | East Basin TN % Difference |
|-------------|-------------------------------|------------------------------|----------------------------|-------------------------------|------------------------------|----------------------------|
| 2007 | 1,859 | 1,870 | 1 | 2,050 | 2,168 | 6 |
| 2008 | 1,627 | 1,476 | 10 | 1,932 | 1,835 | 5 |
| 2009 | 1,686 | 1,982 | 16 | 2,070 | 2,223 | 7 |
| 2010 | 2,210 | 2,108 | 5 | 2,086 | 1,743 | 18 |
| 2011 | 1,627 | 1,945 | 18 | 1,988 | 1,882 | 5 |
| 2012 | 1,743 | 1,974 | 12 | 1,969 | 1,911 | 3 |
| 2013 | 1,632 | 1,736 | 6 | 1,881 | 2,163 | 14 |
| <i>Mean</i> | <i>1,769</i> | <i>1,870</i> | <i>6</i> | <i>1,997</i> | <i>1,989</i> | <i>0</i> |

Table 3.11. BATHTUB calibration for TP, average AGM 2007–13

Note: Shaded cells and bold italic type indicate the means of the simulated and measured values and the percent difference between those means.
ppb = Parts per billion

| Year | West Basin Simulated TP (ppb) | West Basin Measured TP (ppb) | West Basin TP % Difference | East Basin Simulated TP (ppb) | East Basin Measured TP (ppb) | East Basin TP % Difference |
|-------------|-------------------------------|------------------------------|----------------------------|-------------------------------|------------------------------|----------------------------|
| 2007 | 71 | 73 | 3 | 98 | 128 | 27 |
| 2008 | 70 | 42 | 50 | 100 | 84 | 17 |
| 2009 | 70 | 94 | 29 | 100 | 128 | 25 |
| 2010 | 63 | 58 | 8 | 91 | 76 | 18 |
| 2011 | 67 | 54 | 21 | 97 | 85 | 13 |
| 2012 | 69 | 64 | 8 | 97 | 97 | 0 |
| 2013 | 67 | 59 | 13 | 100 | 97 | 3 |
| <i>Mean</i> | <i>68</i> | <i>63</i> | <i>8</i> | <i>98</i> | <i>99</i> | <i>1</i> |

Table 3.12. BATHTUB calibration for chlorophyll *a*, average AGM 2007–13

Note: Shaded cells and bold italic type indicate the means of the simulated and measured values and the percent difference between those means.
ppb = Parts per billion

| Year | West Basin Simulated chlorophyll <i>a</i> (ppb) | West Basin Measured chlorophyll <i>a</i> (ppb) | West Basin chlorophyll <i>a</i> % Difference | East Basin Simulated chlorophyll <i>a</i> (ppb) | East Basin Measured chlorophyll <i>a</i> (ppb) | East Basin chlorophyll <i>a</i> % Difference |
|-------------|---|--|--|---|--|--|
| 2007 | 15 | 15 | 0 | 44 | 42 | 5 |
| 2008 | 15 | 16 | 6 | 37 | 62 | 51 |
| 2009 | 15 | 25 | 50 | 44 | 50 | 13 |
| 2010 | 13 | 10 | 26 | 26 | 16 | 48 |
| 2011 | 14 | 12 | 15 | 25 | 21 | 17 |
| 2012 | 15 | 13 | 14 | 35 | 39 | 11 |
| 2013 | 14 | 15 | 7 | 26 | 26 | 0 |
| <i>Mean</i> | <i>14</i> | <i>15</i> | <i>7</i> | <i>34</i> | <i>37</i> | <i>8</i> |

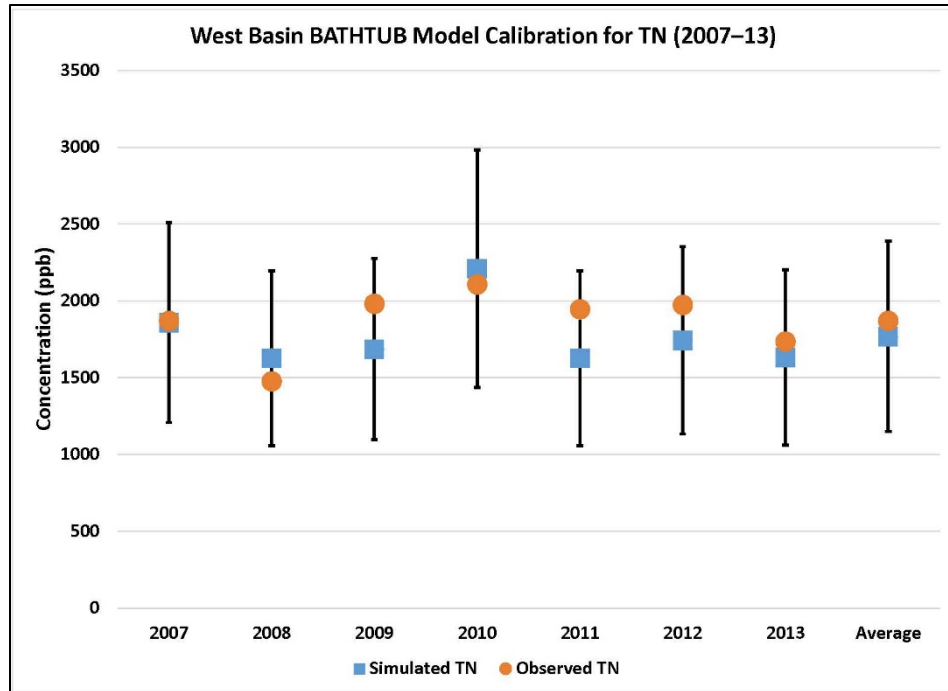


Figure 3.4. West Basin BATHTUB model calibration for TN (2007-13)

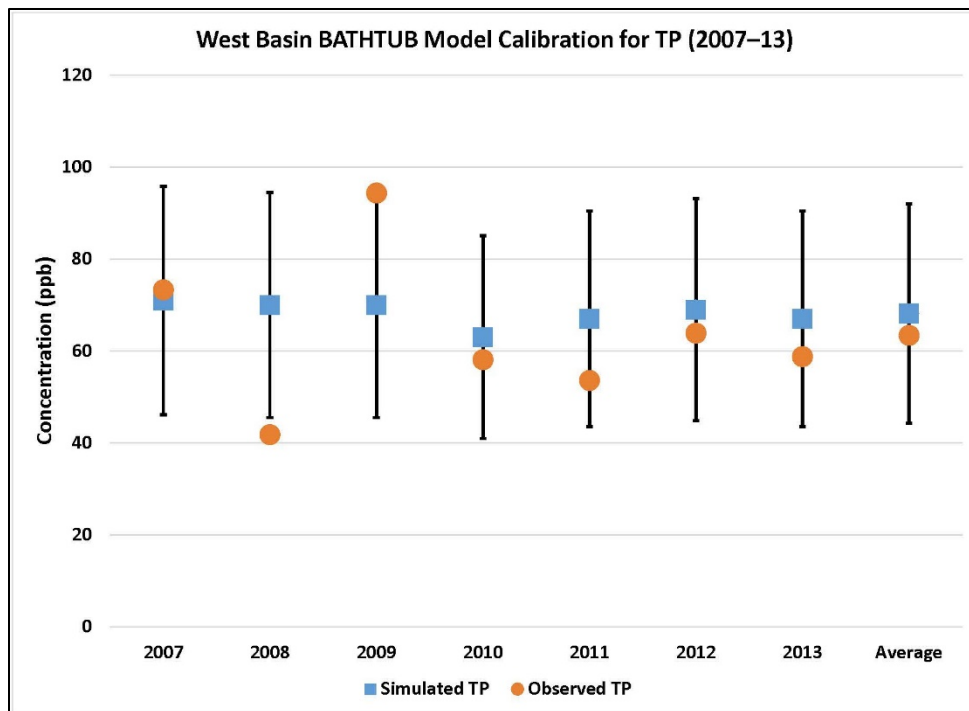


Figure 3.5. West Basin BATHTUB model calibration for TP (2007-13)

