Focus Assessment Report: Taylor Creek/Nubbin Slough Subwatershed S-191 Basin

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This assessment was originally drafted in November of 2021 and primarily completed by April of 2022 which is why the data reviewed were only through Water Year (WY) 2021 as those were the latest data available at that time. The delay in releasing this document was due in part to the additional review and required formatting as it was the initial focus assessment completed. This foreword provides a brief review of the WY2022 data and potential impacts, if any, on the recommendations from the report. It also addresses comments received by the Coordinating Agencies in February of 2023 and a revision to SFWMD flow data.

- The S-191 Basin 5-year average loads and flows for the period of WY2018-WY2022 are 56.7 t for TP, 178.1 t for TN, and 74,600 ac-ft of flow (Draft Chapter 8B 2023 South Florida Environmental Report (SFER)).
- The Basin and Taylor Creek/Nubbin Slough (TCNS) planning targets were revised based on comments from the Coordinating Agencies to be 13.6 t /yr and 19.9 t/yr, respectively. The methodology to develop the targets was the same as described in the report below but are now based on the same timeframe as the targets presented in the 2020 BMAP.
- The 5-year average TP load of 56.7 t is 43.1 t above the revised planning target of 13.6 t/yr for the S-191 Basin which is closer to the target than the WY2017-WY2021 TP load, even accounting for the revised target. One reason for the lower loads for the more recent period could be that the flows from that period were also lower.
- The amount of reduction from recently completed and planned projects, (24.8 t/yr reduction over the long-term) remained the same as did the timeline for the possible achievement (2030).

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[2] The authors acknowledge Jeff Iudicello, Danielle Taylor, Trish Burke, Kathy Pietro, Jesse Markle, Jun Han Megan Jacoby, Christian Avila, Jon Madden, Susan Mason and the Coordinating Agency Technical Team for providing valuable comments and suggestions to this document.

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- Of the five upstream monitoring sites highlighted due to increasing trends, all had lower concentrations in WY 2022 but most remained relatively high (i.e. two > 1,000 µg/L; two > 400 µg/L). The exception was OT34353513 which had a relatively low TP concentration average of 52 µg/L. The recommendations for the sites with the relatively high concentrations remain the same. The recommendation for OT34353513 would be to continue to monitor and, if the concentrations remain low, try to determine the cause(s) of the reductions to see if those conditions might be replicated in other areas with high concentrations.
- In January of 2023, SFWMD revised the flow data at the S385 weir based on new weir flow coefficients. This reduced the flows by 35% which means that the water availability analysis discussion on Nubbin Slough may be overestimating the flows.
- All other recommendations in the report remain the same.

EXECUTIVE SUMMARY

This is an assessment of the S-191 Basin, an area identified as a priority for water quality improvement due to its consistently high total phosphorus (TP) loads, unit area loads (UALs), and TP concentrations. The S-191 Basin discharges to Lake Okeechobee, which is impaired for nutrients. In 2001, the Florida Department of Environmental Protection (FDEP) established a Total Maximum Daily Loads (TMDL) for Lake Okeechobee and allocated a target of 105 metric tons (t) (excluding atmospheric deposition) for TP based on a 5-year moving average. As of 2022, no TDML has been established by FDEP for Total Nitrogen (TN) for Lake Okeechobee. An additional 26 t to 31.2 t TP reduction per year is needed for this basin to achieve the planning target loading of 12.3 t TP per year based on a 5-year moving average.

BASIN CONDITIONS

- The S-191 Basin 5-year average loads and flows for the period of WY2017-WY2021 are 68.3 t for TP, 211.4 t for TN, and 88,000 ac-ft of flow (Zhang et al., 2022).

- To meet its proportional loading share of the Lake Okeechobee TP TMDL of 105 t, the S-191 Basin must only contribute 12.3 t /yr TP to the lake based on a 5-year moving average. The planning target was developed in consultation with FDEP using a method similar to the one used in the 2020 Basin Management Action Plan (BMAP) which used a proportional load to develop targets for areas within the Lake Okeechobee Watershed (LOW) based on a 5-year period. The S-191 Basin planning target was based on the proportion of load contributed by the basin during the 5-year period from WY2016-WY2020.

- Recently completed and newly planned projects with reduction estimates are expected to achieve a 24.8 t/yr TP load reduction over the long-term and may be achieved by 2030, assuming projects are completed as scheduled and long-term average annual reductions can be achieved within five years of operation of the projects.

- An additional 26 t to 31.2 t TP reduction per year is needed for this basin to achieve the planning target loading of 12.3 t TP per year on a 5-year moving average. This is based on a review of the TP loading data from S-191 structure for the two most recent 5-year periods, assuming that all projects operating for five years have realized their TP reductions, and accounting for reductions from recently completed and planned projects where TP load reduction estimates were available.
- Flow at the S-191 structure averaged 82,514 ac-ft/yr during the evaluation period of 2012 to 2021. No flow was observed approximately 65% of the time and the maximum observed flow rate was nearly

5,000 cfs. Five other flow monitoring stations upstream of the S-191 structure had similar "flashy" conditions, meaning that the stations received a high amount of flow in short duration. It is a challenge to plan water quality treatment projects to address these types of conditions as projects will likely be dormant for portions of the year and have periods of dry out when no water is available.

FACTORS CONTRIBUTING TO WATER QUALITY ISSUES

- Based on the amount of Ortho-P (soluble phosphorus) and total suspended solids (TSS) at the S-191 structure, the primary concern appears to be soluble phosphorus. However, a review of field notes from the five upstream sites with increasing trends indicates there are areas within the watershed where particulates can also be a factor.

- Statistically significant increasing trends in TP concentrations were observed at five upstream monitoring sites in the S-191 Basin (TCNS 214, TCNS 220 TCNS 209, LB29353513, and OT34353513). Initial analyses of these sites revealed the insights provided below but additional investigations are needed to determine the exact cause of the increasing concentrations:
    - Dairies are located upstream of four of these five monitoring sites. An initial review of data provided by FDEP indicates groundwater nutrient concentrations reported at the dairy compliance monitoring wells are above the nutrient concentrations observed at the background monitoring wells.
    - The contributing areas for all five sites include land designated as agriculture that is not enrolled in the Florida Department of Agriculture and Consumer Services (FDACS) Best Management Practices (BMP) program. If FDACS determines that those areas are enrollable agricultural lands, the landowners need to be notified of the requirement to implement BMPs or conduct monitoring under Chapter 40E-61, Florida Administrative Code (F.A.C.).
    - The load from the contributing areas at two of the sites has been estimated from monitoring data (TCNS 214 = TP 14 t/yr and TN 44 t/yr; TCNS 209 = TP 2 t/yr and 11 t/yr TN). However, the extent of loads at the upstream sites that ultimately discharge at the S-191 structure to Lake Okeechobee is not known.

AGENCY COMMITMENTS

To assist with achieving the additional 26 to 31.2 t TP reduction needed for the S-191 Basin, the Coordinating Agencies (FDEP, FDACS, and South Florida Water Management District or SFWMD) have committed to the following:

- FDEP will investigate groundwater limits and spray-field discharges related to dairy permitting and work to verify compliance with dairy permits for the areas within the S-191 Basin where there have been increasing trends.
- FDACS will continue BMP enrollment and implementation verification efforts for this basin.
- SFWMD will:
    - Work to develop a new project on Agricultural Ditch (TCNS 214) where there has been increasing trends.
    - Implement an Innovative Technology Project upstream of the S-191 structure (may be a short-term project).
    - Implement the planned Brady Ranch and Grassy Island Flow Equalization Basin (FEB) and Aquifer Storage and Recovery (ASR) projects.
    - Continue to identify and investigate sites with increasing trends with the other Coordinating Agencies.

  - Develop a remote-sensing tool that uses satellite images to evaluate nutrients in the watershed.

- Together the Coordinating Agencies will develop a rapid assessment process to notify and share information when unusual events (e.g., atypically high sample values such as above the 95th percentile or field staff observation of an uncommon occurrence) occur in an effort to be more proactive in managing specific water quality issues.

PROJECT RECOMMENDATIONS

- All project operational considerations:
  - Operations for existing and planned projects should be evaluated basin-wide for comprehensive management and to ensure that they are coordinated, synchronized, and operated synergistically for maximum nutrient reduction and storage.
  - Ensure all project inflow pumps are automated and can start quickly when brief high flow events occur to limit response lag and minimize flow bypass
  - Operate planned FEB and ASR projects to moderate high intensity flow events by reserving storage capacity and increasing baseflow
- Existing projects:
  - Develop passive storage or wetland restoration projects upstream of Nubbin Slough Stormwater Treatment Area (STA) to assist in reducing peak flows and providing steady flow to the STA
  - Continue enhancements of STAs and optimization of Hybrid Wetland Treatment Technology (HWTT) projects and make any necessary repairs to ensure full project utilization and maximum nutrient reductions. Specific recommendations include automating all STA structures at both the Taylor Creek and Nubbin Slough STAs to allow for a quicker response to operational changes to enhance performance and resizing the Nubbin Slough STA inflow pump to ensure steady operation.
- New projects
  - Pursue additional nutrient reduction at the TCNS 214 Dispersed Storage and Treatment Project.
  - Pursue an additional nutrient reduction project on Mosquito Creek.
  - Pursue onsite detention opportunities along Wolff Creek on SFWMD owned lands.
  - Consider additional passive stormwater detention projects and wetland restoration basin-wide to assist with decreasing peak flow events and providing steady flows throughout the basin.
  - Increase, if possible, nutrient reductions and storage of projects currently undergoing design.

ACTIONS NEEDED BY THE COORDINATING AGENCIES

- Conduct a reevaluation of the BMPs employed within the contributing areas of the five upstream sites with increasing trends. Additionally, BMPs implemented in S-191 should be optimized to minimize nutrient inputs to reduce soluble phosphorus (P) and nutrients stored in the soils (legacy P).