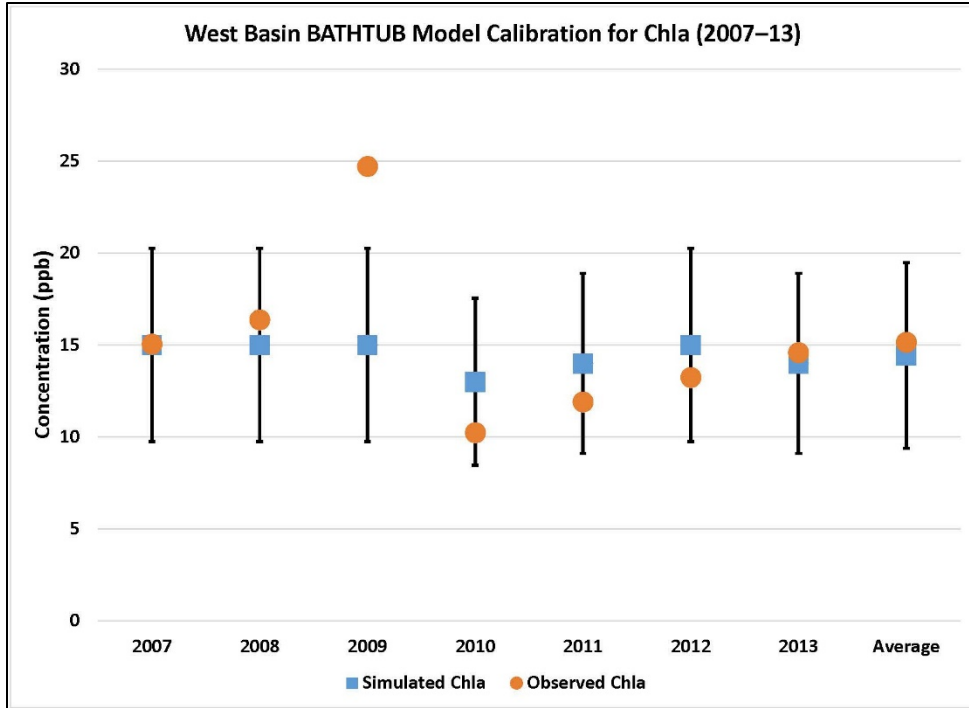


Figure 3.6. West Basin BATHTUB model calibration for chlorophyll *a* (2007–13)

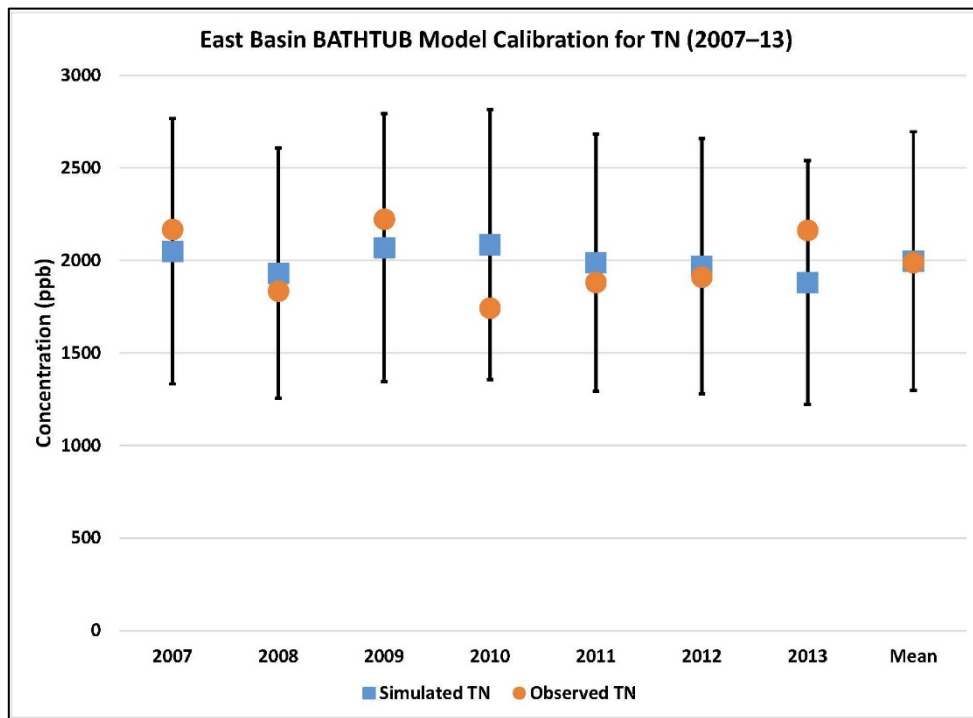


Figure 3.7. East Basin BATHTUB model calibration for TN (2007–13)

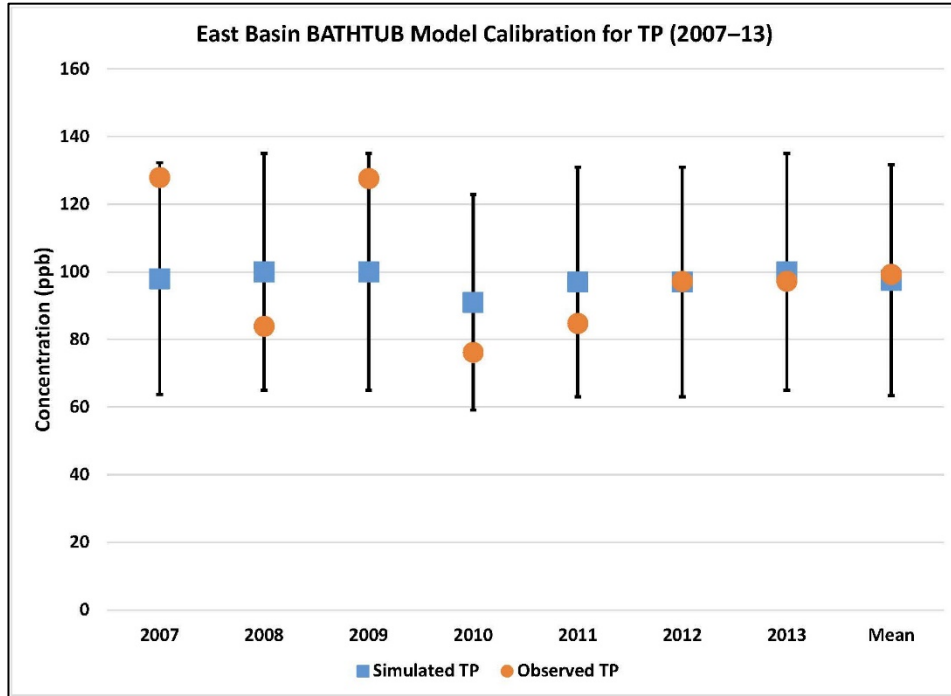


Figure 3.8. East Basin BATHTUB model calibration for TP (2007-13)

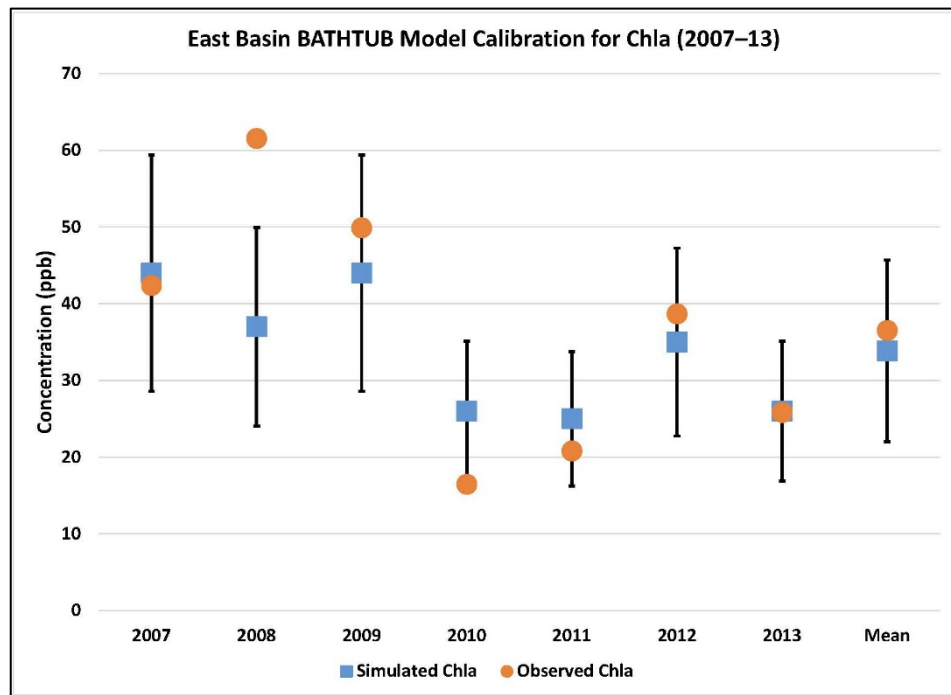


Figure 3.9. East Basin BATHTUB model calibration for chlorophyll *a* (2007-13)

3.2 Scenarios To Achieve the Target Condition

To achieve the chlorophyll *a* target of 11 µg/L in the West Basin and 21 µg/L in the East Basin in every year of the modeling period, the TN and TP loads that achieve the chlorophyll *a* target were simulated using the BATHTUB model. A background condition scenario was run to ensure that the TMDL condition would not abate the natural conditions.

The model runs for the background condition stormwater runoff loads were created by converting all anthropogenic land use types to natural land uses, dividing evenly between forested land and wetlands, and using the resulting loads as the natural background stormwater loads. Atmospheric deposition was left at the existing condition rates. A background groundwater loading rate was simulated by selecting the lowest mean groundwater TN and TP concentrations at groundwater stations that discharged to the slough during the 2015–16 groundwater study conducted by the SCCF Marine Lab (Thompson and Milbrandt 2016), and multiplying the concentrations by the groundwater discharge volume that was calculated for 2007 through 2013.

The lowest wet and dry season TN concentrations recorded at sites that discharged into the slough were 1.33 and 0.74 mg/L, respectively, and the lowest wet and dry TP concentrations were 0.04 and 0.03 mg/L, respectively. The loads from the natural background condition were subtracted from the loads from the existing condition, and the remaining load was considered to be the anthropogenic load.

The anthropogenic loads were incrementally decreased until a chlorophyll *a* concentration of 11 µg/L was achieved every year (TMDL condition) for the West Basin. The TN and TP loads under the natural background condition were used as the TN and TP loads for the TMDL condition for the East Basin.

Figures 3.10 through 3.12 show the annual TN and TP loads and chlorophyll *a* concentrations under the existing and TMDL conditions for the West Basin, and **Figures 3.13 through 3.15** show the scenarios for the East Basin.

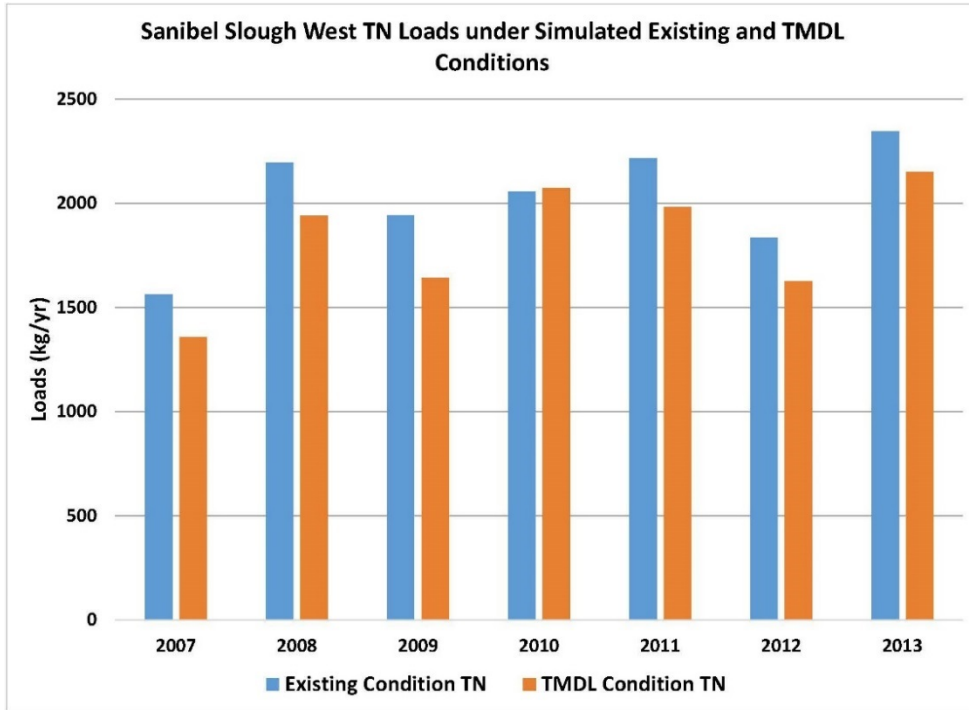


Figure 3.10. Sanibel Slough West simulated TN loads under existing and TMDL conditions