- The FDEP dairy wastewater permitting program should be reviewed to determine if additional BMP requirements or cost share projects are needed to prevent high nutrient concentrations in groundwater and spray-field effluent. And perhaps the requirements for dairy wastewater treatment pond closure should also be reviewed.
- Dairy source control program boundaries need to be clearly delineated so that FDACS and FDEP have a clear understanding of their BMP implementation verification inspection responsibilities.
- Landowners of any applicable unenrolled lands within the contributing areas of the five upstream sites with increasing trends should be notified of the requirement to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Continue investigations into the five upstream monitoring sites with increasing TP concentration trends (TCNS 214, TCNS 220, TCNS 209, OT34353513, and LB29353513) to determine the potential causes and develop actions to reverse the trends.
- SFWMD to notify FDEP of the septic tank clusters located within the contributing areas for TCNS 214 and TCNS 220 and adjacent to LB29353513. FDEP will review these septic tank clusters which may be addressed under future plan requirements under the Clean Waterways Act.

Research needs are also presented in the report in the Research and Technology Needs Section and in **Appendix A1.**

INTRODUCTION

BACKGROUND

The Northern Everglades and Estuaries Protection Program (NEEPP; Section 373.4595, Florida Statutes) directs the SFWMD in cooperation with FDEP and FDACS, collectively referred to as the Coordinating Agencies, and local entities, to complete a watershed protection plan (WPP) for LOW. In 2020, SFWMD began the process of reviewing all the Northern Everglades WPPs annually and committed at the February 11, 2021, SFWMD Governing Board meeting to complete basin-specific assessments in areas identified to be the highest priority for action as part of the watershed protection planning process. The purpose of the assessments is to gather information to pinpoint the most significant nutrient sources contributing to the water quality problems, determine what remains to be done to improve water quality, and recommend strategic actions for future planning. Information from the assessments will be used to update the WPPs and to inform future FDEP Lake Okeechobee Basin Management Action Plan (BMAP) updates. This report documents the assessment completed for the S-191 Focus Area Basin which is in the TCNS Subwatershed. Items considered as part of this assessment and the location of the discussion of those items are detailed in **Appendix A2**.

SELECTION OF THE S-191 BASIN

SFWMD began the assessment process in WY2020 (May 1, 2019–April 30, 2020) by determining which areas of the LOW to focus on first. The LOW is quite large consisting of 3,450,475 acres and it is divided into nine subwatersheds which are further divided into basins (**Figure 1**). In summer 2020, a SFWMD team of subject matter experts reviewed water quality data available through WY2019 and other technical information to determine the watershed focus areas. The team consisted of scientists and engineers with expertise in water quality monitoring and data analysis, nutrient treatment technologies, STAs, lake and estuarine ecology, and the Northern Everglades landscape. The team recommended reviewing the Taylor Creek/Nubbin Slough (TCNS) subwatershed because it had consistently high total phosphorus (TP)

unit area loads (UALs) and some of the highest TP loads relative to other subwatersheds for the 5-year periods beginning WY2012-WY2016 up to WY2015-WY2019. **Table 1** presents the LOW 5-year average data for WY2015-WY2019 that the team reviewed.

The TCNS subwatershed is divided into five basins (**Figure 2**) and the team reviewed TP UALs, flow weighted mean concentrations (FWMCs), TP load contributions and statistical trends. The S-191 Basin had the highest TP load (**Table 2**), had the second highest UAL, and it had statistically significant increasing trends in TP FWMC as determined by the analysis completed by FDEP in the 2020 Lake Okeechobee BMAP update (FDEP 2020). It was also largest contributor of load to TCNS from the period of WY2005 to WY2018 (**Figure 3**). The S-191 Basin was also identified as a priority 1 Targeted Restoration Areas (TRAs) for TP and TN as defined by FDEP in the 2020 Lake Okeechobee BMAP update (FDEP, 2020). Thus, the team recommended considering S-191 as a focus area. To provide transparent and collaborative opportunities, public workshops were held between June and September 2020 to facilitate public participation in the process of identifying focus areas, potential projects, and additional programs needed to improve water quantity, quality, timing, and distribution. As a result, S-191 Basin within the TCNS subwatershed was selected as a focus area in the LOW.

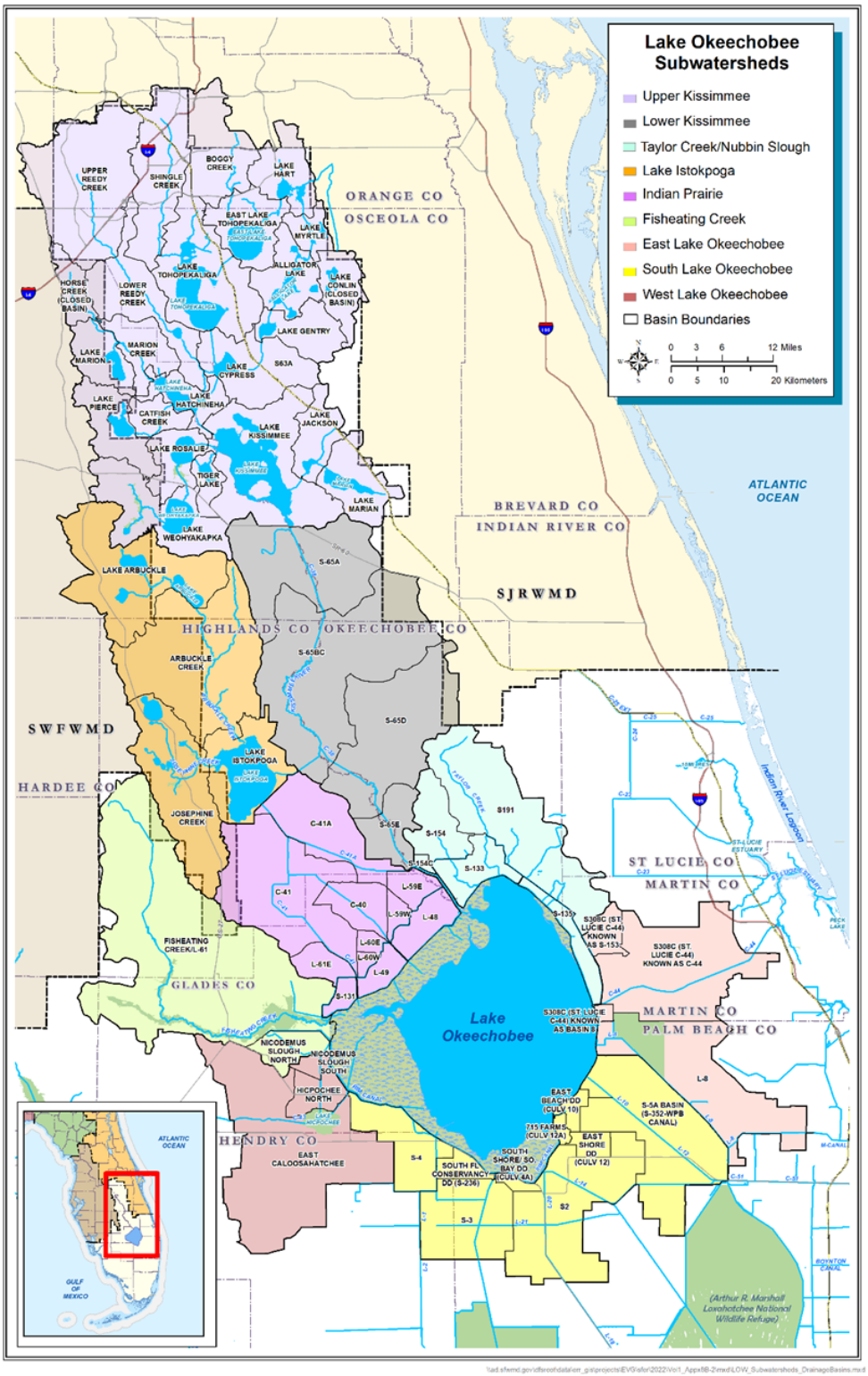

Figure 1. Subwatersheds and Basins within the LOW.

Table 1. LOW 5-year average TP data (WY2015-WY2019).

Subwatershed	TP UAL (lb/ac)	TP FWMC (µg/L)	TP Load (t)	Discharge (ac-ft)	Area (ac)
Taylor Creek/Nubbin Slough	1.17	477	104.7	178,000	197,795
Indian Prairie	0.7	223	87.3	317,000	276,577
Lower Kissimmee	0.64	229	124.7	441,000	429,188
Fisheating Creek	0.44	175	63.6	295,000	318,042
Lake Istokpoga	0.27	97	47.7	400,000	394,203
Upper Kissimmee	0.2	78	93.4	976,000	1,028,421
South Lake Okeechobee	0.16	279	26.8	77,700	363,141
East Lake Okeechobee	0.15	191	16.7	71,100	239,013
West Lake Okeechobee	0	168	0	36	204,094

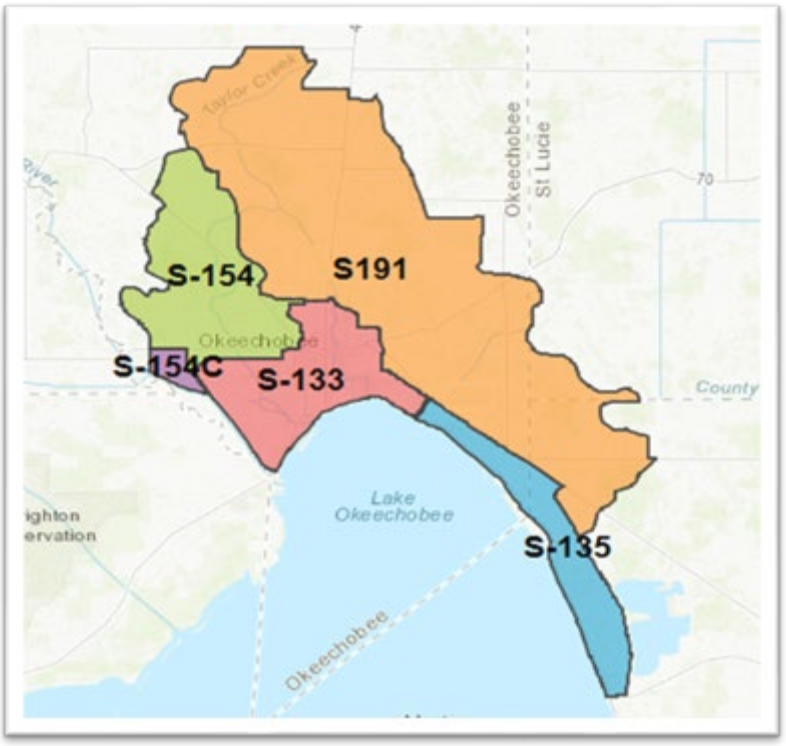

Figure 2. The Five Basins within the Taylor Creek/Nubbin Slough Subwatershed.