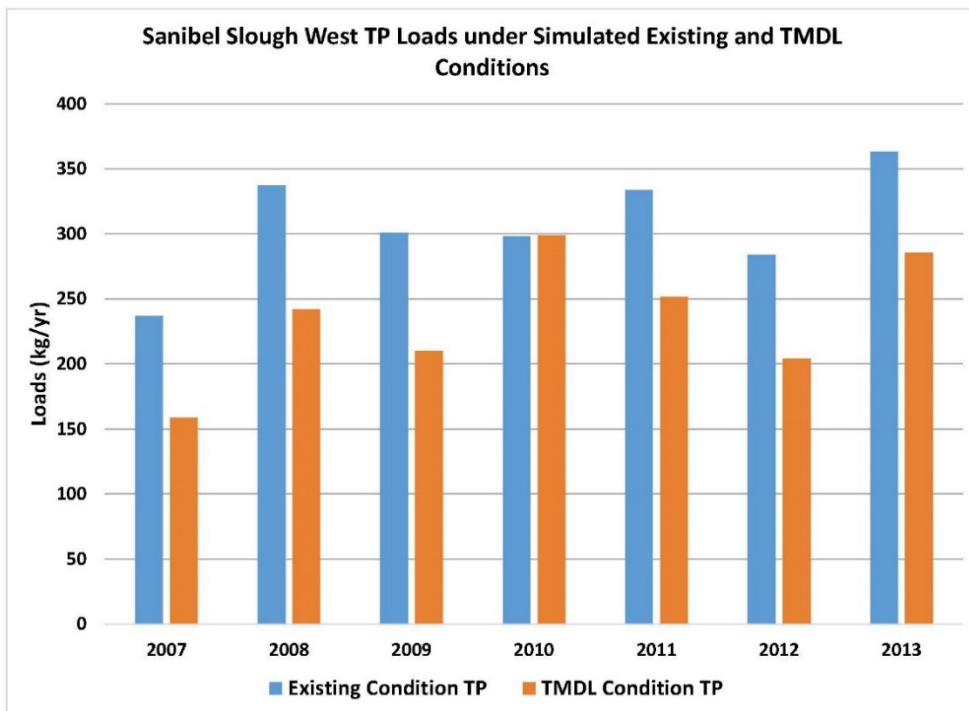


Figure 3.11. Sanibel Slough West simulated TP loads under existing and TMDL conditions

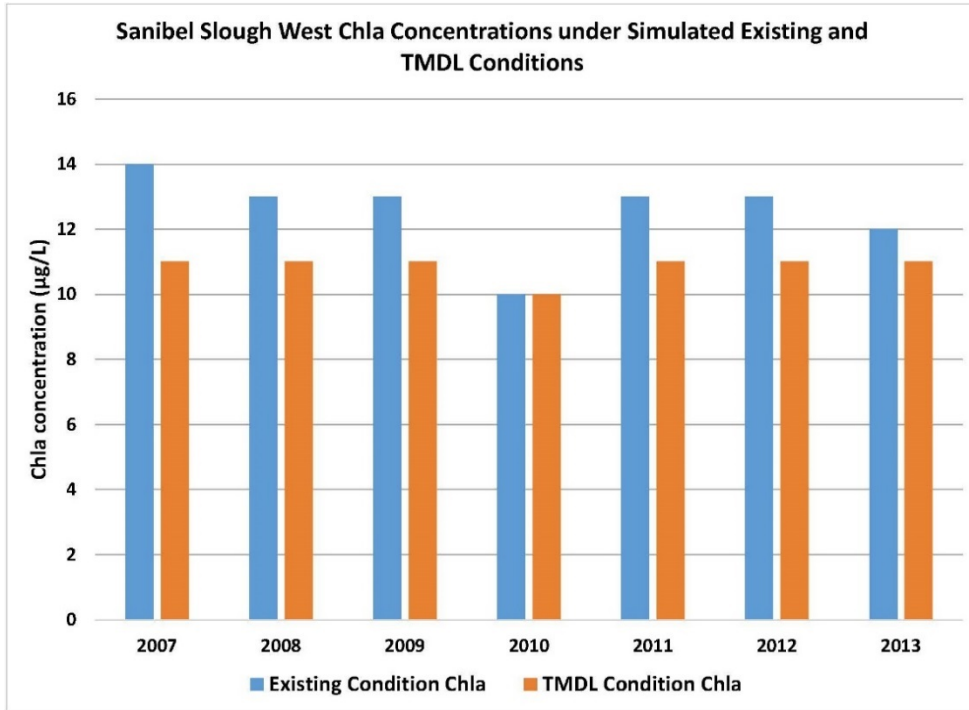


Figure 3.12. Sanibel Slough West simulated chlorophyll *a* concentrations under existing and TMDL conditions

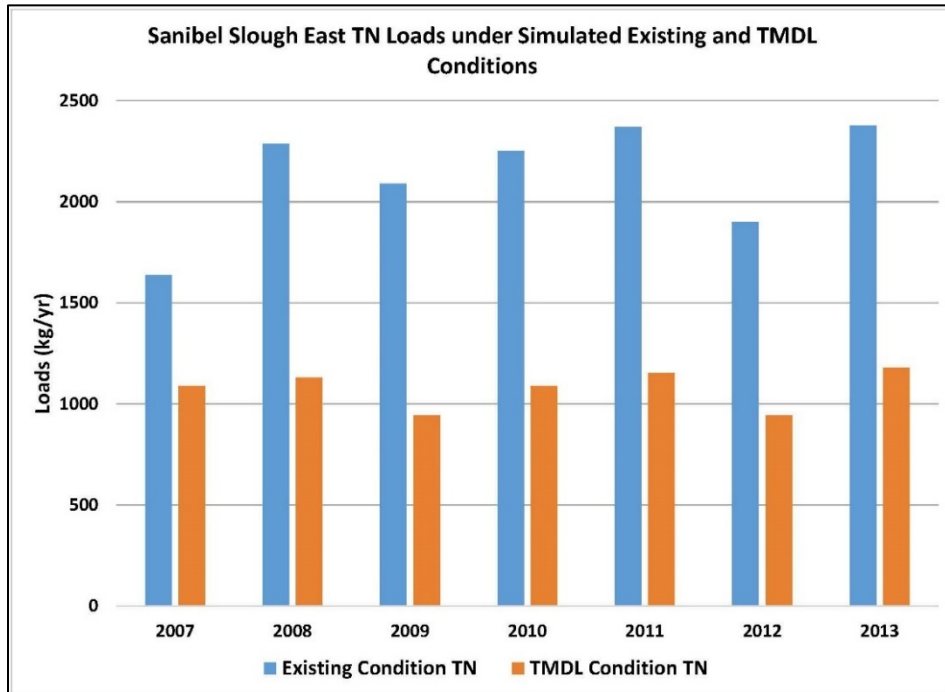


Figure 3.13. Sanibel Slough East simulated TN loads under existing and TMDL conditions

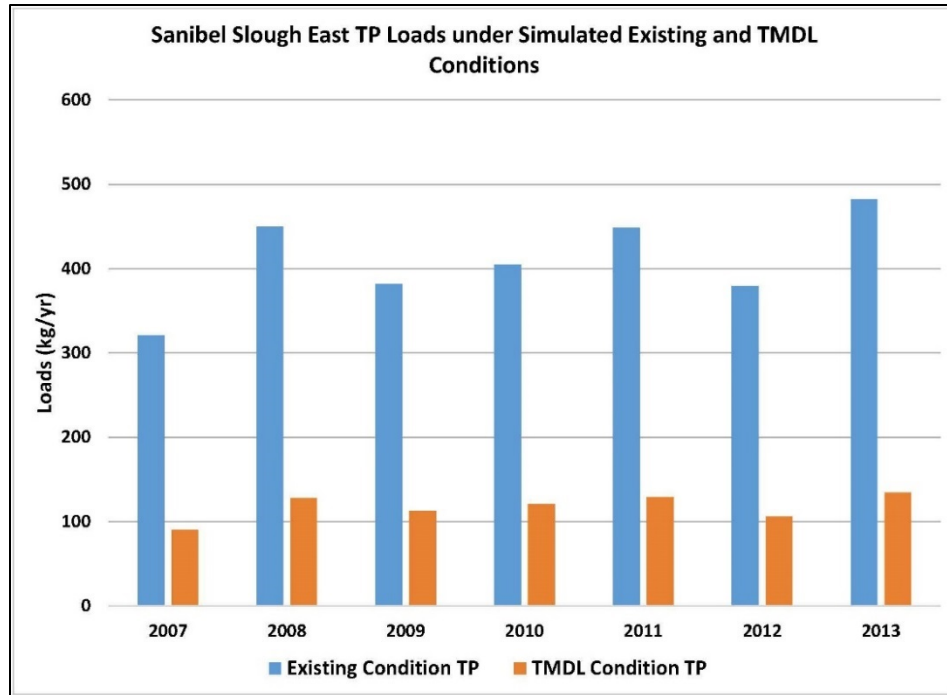


Figure 3.14. Sanibel Slough East simulated TP loads under existing and TMDL conditions

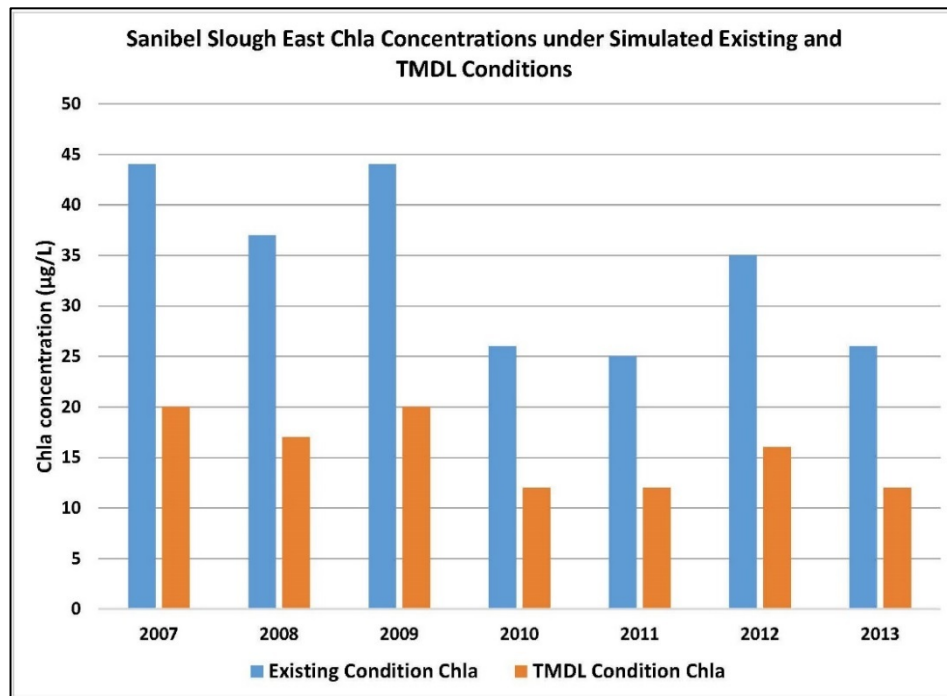


Figure 3.15. Sanibel Slough East simulated chlorophyll *a* concentrations under existing and TMDL conditions

3.3 Calculation of the TMDLs

The existing conditions evaluated for establishing the TMDLs were the TN and TP loads as simulated for the 2007–13 period, as described in **Section 3.1.2** and summarized in **Table 3.8**. For the purpose of establishing the TMDLs, the existing condition nutrient loads used in the percent reduction calculation are the maximum simulated annual TN and TP loads in the model period. The maximum simulated existing condition nutrient loads for TN are 2,343 kg/yr in the West Basin and 2,568 kg/yr in the East Basin, and the maximum TP loads in the West and East Basins are 363 and 544 kg/yr, respectively.

The use of the maximum value in setting the TMDL is considered a conservative assumption for establishing reductions, as this will ensure that all exceedances of the nutrient targets are addressed. For the purpose of the percent reduction calculation in the equation below, the "target loads" are the maximums of the 3-year rolling averages of the annual loads necessary to meet the chlorophyll *a* target of 11 µg/L for the West Basin and 21 µg/L in the East Basin, as described in **Section 2.4.3** and summarized in **Tables 2.5** and **2.6**. The target loads for TN are 1,903 kg/yr in the West Basin and 1,091 kg/yr in the East Basin, and the target TP loads in the West and East Basins are 241 and 143 kg/yr, respectively. **Table 3.13** summarizes the variables and the percent reduction.

The equation used to calculate the percent reduction is as follows:

$$\frac{[\text{maximum existing load} - \text{target load}] \times 100}{\text{maximum existing load}}$$

Table 3.13. Summary of variables for the percent reduction calculations

| Condition | West Basin TN Loads (kg/yr) | West Basin TP Loads (kg/yr) | East Basin TN Loads (kg/yr) | East Basin TP Loads (kg/yr) |
|-----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Maximum Existing Load | 2,568 | 363 | 2,377 | 482 |
| Target Load | 1,903 | 241 | 1,091 | 123 |
| % Reduction | 26 | 34 | 54 | 74 |

For Sanibel West Slough, an 26 % reduction in the existing TN loads and a 34 % reduction in the existing TP loads are necessary to meet the target conditions. The Sanibel East Slough TMDLs represent a 54 % reduction for TN and a 74 % reduction in TP to achieve the target conditions. The nutrient TMDL values, which are expressed as a rolling 3-year average load not to be exceeded, address the anthropogenic nutrient inputs that contribute to the exceedances of the chlorophyll *a* restoration target.

Chapter 4: Determination of Loading Allocations

4.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\text{TMDL} \cong \sum \text{WLAS}_{\text{wastewater}} + \sum \text{WLAS}_{\text{NPDES Stormwater}} + \sum \text{LAs} + \text{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (1) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as "percent reduction" because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the "maximum extent practical" through the implementation of best management practices (BMPs).

This approach is consistent with federal regulations (40 Code of Federal Regulations § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDLs for the Sanibel Slough Basins are expressed in terms of kg/yr and percent reduction of TN and TP, and represent the annual load of TN and TP that the waterbody can assimilate while maintaining a balanced aquatic flora and fauna (see **Table 4.1**). These TMDLs were based on 3-year rolling averages of simulated data from 2007 to 2013. The restoration goal is to achieve chlorophyll *a* concentrations of 11 µg/L and 21 µg/L, as an AGMs not to be exceeded more than once in any consecutive 3-year period, in Sanibel Slough West and East, respectively.

Table 4.1. TMDL components for nutrients in Sanibel Slough West (WBID 2092F1) and Sanibel Slough East (WBID 2092F2)

¹ The TMDL represents a 3-year rolling average of annual loads, not to be exceeded. Dividing by 365 days yields daily TMDL loads.