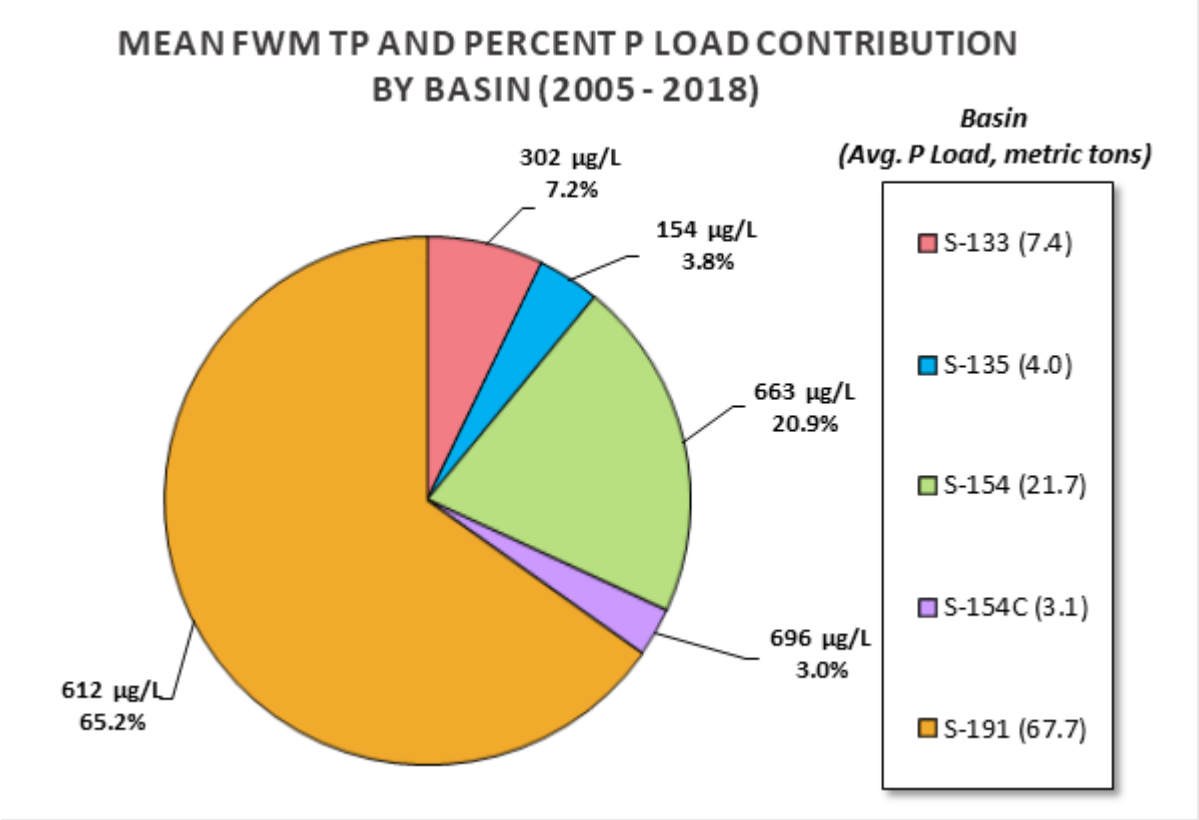

Figure 3. Percent contribution of TP load from the basins within Taylor Creek/Nubbin Slough Subwatershed for the period WY2005-WY2018.

Table 2. 5-year averages for WY2015-WY2019 for the 5 basins comprising the Taylor Creek/Nubbin Slough Subwatershed, including the S-191 Basin.

Taylor Creek/Nubbin Slough	TP UAL (lb/ac)	TP FWMC (µg/L)	TP Load (t)	Discharge (ac-ft)	Area (ac)
S-154C Basin	2.71	711	2.6	2,990	2,134
S-191 Basin	1.28	627	69.7	90,100	120,464
S-154 Basin	1.22	580	17.6	24,700	31,815
S-133 Basin	0.75	243	8.7	29,000	25,626
S-135 Basin	0.75	157	6.1	31,300	17,756
Subwatershed Total	**1.17**	**477**	**104.7**	**178,000**	**197,795**

NUTRIENT AND STORAGE TARGETS FOR THE S-191 BASIN

The S-191 Basin was identified as a TRA 1 for TP in the BMAP (FDEP, 2020). The TP reduction planning targets for the TCNS subwatershed and the S-191 Basin were developed in consultation with FDEP (S. Davis, personal communication, March 17, 2021) and are based on the proportion of load contributed by the subwatershed or basin during the 5-year period from WY2016–WY2020 (**Table 3**) and the TMDL. The TP planning target load for the TCNS subwatershed is 18.5 t/yr and the planning target load for S-191 basin is 12.3 t/yr based on a 5-year moving average. The purpose of the planning targets is

to allow an assessment of existing and proposed programs and projects against the planning targets to determine where adjustments are needed.

The TMDL for Lake Okeechobee does not address nitrogen, although it is a concern for the downstream Caloosahatchee and St. Lucie Rivers. While there are no nitrogen planning targets for the S-191 basin, the Lake Okeechobee BMAP (FDEP, 2020) identified where nitrogen could be reduced through projects and programs and evaluated the TN concentrations against the benchmark of the numeric nutrient criteria (1,540 µg/L for TN) to determine the TRA priority. The S-191 Basin was given a TRA priority 1 for TN.

There are no storage targets specifically set for the S-191 Basin. The Phase II Technical Plan for the Lake Okeechobee Watershed Construction project was required by the NEEPP statute to design projects and identify additional measures needed to improve water quality and quantity, and it identified a storage target range for the LOW to be 900,000 to 1,300,000 ac-ft/yr (SFWMD et al., 2008) but no specific targets were provided at the basin level. In 2015, an independent technical review completed by the University of Florida Water Institute recommended conducting a strategic planning exercise to provide for additional water storage and treatment north of Lake Okeechobee (University of Florida, 2015). The 2020 BMAP (FDEP, 2020) and Lake Okeechobee WPP (Betts, et al. 2020) considered flow to potentially be an issue for the S-191 Basin, so it was given a TRA priority 2 for flow but no specific planning targets in terms of storage have been determined. The development of storage goals throughout the LOW is needed in order to determine a storage target for the S-191 Basin.

Table 3. Load and TP planning reduction targets for WY2016-WY2020 for S-191, within the Taylor Creek/Nubbin Slough Subwatershed.

Subwatershed/Basin	WY2016–WY2020 TP Load (t/yr)	% Contribution of Load	TP Load Required Reduction (t/yr)	TP Target (t/yr)
Taylor Creek/Nubbin Slough	95.1	17.6	76.6	18.5
• S-191	63.1	11.7	50.8	12.3
Total Load to Lake from all 9 Subwatersheds[a]	540.3	100	435.30	105.0

[a] Does not include atmospheric deposition.

BASIN FEATURES

The S-191 Basin covers 120,464 acres on the northeast side of Lake Okeechobee (**Figure 1**) in the TCNS Subwatershed. It is primarily located in Okeechobee County, but also includes a small portion of St. Lucie and Martin Counties.

HYDROLOGY

Historically, the S-191 Basin was hydrologically distinct from the other basins within the TCNS subwatershed, as it neither flowed into nor received water from any of the other TCNS basins. Currently, the Lakeside Ranch STA allows treated water from S-191 Basin to flow into the S-135 Basin. With the recent completion of the S-191A pump station in August 2021, water from the S-135 basin can now be pumped into the S-191 Basin.

Little Bimini Creek, Otter Creek and Taylor Creek headwaters are all located in the northern region of the S-191 Basin. Little Bimini Creek and Otter Creek flow into Taylor Creek (**Figure 4**). Water from those tributaries can then flow to the Taylor Creek STA. Agricultural Ditch drains the eastern portion of the northern region and then flows into Taylor Creek. Wolff Creek drains the northwestern region of S-191,

then also flows into Taylor Creek. At this convergence, the conveyance becomes the L63N Canal near the S-192 Structure (**Figure 4 inset**). The S-192 Structure, located at the boundary between S-191 and S-133 basins, is normally closed. It is only opened for maintenance purpose when it is necessary to divert flow away from L-63N. . The L-63 N Canal continues to flow south and east towards the S-191 Structure. Mosquito Creek drains the central portion of the basin and flows into the L-63N Canal. The L-63N Canal flows to the C-59 Canal which discharges through the S-191 structure into Lake Okeechobee. In the southeastern portion of the basin there are 3 tributaries which each flow to the L-63S Canal: Nubbin Slough, Henry Creek and Lettuce Creek. The Nubbin Slough STA treats water from Nubbin Slough and then discharges treated water back into Nubbin Slough downstream. Southeast of Lettuce Creek the L-63S Canal becomes the L-64 Canal. Normally water in L-64 flows north to L-63S. Rarely, water in the L-64 Canal can flow south through the L65C culvert into the L-65 Canal in the S-153 Basin and eventually into the C-44 Canal which can flow into Lake Okeechobee or the St. Lucie River. However, L65C is normally closed. The L-63S Canal historically flowed northwest to the C-59 Canal and through the S-191 Structure into the lake. However, with the establishment of the Lakeside Ranch STA in 2013, water in L-63 S can flow into the Lakeside Ranch STA and discharge into the L-47 Rim Canal. Historically, water from the L-47 Rim Canal entered Lake Okeechobee via the S-135 pump station or via G36 boat lock. With the completion of the S-191A pump structure in August of 2021, SFWMD gained the flexibility to either discharge water from the L-47 Rim canal via the S-135 pump station or pump it back into the S-191 Basin where it can either be discharged through the S-191 Structure or recirculated back into the Lakeside Ranch STA via C-59 and L-63S canals.

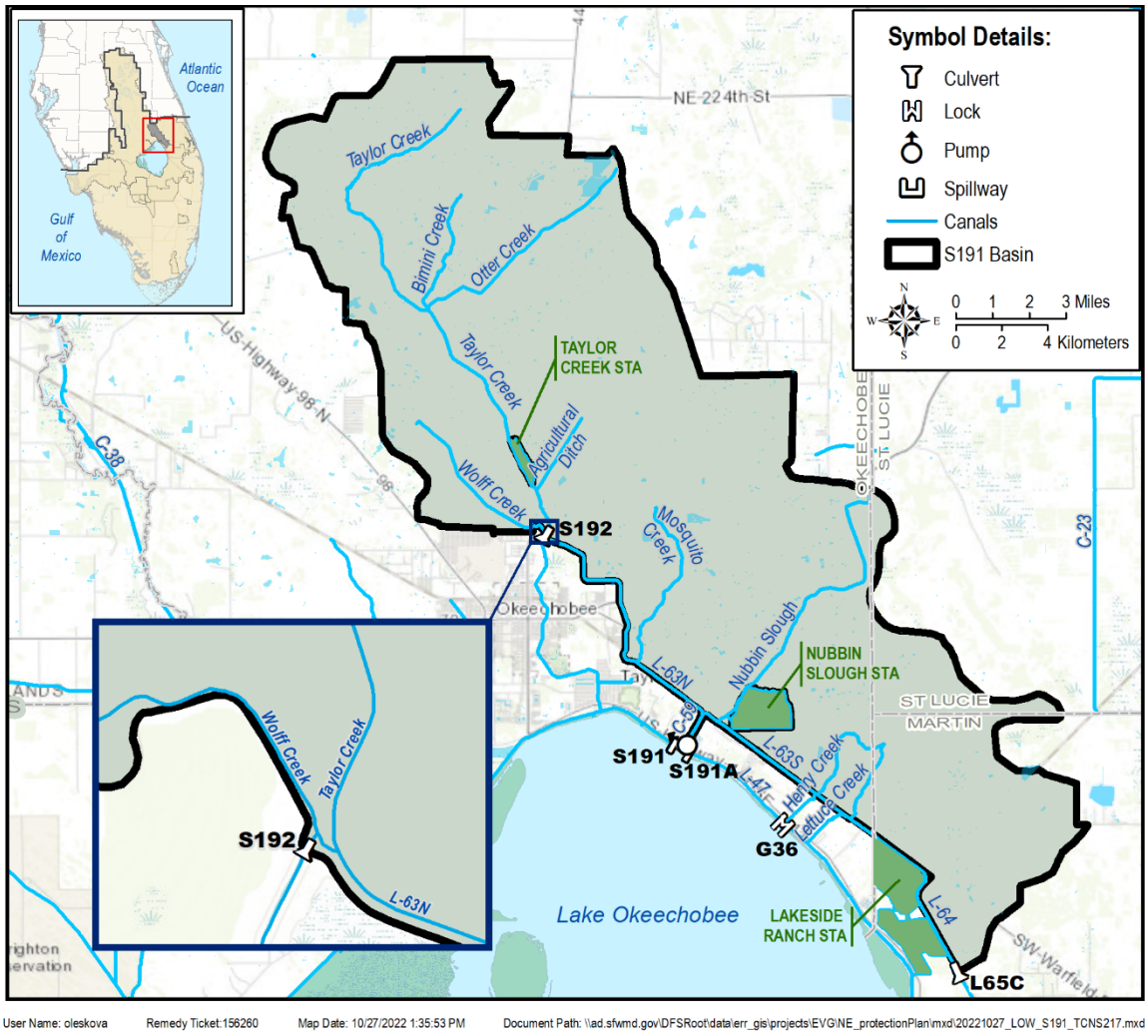

Figure 4. Hydrology of the S-191 Basin.

SOILS AND TOPOGRAPHY

According to the Soil Survey Geographic Database (SSURGO) provided by USDA NRCS in 2020, there are two major soil series found in the S-191 Basin (**Figure 5**), the Immokalee series (28.7% of basin) and the Myakka series (27.2% of basin). **Figure 5** only shows the top 90% of soils in the S-191 basin. A full list of soil series in the basin can be found in **Appendix A3** of this document. Both soil series are deep and, poorly drained soils that are rapidly permeable in the A and E horizons and moderately rapid in the Bh horizon. Both have a seasonal high water-table at a depth of 6 to 18 inches from June through September and during the remainder of the year, it is typically at a depth of 18 to 40 inches (Lewis et al, 2003).

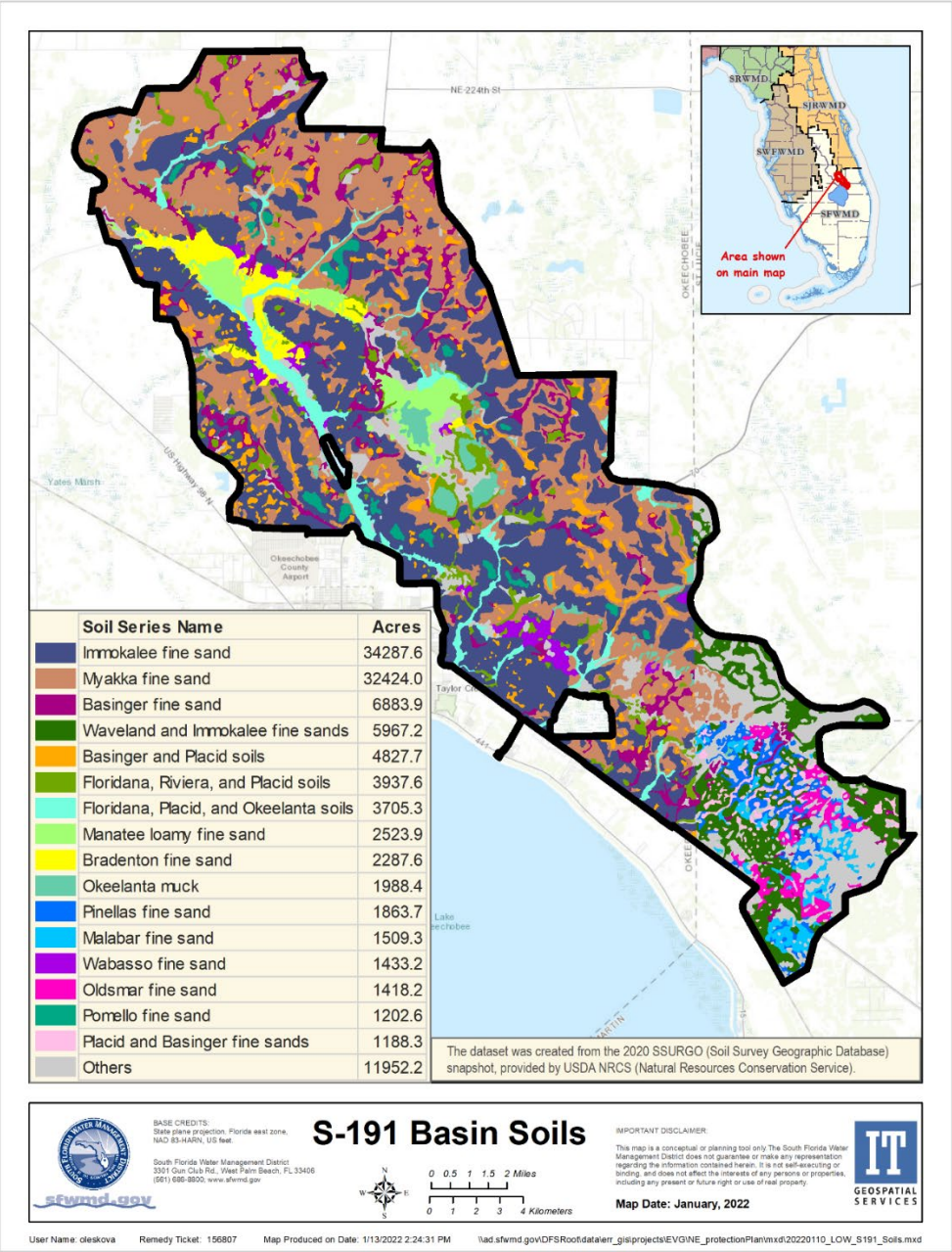

Figure 5. Most common soils found in the S-191 Basin (NRCS USDA, 2020).

The TCNS subwatershed, including the S-191 Basin, contains relatively flat terrain. The lowest elevation is around 26 feet NAVD 88 and the highest elevation is around 66 feet NAVD 88 (**Figure 6**). The northern portion of the basin is relatively higher in elevation compared to the area in the south near the lake.