² The required percent reductions listed in this table represent the reduction from all sources.

N/A = Not applicable

| Waterbody (WBID) | Parameter | TMDL (kg/yr) ¹ | WLA Wastewater (% reduction) | WLA NPDES Stormwater (% reduction) ² | LA (% reduction) ² | MOS |
|------------------|-----------|---------------------------|------------------------------|---|-------------------------------|----------|
| 2092F1 | TN | 1,903 | N/A | 26% | 26% | Implicit |
| 2092F1 | TP | 241 | N/A | 34% | 34% | Implicit |
| 2092F2 | TN | 1,091 | N/A | 54 % | 54 % | Implicit |
| 2092F2 | TP | 123 | N/A | 74 % | 74 % | Implicit |

4.2 Load Allocation

To achieve the load allocation (LA), current TN and TP loads require a 26 % and 34 % reduction in the Sanibel Slough West Basin and a 54 % and 74 % reduction in the Sanibel Slough East Basin, respectively.

As the TMDLs are based on the percent reduction in total watershed loading and any natural land uses are held harmless, the percent reductions for anthropogenic sources may be greater. It should be noted that the LA includes loading from stormwater discharges regulated by DEP and the water management districts that are not part of the NPDES stormwater program (see **Appendix A**).

4.3 Wasteload Allocation

4.3.1 NPDES Wastewater Discharges

There are two NPDES wastewater facilities in the Sanibel Slough basins: IWA (NPDES FL0025593) and Donax WRF (FLA014430). However, there are no direct discharges to surface waters of Sanibel Slough. As such, a WLA for wastewater discharges is not applicable.

4.3.2 NPDES Stormwater Discharges

Lee County the City of Sanibel are covered by a Phase I NPDES MS4 permit (FLS000035), and areas within their jurisdiction in the Sanibel Slough Watershed are responsible for an 26 % reduction in TN and a 34 % reduction in TP from the current anthropogenic loading in the West Basin. Likewise, a 54 % reduction in TN and a 74 % reduction in TP will be necessary in the East Basin. It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over.

4.4 Margin of Safety (MOS)

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings.

Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of these TMDLs. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody (Clean Water Act, Section 303[d][1][c]). Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as predicting water quality response. The effectiveness of management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty.

An implicit MOS was used because the TMDLs were based on the conservative decisions associated with a number of the modeling assumptions in determining assimilative capacity (i.e., loading and water quality response for Sanibel Slough). The TMDLs were developed using water quality results from both high- and low-rainfall years, and the attenuation of nutrients in transport from nonpoint source areas to Sanibel Slough was not considered. Therefore, the required load reductions may lead to lower-than-anticipated nutrient concentrations by the time the loads reach the waterbody.

Additionally, the TMDL nutrient load targets are established as annual limits not to be exceeded based on the development of site-specific alternative water quality targets, and reductions are based on maximum existing conditions to ensure that all exceedances of the nutrient targets are addressed. Furthermore, the TMDL nutrient load targets were derived based on the target chlorophyll *a* concentrations being met in every year of the model simulation, providing a margin of safety for achieving the restoration goal of a chlorophyll *a* concentration of 11 µg/L in the West Basin and 21 µg/L in the East Basin, expressed as an AGM, not to be exceeded more than once in any consecutive 3-year period.

Chapter 5: Implementation Plan Development and Beyond

5.1 Implementation Mechanisms

Following the adoption of a TMDL, implementation takes place through various measures. The implementation of TMDLs may occur through specific requirements in NPDES wastewater and MS4 permits, and, as appropriate, through local or regional water quality initiatives or basin management action plans (BMAPs).

Facilities with NPDES permits that discharge to the TMDL waterbody must respond to the permit conditions that reflect target concentrations, reductions, or wasteload allocations identified in the TMDL. NPDES permits are required for Phase I and Phase II MS4s as well as domestic and industrial wastewater facilities. MS4 Phase I permits require a permit holder to prioritize and take action to address a TMDL unless management actions are already defined in a BMAP for that particular TMDL. MS4 Phase II permit holders must also implement responsibilities defined in a BMAP.

5.2 BMAPs

BMAPs are discretionary and are not initiated for all TMDLs. A BMAP is a TMDL implementation tool that integrates the appropriate management strategies applicable through existing water quality protection programs. DEP or a local entity may develop a BMAP that addresses some or all of the contributing areas to the TMDL waterbody.

Section 403.067, F.S. (the FWRA), provides for the development and implementation of BMAPs. BMAPs are adopted by the DEP Secretary and are legally enforceable.

BMAPs describe the management strategies that will be implemented as well as funding strategies, project tracking mechanisms, water quality monitoring, and the fair and equitable allocations of pollution reduction responsibilities to the sources in the watershed. BMAPs can also identify mechanisms to address potential pollutant loading from future growth and development.

The most important component of a BMAP is the list of management strategies to reduce pollution sources, as these are the activities needed to implement the TMDLs. The local entities that will conduct these management strategies are identified and their responsibilities are enforceable. Management strategies may include wastewater treatment upgrades, stormwater improvements, and agricultural BMPs.

[Additional information about BMAPs](#) is available online.

5.3 Implementation Considerations for the Waterbody

In addition to addressing reductions in watershed pollutant contributions to impaired waters during the implementation phase, it may also be necessary to consider the impacts of internal sources (e.g., sediment nutrient fluxes or the presence of nitrogen-fixing cyanobacteria) and the results of any associated remediation projects on surface water quality. Approaches for addressing these other factors should be included in a comprehensive management plan for the waterbody. Additionally, the current water quality and water level monitoring of Sanibel Slough should continue and be expanded, as necessary, during the implementation phase to ensure that adequate information is available for tracking restoration progress.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Rule 62-40, F.A.C. In 1994, DEP stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations, as authorized under Part IV of Chapter 373, F.S.

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990 to address stormwater discharges associated with industrial activity, which includes 11 categories of industrial activity, construction activities disturbing 5 or more acres of land, and large and medium MS4s located in incorporated places and counties with populations of 100,000 or more.

However, because the master drainage systems of most local governments in Florida are physically interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 special districts; community development districts, water control districts, and Florida Department of Transportation (FDOT) throughout the 15 counties meeting the population criteria. DEP received authorization to implement the NPDES stormwater program in October 2000. The authority to administer the program is set forth in Section 403.0885 F.S.