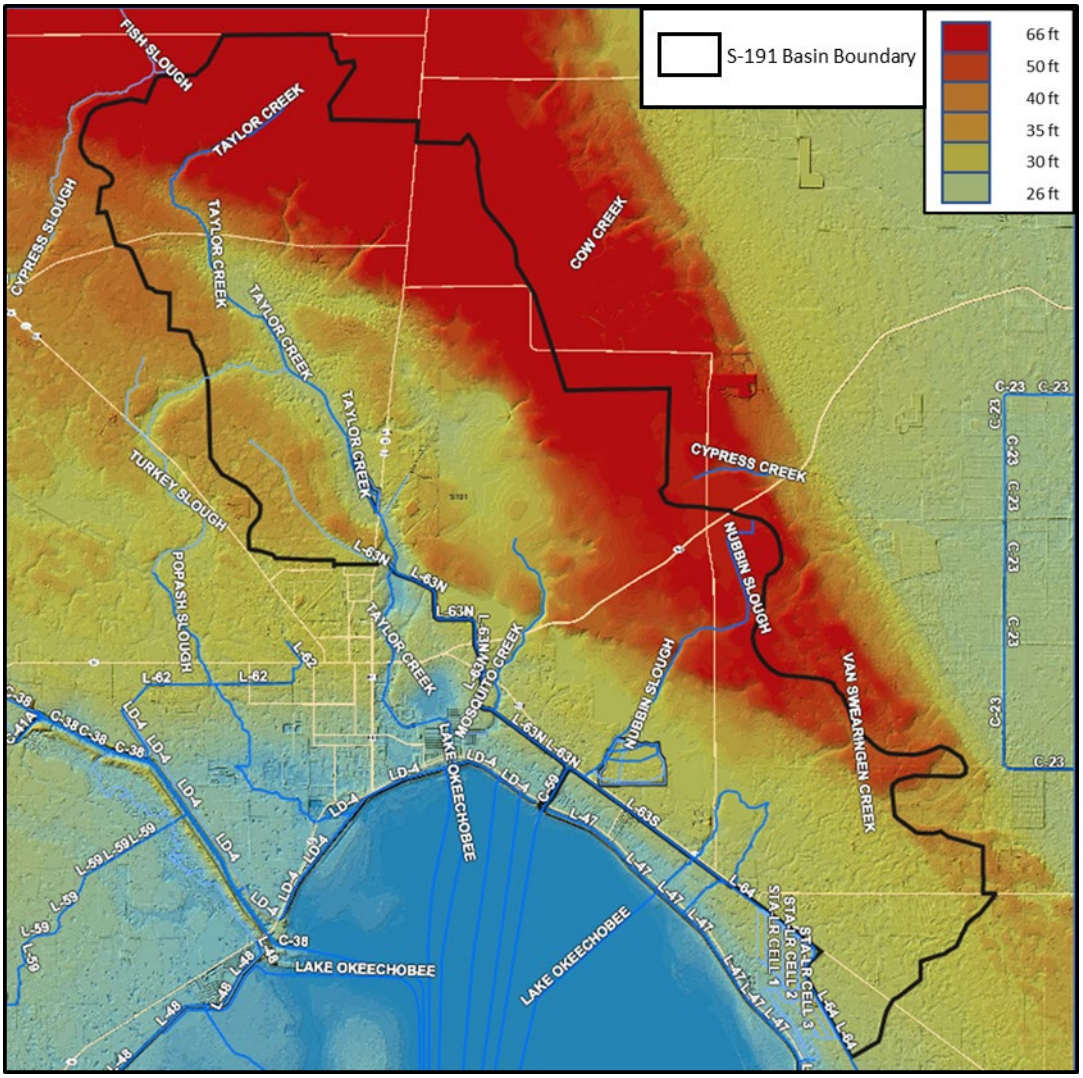

Figure 6. NAVD88 ground surface elevation of the S-191 Basin.

LAND USES

The land use within the S-191 Basin is primarily agriculture with some urban and natural areas (**Figure 7**). The agricultural land use has appeared to increase since 1995 by about 10% while the natural areas have decreased by about 8% (**Table 4**). The non-agricultural areas (residential, utilities, etc.) appeared to have fluctuated slightly since 1995. It is not certain if the changes are a result of reclassification of certain land areas from one study to the next or actual decrease in the amount of non-agricultural lands.

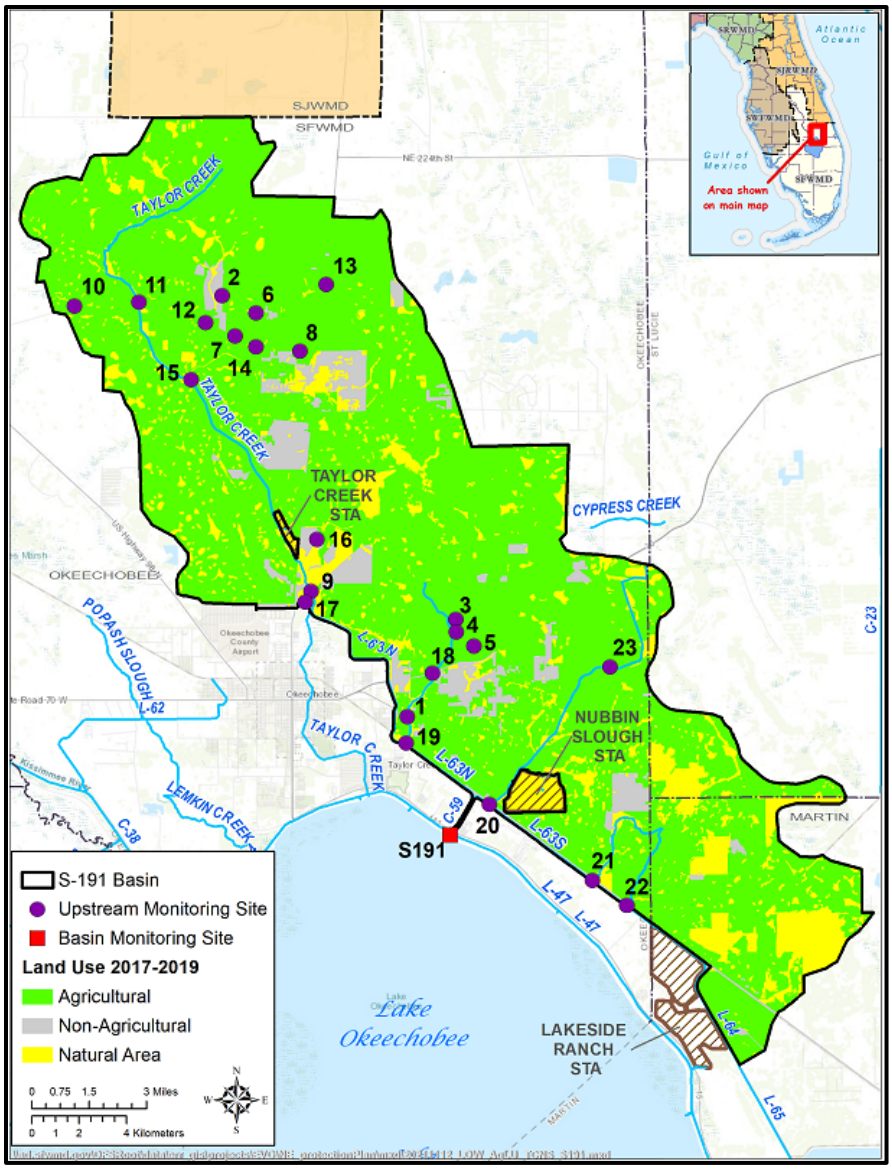

Figure 7. Land use (2017-2019) within the S-191 Basin with basin (red squares) and upstream (purple circles) monitoring sites.

Table 4. Percent land use in the S-191 Basin.

Land Use	1995	2008	2014	2017-2019
Agriculture	70%	78%	77%	80%
Natural	22%	14%	13%	14%
Non-agricultural	8%	8%	10%	6%

PUBLIC LAND OWNERSHIP

The majority of land within the S-191 Basin is privately owned but there are areas of state-owned land (**Figure 8**). These areas are owned by either the SFWMD or the Board of Trustees of the Internal Improvement Fund of the State of Florida (TIITF). The properties owned by SFWMD are located west of the Taylor Creek STA, north of the Nubbin Slough STA, and in the southwestern portion of the basin. The property owned by TIITF is east of the Taylor Creek STA and on the northeast side of the basin along the boundary.

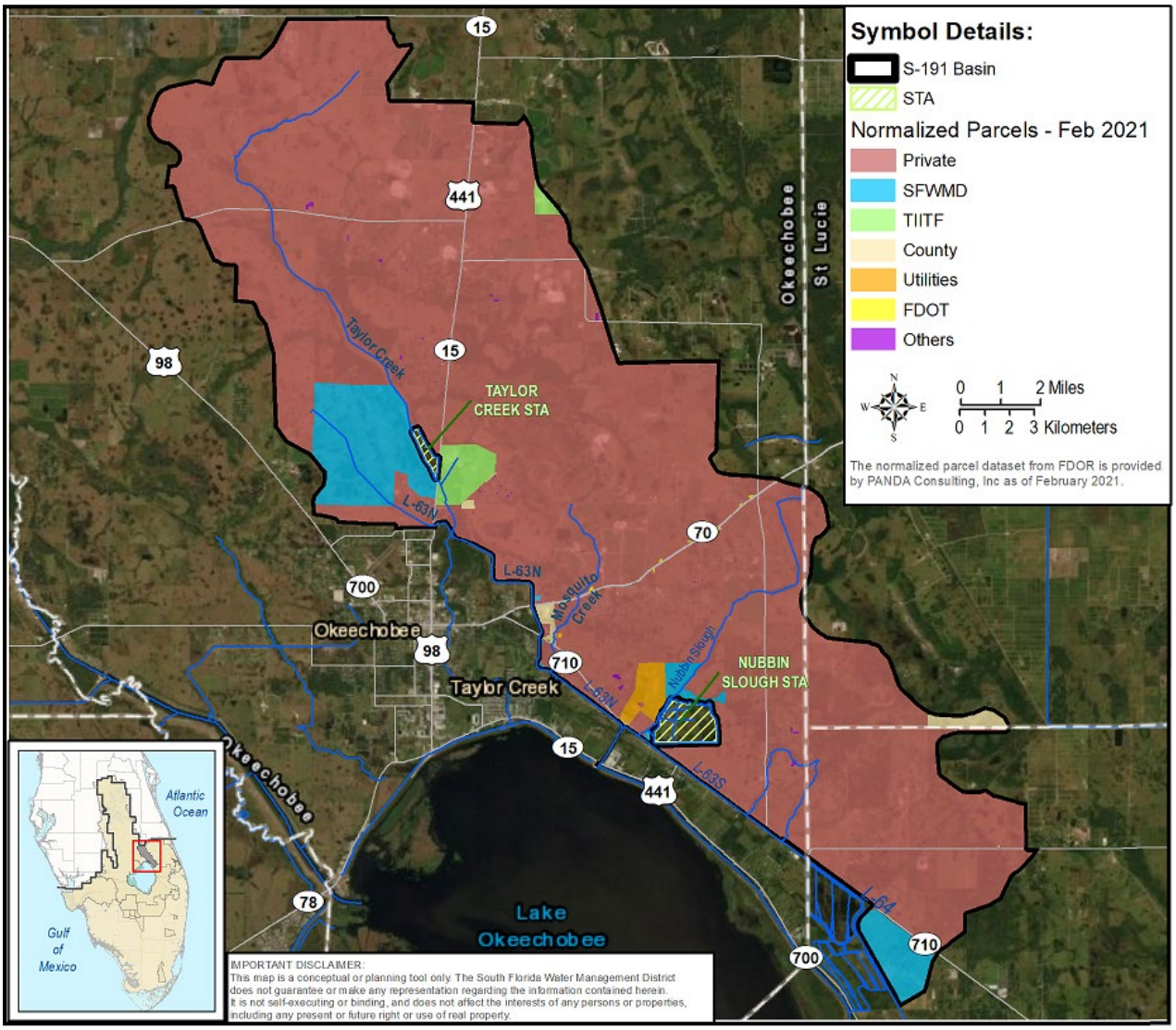

Figure 8. Land ownership highlighting state-owned lands in the S-191 Basin as of February 2021.

BASIN LEVEL ANALYSIS

SFWMD currently monitors at two hydrologic levels within the LOW: subwatershed and basin level (basin monitoring sites) and subbasin level (upstream monitoring sites) (**Figure 7**). The basin level sites have measurements of flow and nutrient concentrations so loads can be determined. The upstream level sites are used to identify areas of interest further upstream within the basin and most only have

measurements of nutrient concentrations. To identify factors contributing to the water quality issues, data from both levels were reviewed. This section covers the basin level analysis and the Upstream Level Analysis Section discusses the upstream level data and highlights the areas of interest.

The most recent 5-year TP and TN data for the basins in the TCNS subwatershed are presented in **Table 8** (Zhang et al., 2022). The S-191 Basin had a 5-year (WY2017-WY2021) average TP load of 68.3 t which is 56 t above the long-term average annual planning target for this basin of 12.3 t/yr.

Table 8. Basin monitoring data summarized with the 5-year average (WY2017–WY2021) for each basin within the Taylor Creek/Nubbin Slough Subwatershed (Source Zhang et al. 2022).

Taylor Creek/Nubbin Slough Subwatershed								
Basins	TP			TN			Flow (ac-ft)	Area (ac)
	Load (t)	UAL (lb/ac)	FWMC (µg/L)	Load (t)	UAL (lb/ac)	FWMC (µg/L)		
S-133	8.5	0.73	260	58.2	5.01	1,790	26,400	25,626
S-135	6.1	0.76	162	61.4	7.62	1,640	30,400	17,756
S-154	16.5	1.14	623	56.0	3.88	2,120	21,400	31,815
S-154C	2.0	2.07	735	6.8	7.01	2,490	2,210	2,134
S-191	68.3	1.25	629	211.4	3.87	1,950	88,000	120,464
Subwatershed Total	**101.3**	**1.13**	**488**	**393.8**	**4.39**	**1,900**	**168,000**	**197,795**

Figures 9 and **10** depict the annual TP loads, annual TP FWMC and the 5-year rolling average TP load for the period of record for the S-191 Basin and annual TN loads, annual TN FWMC and the 5-year rolling average TN load for the period of record for the S-191 Basin, respectively. There are some break points in the data (depicted by purple lines) which can loosely be matched up to projects and programs implemented in the basin. Prior to 1987, the TP loads were often over 150 t each year. From the period between 1987 and 2009, there were several key programs and regulations that were put in place to improve water quality (**Table 9**). During this period, the annual TP basin loads exceeded 100 t seven times but never exceeded 150 t/yr. Since WY2009, the TP loads have only exceeded 100 t /yr one time in WY2018 which had the second highest rainfall (**Figure 11**) for the S-191 Basin from the period of WY1977 to WY2021. This would indicate that the TP loads from this basin have been decreasing and that the various projects and programs were making a difference. Additionally, a trend analysis completed for S-191 as part of the 2020 LOPP update found statistically significant decreasing trends for flows and TP loads for the period of WY1991-WY2018 (Betts et al. 2020). However, the TP FWMC which appeared to be decreasing in the period between WY1977 and WY1987, does not appear to have decreased much since that time which indicates that additional improvements are needed. Also, the basin loads are still 56 t above the long-term average annual planning target. The TN load data follow a similar pattern as the TP load data, but the TN FWMC did not appear to decrease (**Figure 10**). This would suggest that those same projects and programs have made reductions in TN loads possibly through additional storage and reduction in discharge volumes.

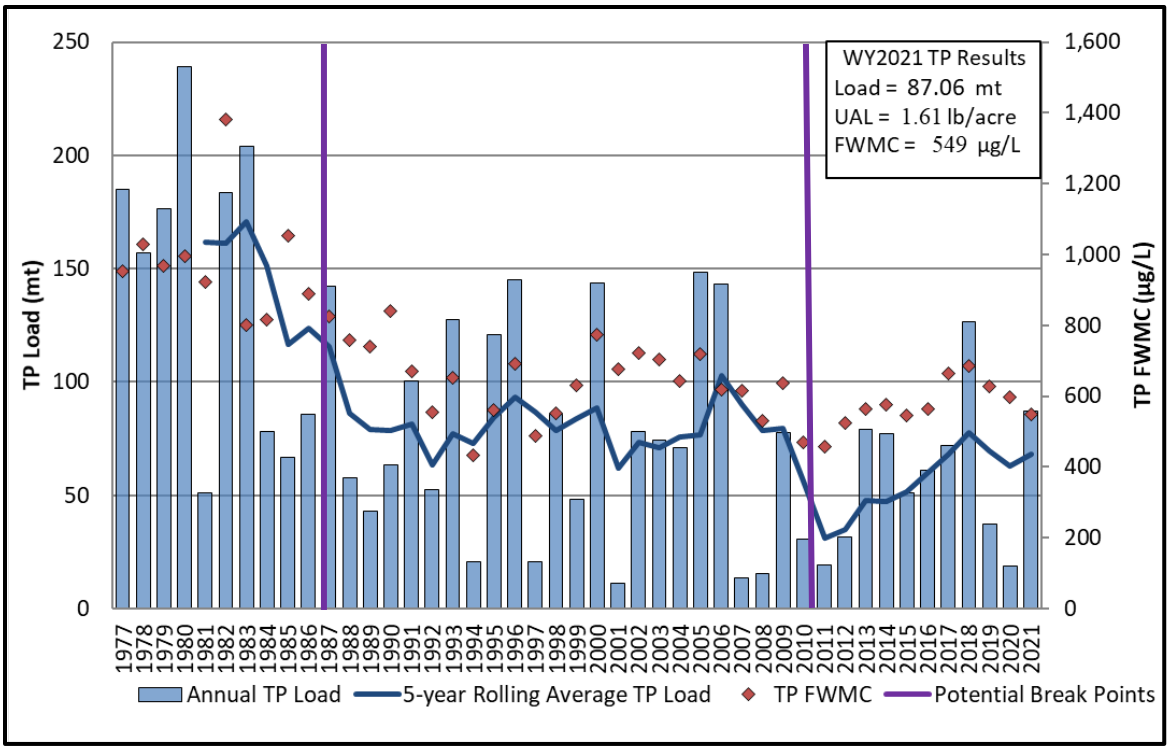

Figure 9. TP load and FWMC data for WY1989-WY2021 with the 5-year rolling average for the S-191 Basin.

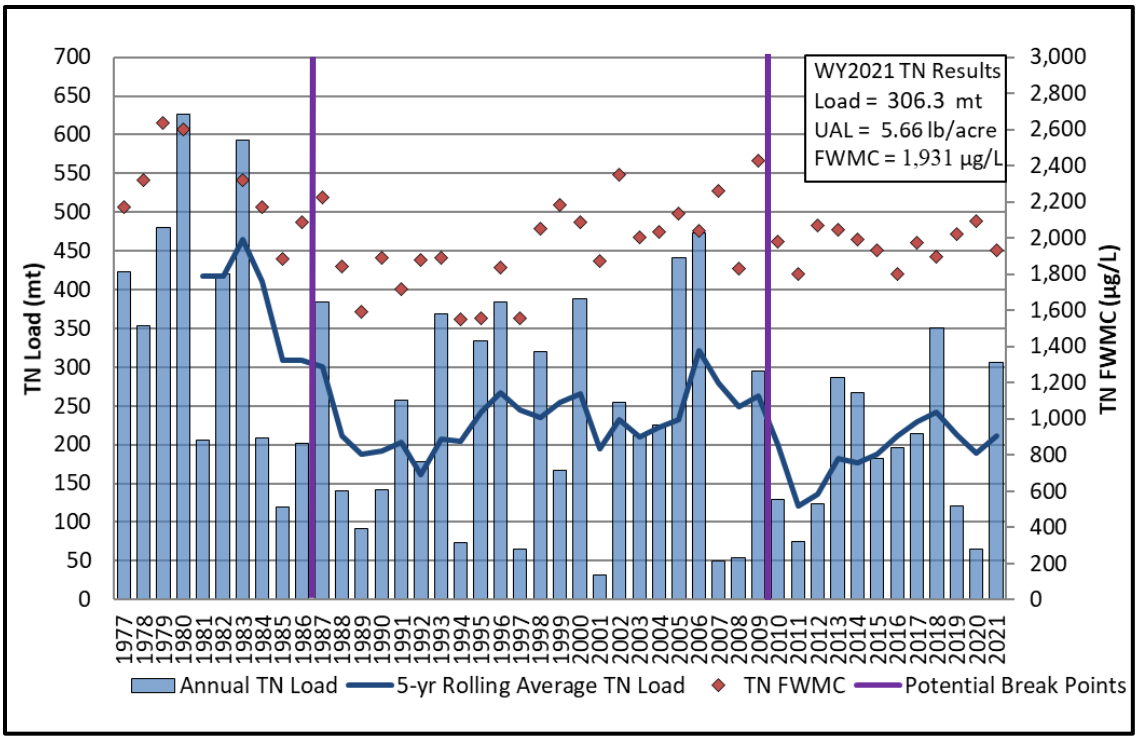

Figure 10. TN load and FWMC data for WY1989-WY2021 with the 5-year rolling average for the S-191 Basin.