The Phase II NPDES stormwater program, promulgated in 1999, addresses additional sources, including small MS4s and small construction activities disturbing between 1 and 5 acres, and urbanized areas serving a minimum resident population of at least 1,000 individuals. While these urban stormwater discharges are technically referred to as "point sources" for the purpose of

regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that Phase I MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Information in Support of Site-Specific Interpretations of the Narrative Nutrient Criterion

Table B-1. Spatial extent of the numeric interpretation of the narrative nutrient criterion

| Location | Description |
|---|--|
| Waterbody name | Sanibel Slough West; Sanibel Slough East |
| Waterbody type(s) | Estuary |
| Waterbody ID (WBID) | WBID 2092F1 and 2092F2 (see Figure 1.1 of this TMDL report) |
| Description | <p>Sanibel Slough is located on Sanibel Island in Lee County, Florida. Sanibel Slough is divided into East and West Basins by a control weir located at Tarpon Bay Road.</p> <p>Sanibel Slough West has an estimated surface area of 0.58 km² and an average depth of 1.73 m, and it has rare discharges to Tarpon Bay at a control weir at Sanibel-Captiva Road. The Sanibel Slough West Watershed covers 1,978 acres, of which wetlands is the largest land use type (55 %), followed by low- and medium-density residential, which make up 18 % and 11 % of the watershed, respectively.</p> <p>Sanibel Slough East has an estimated surface area of 0.14 km² and average depth of 1.77 m, and it discharges to San Carlos Bay at a control weir at Beach Road. The Sanibel Slough East Watershed covers 1,255 acres, of which wetlands is the largest land use type (40 %), followed by medium- and low-density residential, which make up 19 % and 9 % of the watershed, respectively.</p> <p>A more detailed description of the Sanibel Slough system is provided in Chapter 1 of this TMDL report.</p> |
| Specific location (latitude/longitude or river miles) | <p>The center of Sanibel Slough West is located at N: 26°26'17.8"/ W: 82°6'26.3". The site-specific criteria apply as a spatial average for the estuary, as defined by WBID 2092F1.</p> <p>The center of Sanibel Slough East is located at N: 26°26'6.7"/ W: 82°3'18.6". The site-specific criteria apply as a spatial average for the estuary, as defined by WBID 2092F2.</p> |
| Map | Figure 1.1 shows the general location of Sanibel Slough and its watershed, and Figure 1.7 shows the land uses in the watershed. |
| Classification(s) | Class III Marine |
| Basin name (HUC 8) | Charlotte Harbor Basin (03100103) |

Table B-2. Description of the numeric interpretation of the narrative nutrient criterion

| Numeric Interpretation of Narrative Nutrient Criterion | Parameter Information Related to Numeric Interpretation of the Narrative Nutrient Criterion |
|---|--|
| <p>NNC summary: Default estuary classification (if applicable) and corresponding NNC</p> | <p>Sanibel Slough East and Sanibel Slough West are classified as Class III non-ENR estuaries, meaning that they are not expressly provided by name in Subsection 62-302.532(1), F.A.C., or delineated in the maps of the Florida ENRs incorporated by reference in Subsection 62-302.532(3), F.A.C., and therefore the narrative nutrient criterion applies. The interpretation of the narrative nutrient criterion for non-ENR estuaries is a chlorophyll <i>a</i> target of 11 µg/L, expressed as an AGM not to be exceeded more than once in any consecutive 3-year period.</p> |
| <p>Proposed TN, TP, chlorophyll <i>a</i>, and/or nitrate + nitrite concentrations (magnitude, duration, and frequency)</p> | <p>Numeric interpretations of the narrative nutrient criterion: This TMDL is adding chlorophyll <i>a</i>, TN, and TP criteria for Sanibel Slough East and West, as there are no generally applicable chlorophyll <i>a</i>, TN, or TP NNC for non-ENR estuaries.</p> <p>The NNC for chlorophyll <i>a</i> in Sanibel Slough West will be 11 µg/L expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. The NNC for chlorophyll <i>a</i> in Sanibel Slough East will be 21 µg/L expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period.</p> <p>The TN and TP NNC are expressed as 3-year average loads not to be exceeded. The Sanibel Slough West TN and TP loads are 1,903 and 241 kg/yr, respectively. The Sanibel Slough East TN and TP loads are 1,091 and 123 kg/yr, respectively.</p> <p>Nutrient concentrations are provided for comparative purposes only. The TN and TP reference concentrations for the West Basin are 1.60 and 0.06 mg/L, respectively, and for the East Basin, 1.00 and 0.04 mg/L, respectively.</p> |
| <p>Period of record used to develop numeric interpretations of the narrative nutrient criterion for TN and TP</p> | <p>The criteria were developed based on the application of a modified SCS curve CN and PLSM watershed model and the receiving water BATHTUB model that simulated hydrology and water quality conditions over the 2007–13 period. The primary datasets for this period include the water quality data from the IWR Database (Run 52). Rainfall data were obtained from two weather stations, the MesoWest station in the J.N. "Ding" Darling National Wildlife Refuge and the St. James station on Pine Island, Florida. Evapotranspiration data were based on data from the SFWMD, and stage data for 2007–13 were obtained from the City of Sanibel. Land use data used to establish watershed nutrient loads for the 2007–13 simulation period were obtained from the SFWMD 2008–09 land use layer. A complete description of the data used in the derivation of the proposed site-specific criteria is provided in Sections 2.3 and 3.1 of this TMDL report.</p> |
| <p>How the criteria developed are spatially and temporally representative of the waterbody or critical condition.</p> | <p>The model calibration for Sanibel Slough used all available data for the estuary from 2007 to 2013. The annual average rainfall for 2007 to 2013 ranged from 28.5 to 43.0 in/yr, and the median was 37.8 in/yr. The years 2007, 2009, and 2012 were dry, and 2008, 2011, and 2013 were wet. This time span captures the hydrologic variability of the Sanibel Slough system.</p> <p>In addition, model calibration for the Sanibel Slough West and Sanibel Slough East TMDLs was based on water quality data collected across the individual basins. Figure 2.1 shows the locations of the sampling stations in Sanibel Slough. Monitoring stations were found across the spatial extent, with three sites sampled in each basin, and represent the spatial distribution of nutrient dynamics in the estuary systems. Data were collected from the City of Sanibel (21FLSBL...) and DEP (21FLFTM...). Water quality data for variables relevant to TMDL development are available on request.</p> |

Table B-3. Summary of how designated use(s) are demonstrated to be protected by the criterion

| Designated Use Requirements | Information Related to Designated Use Requirements |
|---|--|
| <p>History of assessment of designated use support</p> | <p>DEP used the IWR Database to assess water quality impairments in the Sanibel River (WBID 2092F). The waterbody was verified as impaired for nutrients based on an elevated annual average TSI during the Cycle 1 verified period (the verified period for the Group 2 basins is January 1, 1996–June 30, 2003). At the time the Cycle 1 assessment was performed, WBID 2092F was classified as a high-color lake (color higher than 40 PCU), and the IWR methodology used the water quality variables TN, TP, and chlorophyll <i>a</i> in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. The TSI threshold (60 for high-color lakes) was exceeded in multiple years during the verified period and was sufficient to identify the waterbody as impaired for nutrients.</p> <p>During the Cycle 2 assessment, WBID 2092F was reclassified as a stream, and the IWR methodology used an annual average chlorophyll <i>a</i> threshold of 20 µg/L in interpreting Florida's narrative nutrient threshold. In the Cycle 2 verified period (January 2001–June 2008), annual mean chlorophyll <i>a</i> values exceeded the threshold of 20 µg/L in 2007, and the waterbody remained on the Verified List.</p> <p>The waterbody was again reclassified for the more recent Cycle 3 assessment and was assessed as an estuary because of long-term specific conductance and the plant community characterization. The IWR methodology used an AGM chlorophyll <i>a</i> threshold of 11 µg/L to assess the waterbody during the verified period (January 1, 2007–June 30, 2014). chlorophyll <i>a</i> values exceeded the threshold of 11 µg/L during every year of the verified period, and the waterbody remained on the Verified List. See Section 2.3 of this TMDL report for a detailed discussion.</p> |
| <p>Basis for use support</p> | <p>Water quality targets for the TMDLs were based on model simulations of natural background conditions, which are inherently protective of designated uses. The chlorophyll <i>a</i> target for Sanibel Slough West is 11 µg/L, and was determined to represent the chlorophyll <i>a</i> concentration that would sustain a low eutrophic condition and would not abate the natural condition while maintaining the natural condition's designated uses. The chlorophyll <i>a</i> target for Sanibel Slough East is 21 µg/L, and was determined to represent the chlorophyll <i>a</i> concentration that would not abate the natural condition while not being exceeded and maintaining the natural condition's designated uses.</p> <p>The TN and TP reference concentrations are for comparative purposes only, and they represent the estuary nutrient concentrations expected to achieve the respective chlorophyll <i>a</i> concentrations. The TN and TP reference concentrations for the West Basin are 1.60 and 0.06 mg/L, respectively, and for the East Basin, 1.00 and 0.04 mg/L, respectively.</p> |
| <p>Approach used to develop the criteria and how it protects uses.</p> | <p>For the Sanibel Slough nutrient TMDLs, DEP created loading-based criteria using a watershed loading model to simulate loading from the Sanibel Slough Watershed, and this information was fed into individual receiving water models (BATHTUB) for Sanibel Slough West and Sanibel Slough East. The maximum of the 3-year rolling averages of TN and TP loadings to achieve the chlorophyll <i>a</i> target in the West basin was determined by incrementally decreasing the TN and TP loads from anthropogenic sources into the slough until the chlorophyll <i>a</i> target was achieved. The maximum of the 3-year rolling averages of TN and TP loadings to achieve the chlorophyll <i>a</i> target in</p> |