Table 9. Timeline of major source control activities and treatment projects within the S-191 Basin.

Date	Major Source Control Activities
1987	FDER/FDEP Dairy Rule adopted
1989	Dairy Buyout Program implemented
1990	WOD permits issued
1995	ERP program implemented
2002	FDACS Agricultural Nutrient Management Plans for Dairies
2003	FDACS BMP Rule for Lake Okeechobee Priority Basins (S191)
2003	Phase II MS4 permits issued to St. Lucie and Martin Counties
2004-2007	Davie Dairy BAT Projects
2004-2008	Phosphorus Source Control Grant Program Projects: QED - McArthur Farms 3, Davie Dairy Cooling Pond, Evans Properties- Bassett Grove and Taylor Creek ATS NRF
2004-2008	Former Dairy Remediation Projects: Candler Ranch, McArthur Dairy 5 and Mattson Dairy
2006	FDACS BMP Rule adopted for all basins in the Lake Okeechobee Watershed
2008	Taylor Creek STA became operational
2008	Nubbin Slough and Mosquito Creek HWTT completed
2012	Grassy Island HWTT completed
2012	Phase II MS4 permit issued to Okeechobee County
2013	Lakeside Ranch Phase I STA became operational (S135 & S191)
2014	Grassy Island HWTT was expanded
2016	Nubbin Slough STA became operational
2018	Lakeside Ranch Phase II STA construction completed (S135 & S191)

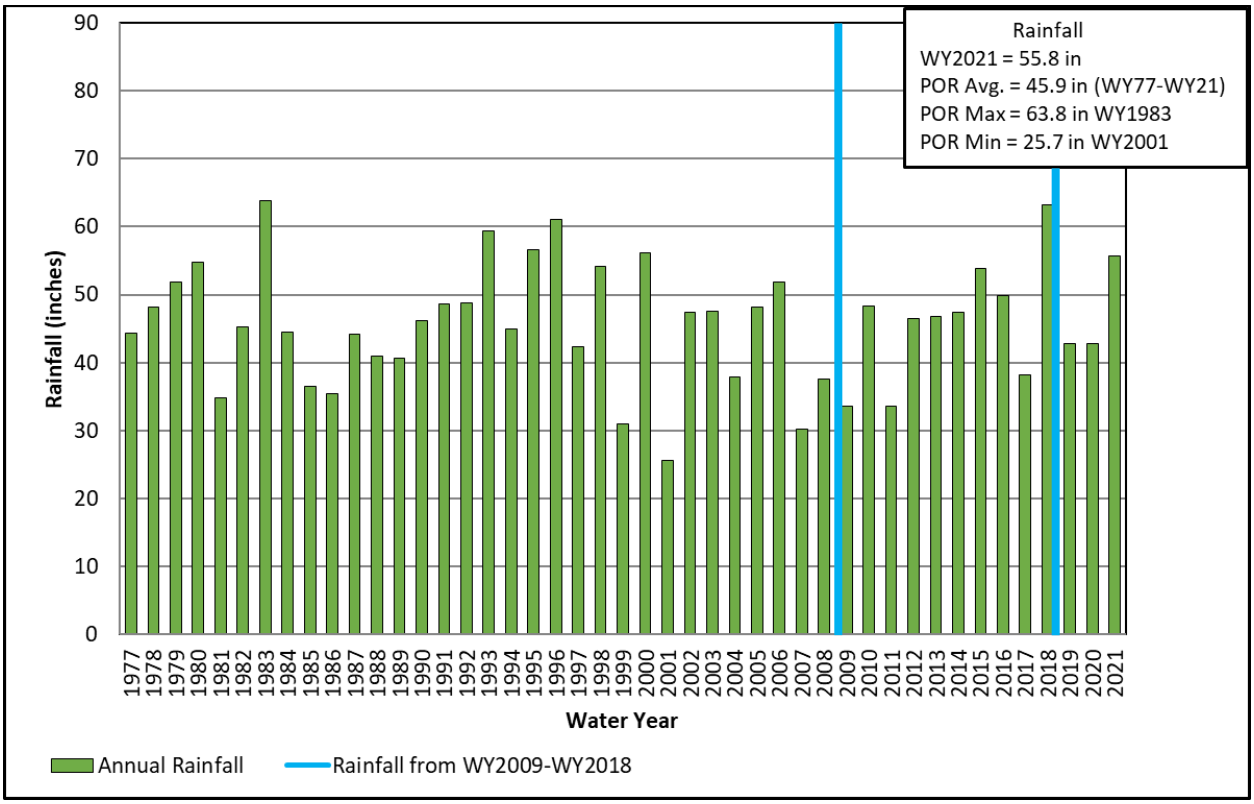

Figure 11. Annual Rainfall (inches) for WY1989-WY2021 for the S-191 Basin based on representative monitoring stations within the S-191 Basin and using a Thiessen polygon weighting method.

The annual rainfall for the S-191 Basin is presented in **Figure 11**. To determine the impacts of rainfall variability, SFWMD developed a rainfall regression equation for the S-191 Basin which can be used to provide a comparison of measured load against a reference period load (Wang, 2021). This can assist with tracking progress from projects and programs implemented in the basin. The reference period for the S-191 Basin was WY1977-WY1988 which was prior to the implementation of the majority of the projects and programs in the basin (**Table 9**). **Figure 12** depicts the annual TP loads and rainfall adjusted TP loads along with the 5-year Rolling average TP loads and rainfall adjusted loads. The rainfall adjusted annual loads and 5-year rolling average indicate what the loads would be if no projects and programs had been implemented within the S-191 Basin. The rainfall adjusted TP loads have been greater than the measured loads annually since the end of the reference period which is another indication that the projects and programs within the basin appear to have reduced loads from historic levels.

The rainfall adjusted loads indicate that the 5-year rolling average would increase during the period of WY2011-WY2018 and a review of the measured 5-year rolling average TP load from that same period does appear to increase during that period. The 2020 Lake Okeechobee BMAP update (FDEP, 2020) used a Seasonal Kendall Tau test (SKT) analysis and found a statistically significant increasing trend in TP FWMC at the S-191 structure for the period of WY2009 – WY2018. The SKT test is non-parametric and factors out seasonality. It is used to detect statistically significant trends in data. The "seasons or months" are only compared to each other. Non-parametric tests are the best types of statistical tests to use on data that are not normally distributed (i.e. in a bell curve – which is the case with this data). While the SKT analysis indicates an increasing trend at the S-191 structure, the rainfall adjusted loads analysis would seem to indicate that the trend may have been due to increased rainfall. The annual rainfall from that period is depicted between the blue bars in **Figure 11** and the data from that period is provided in **Table 10**. A statistical analysis of rainfall for that period is needed to determine if the trend is significant. If there is a

significant increasing trend in rainfall, that may indicate that the SKT analysis does not factor out increasing trends in rainfall. Future analyses should include rainfall analyses as concentration data to try to discern the trends.

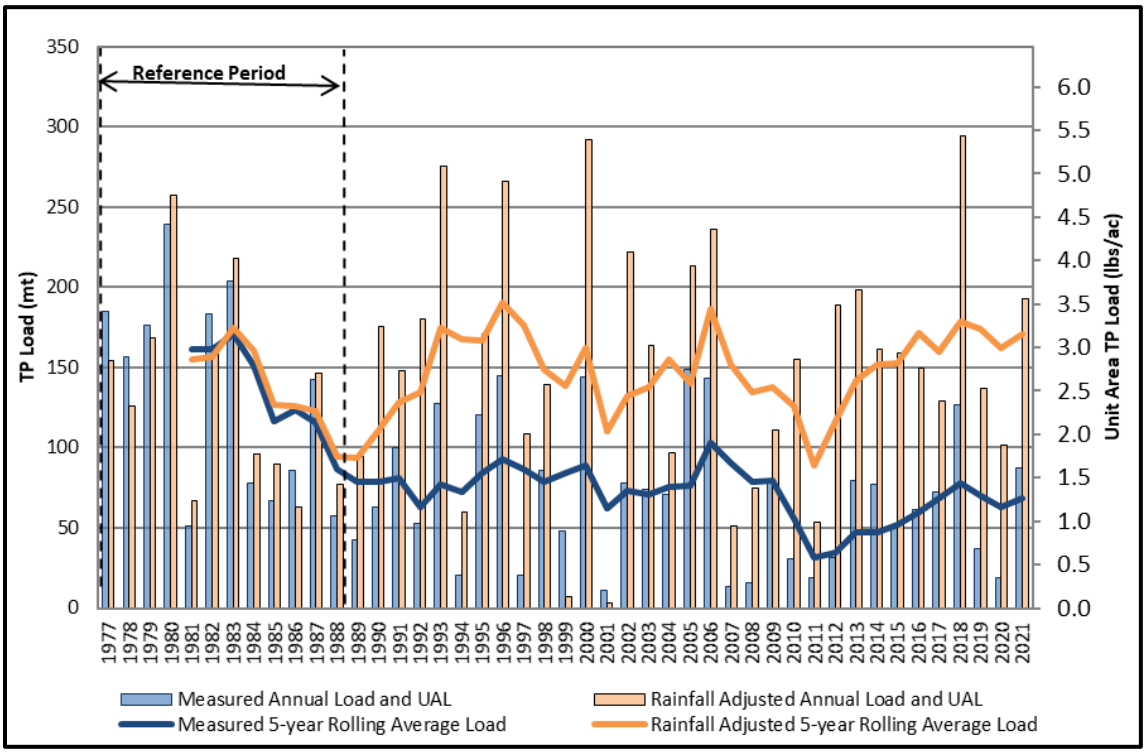

Figure 12. Annual TP load and UAL (measured and rainfall adjusted) data for WY1977-WY2021 with the 5-year rolling averages (measured and rainfall adjusted) for the S-191 Basin.