| Designated Use Requirements | Information Related to Designated Use Requirements |
|--|---|
| | <p>the East basin was determined by the distribution of loads in the natural background condition. A more detailed description of the derivation of the TMDL and criteria are provided in Section 2.4 of this TMDL report.</p> |
| <p>How the TMDL analysis will ensure that nutrient-related parameters are attained to demonstrate that the TMDLs will not negatively impact other water quality criteria.</p> | <p>DEP notes that there is a DO impairment for Sanibel Slough East and West and will be working to ascertain whether the current standard is appropriate or whether site-specific criteria will need to be developed. The system is impaired for DO based on current assessments applying the DO percent saturation standard of 42 %, and analyses showed no significant relationship between nutrients and DO.</p> <p>Because of the nature of the slough system, the existing DO criterion for the system may not be achievable. It is likely that the lower DO in this system is a result of physical alteration and therefore is not being directly addressed in this TMDL analysis. Reducing nutrient loads entering the waterbody will likely have some positive effect on DO levels while not negatively impacting other water quality parameters for the estuary.</p> |

Table B-4. Documentation of the means to attain and maintain water quality standards for downstream waters

| Downstream Waters Protection and Monitoring Requirements | Information Related to Downstream Waters Protection and Monitoring Requirements |
|---|---|
| <p>Identification of downstream waters: List receiving waters and identify technical justification for concluding downstream waters are protected.</p> | <p>Sanibel Slough West has a weir control structure at Sanibel-Captiva Road on the northern side of the island that discharges into Tarpon Bay, which eventually flows into San Carlos Bay. Sanibel Slough East has a weir control structure, located at Beach Road on the eastern side of the island, which drains to a system of canals that eventually flows into San Carlos Bay.</p> <p>San Carlos Bay (including Tarpon Bay, WBID 2065H1) is a Class II estuary that has estuary-specific numeric interpretations of the NNC for chlorophyll <i>a</i>, TN, and TP. Based on the most recent assessment, completed on April 27, 2016, for the Group 2 basins, San Carlos Bay is not impaired for nutrients. As evidenced by the healthy existing condition in San Carlos Bay, the existing loads from Sanibel Slough to San Carlos Bay have not led to an impairment of the downstream water. Therefore, the reductions in nutrient loads prescribed in the TMDL are not expected to cause nutrient impairments downstream. See Section 2.6 of this TMDL report.</p> |
| <p>Summary of existing monitoring and assessment related to the implementation of Subsection 62-302.531(4), F.A.C., and trends tests in Chapter 62-303, F.A.C.</p> | <p>The City of Sanibel and DEP conduct routine monitoring of Sanibel Slough. The data collected through these monitoring activities will be used to evaluate the effect of BMPs implemented in the watershed on estuary TN and TP loads in subsequent water quality assessment cycles.</p> |

Table B-5. Documentation to demonstrate administrative requirements are met

| Administrative Requirements | Information for Administrative Requirements |
|--|---|
| <p>Notice and comment notifications</p> | <p>DEP published a Notice of Development of Rulemaking on January 17, 2017, to initiate TMDL development for impaired waters in the Charlotte Harbor Basin. DEP held 2 rule development public workshops for the TMDLs in Sanibel, Florida. The first public workshop was held on February 17, 2017, to present the draft Sanibel TMDL to local stakeholders. Public comments were received for the TMDLs afterwards. The second public workshop was held on June 6, 2017, to present Sanibel TMDL revisions based on public comments to the local stakeholders. Another 30-day public comment period was provided to the stakeholders. DEP has prepared a responsiveness summary for these comments.</p> |
| <p>Hearing requirements and adoption format used; responsiveness summary</p> | <p>Following the publication of the Notice of Proposed Rule, DEP will provide a 21-day challenge period and a public hearing that will be noticed no less than 45 days prior.</p> |
| <p>Official submittal to EPA for review and General Counsel certification</p> | <p>If DEP does not receive a rule challenge, the certification package for the rule will be prepared by the DEP program attorney. DEP will prepare the TMDLs and submittal package for the TMDLs to be considered a site-specific interpretation of the narrative nutrient criterion, and submit these documents to the EPA.</p> |

Appendix C: Important Links

Cover page:

DEP website: <http://www.dep.state.fl.us>

Acknowledgments:

Email address, Sara Davis: sara.c.davis@dep.state.fl.us

Email address, Pamela Flores: pamela.flores@dep.state.fl.us

Websites:

DEP TMDL Program: <http://www.dep.state.fl.us/water/tmdl/index.htm>

DEP IWR: <http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf>

DEP Florida STORET Program: <http://www.dep.state.fl.us/water/storet/index.htm>

DEP 2016 Integrated Report: <http://www.dep.state.fl.us/water/docs/2016-Integrated-Report.pdf>

DEP Criteria for Surface Water Quality Classifications:

<http://www.dep.state.fl.us/legal/Rules/shared/62-302/62-302.pdf>

Florida Surface Water Quality Standards:

<https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-302>

DEP BMAPs: <http://www.dep.state.fl.us/water/watersheds/bmap.htm>

EPA Region 4, TMDLs in Florida:

<https://archive.epa.gov/pesticides/region4/water/tmdl/web/html/index-2.html>

EPA National STORET Program: <https://www.epa.gov/waterdata/storage-and-retrieval-and-water-quality-exchange>

Chapter 5:

BMAPs: <http://www.dep.state.fl.us/water/watersheds/bmap.htm>

References:

J.N. "Ding" Darling National Wildlife Refuge:

https://www.fws.gov/refuge/JN_Ding_Darling/about.html

U.S. Census Bureau: <https://www.census.gov/>