Table 10. Rainfall for WY2009 to WY2018 in the S-191 Basin.

Water Year	Annual Rainfall (in)
2009	33.56
2010	48.38
2011	33.60
2012	46.45
2013	46.86
2014	47.34
2015	53.86
2016	49.87
2017	38.17
2018	63.16

As part of the 2020 Lake Okeechobee Protection Plan (LOPP) update, SFWMD LOPP technical team reviewed the S-191 Basin (Betts et al., 2020) to determine factors contributing to water quality issues within the basin. Although there was a statistically significant decreasing trend in TP loads and flows for the

period of WY1991 – WY2018, the team concluded that the S-191 Basin had nutrient issues because the average FWMC in the WY2005-WY2018 period was 612 µg/L. The reductions in TP loads observed from WY1991 – WY2018, may be due to the reductions in flows during this time period. The S-191 Basin represented the majority of the flow (55.8%) and TP load (65.2%) for TCNS subwatershed for the period of WY2005-WY2018.

To determine if the nutrient issues at the S-191 structure were related to soluble phosphorus or particulates, a comparison was made between the TP and Ortho P collected at the S-191 Basin structure (**Figure 13**). Data used for this analysis were collected from grab samples, only when flow was detected on dates when both Ortho P and TP samples were collected. **Table 11** lists the average annual concentrations, number of samples and percentage of the data that were Ortho P used to create **Figure 13**. Within the most recent 5-years (WY2017-WY2021), nutrients seem to be more soluble than particulate. From WY2017-WY2021, the percentages of OPO_4 to TP range from 83% to 90%. Total suspended solids (TSS) are collected as part of the routine sampling at the S-191 structure. A review of recent data indicates that the concentrations of TSS have been at or below the method detection limit for the last 10 water years which indicate that suspended solids are not an issue at the structure. Thus, additional efforts for BMPs and projects should address soluble P.

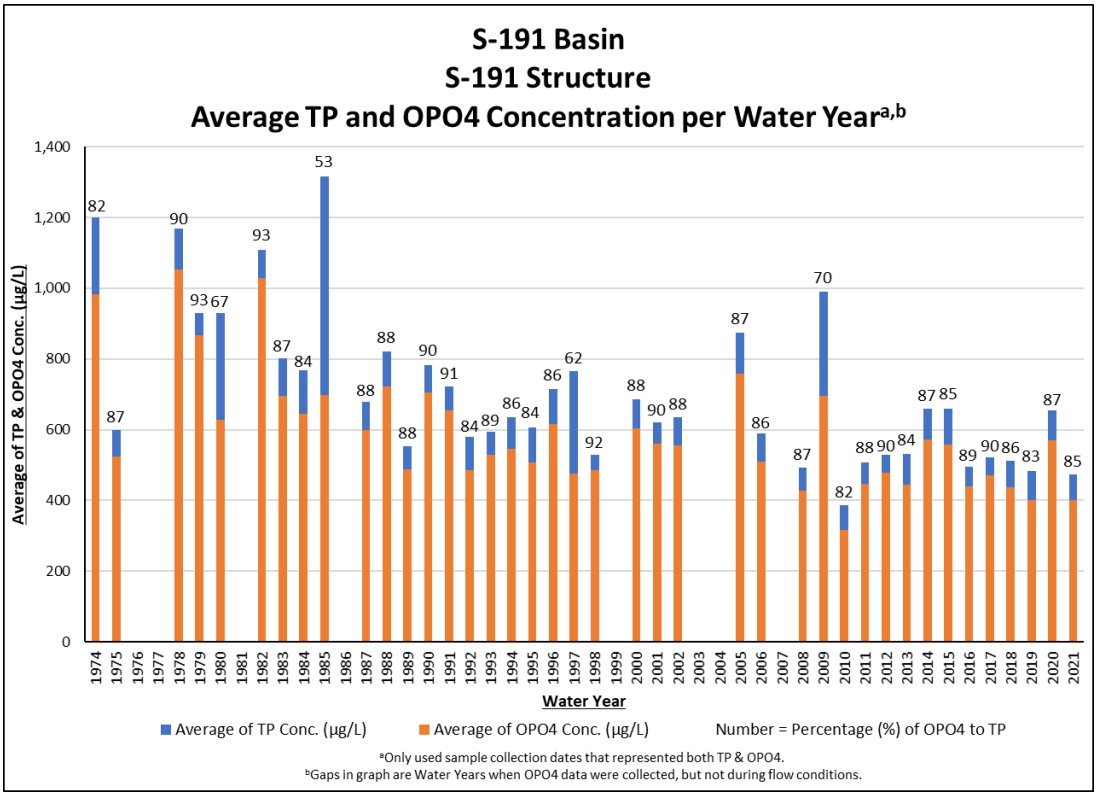

Figure 13. Average TP and OPO_4 concentrations per water year at the S-191 Basin structure.

Table 11. Speciation Information per Water Year at the S-191 Basin structure.

S-191 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
1974	1,200	981	82%	1
1975	600	523	87%	1
1976[b]	-	-	-	-
1977[b]	-	-	-	-
1978	1,168	1,052	90%	1
1979	930	866	93%	1
1980	929	627	67%	3
1981[b]	-	-	-	-
1982	1,109	1,029	93%	3
1983	802	695	87%	8
1984	767	645	84%	3
1985	1,317	699	53%	1
1986[b]	-	-	-	-
1987	679	598	88%	2
1988	822	723	88%	3
1989	552	488	88%	1
1990	783	704	90%	3
1991	722	654	91%	11
1992	580	486	84%	5
1993	593	528	89%	12
1994	635	546	86%	2
1995	605	508	84%	15
1996	715	615	86%	18
1997	766	475	62%	3
1998	529	485	92%	2
1999[b]	-	-	-	-
2000	687	605	88%	3
2001	620	560	90%	1
2002	634	555	88%	1
2003[b]	-	-	-	-
2004[b]	-	-	-	-
2005	874	758	87%	3
2006	589	509	86%	4
2007[b]	-	-	-	-
2008	492	427	87%	1
2009	991	696	70%	1
2010	386	317	82%	2
2011	508	446	88%	2
2012	530	477	90%	4
2013	531	445	84%	6
2014	660	572	87%	4
2015	659	558	85%	3
2016	496	439	89%	4
2017	522	472	90%	2
2018	511	437	86%	6
2019	483	401	83%	6
2020	656	571	87%	2
2021	473	401	85%	5
Minimum	**386**	**317**	**53%**	**1**
Maximum	**1,317**	**1,052**	**93%**	**18**
Average	**703**	**589**	**85%**	**4**

[a]Only used sample collection dates that represented both TP & OPO4.

[b]Gaps in graph are Water Years when OPO4 data were collected, but not during flow conditions.

PROJECT AND PROGRAMS EVALUATION

Evaluation of the projects and practices currently implemented in the basin is important to see if any adjustments are needed. Source control activities have been implemented in the S-191 Basin since the 1980's (**Table 9**) and as mentioned above have assisted with loading reductions to the basin. Details on past projects and programs can be found in previous LOW protection plans and SFERs. Additional information on completed projects by other entities such as Okeechobee County and the Florida Department of Transportation can be found in the BMAP update (FDEP, 2020).

PROJECTS

Currently there are six operating and two planned SFWMD projects to help reduce nutrient loading and increase storage within the S-191 Basin (**Figure 14, Table 12**). For WY2021 the operating projects removed 23.4 t TP and 58.9 t TN, and stored 7,275 ac-ft, although storage is not the primary objective of the projects currently operating (Zhang et al, 2022). Additionally, as part of the Federal Comprehensive Everglades Restoration Plan (CERP) Lake Okeechobee Watershed Restoration Project (LOWRP) ASR wells will be implemented. The ASR wells are currently under design and potential well clusters are located within the S-191 Basin. Once constructed these well clusters will provide additional storage and may provide ancillary water quality benefits (**Figure 14**).

Three of the six projects for the S-191 Basin are STAs which assist in treating the runoff from the basin before it discharges into Lake Okeechobee. Two of the STAs (Taylor Creek and Lakeside Ranch) have had some operational challenges since startup, but overall, these two STAs have performed well with respect to TP load reduction. The third STA (Nubbin Slough) has had various structural issues which restricted its operation and affected its nutrient load reduction performance since startup. SFWMD recently completed repairs to the STA and has made and continues to make adjustments to improve the nutrient load reduction performance of all three STAs. Observed data collected since STA startup indicate that actual inflow volumes, TP concentrations and loads are different from the values used for the original design, therefore, the predicted long-term average annual STA TP load reductions need to be updated. The observed STA inflow data and observed phosphorus settling rates (Ke) (Walker 1995) for Taylor Creek STA and Lakeside Ranch STA Phase I were used to update the anticipated long-term average annual TP load reductions for these STAs as discussed below. For Nubbin Slough and Lakeside Ranch STAs which do not have as much observed data for STA operations, different scenarios were explored to estimate the long-term TP load reduction ranges and then a conservative estimate was selected.

Taylor Creek STA (**Figure 14**) has had some periods of dry-out which have likely affected its treatment performance[5] in some years despite performing well from a TP load reduction perspective over its period of operation. Upcoming planned storage projects including a FEB and ASR wells on the Grassy Island property should supply water and reduce the periods of dry-out and improve the nutrient reduction performance this STA. SFWMD has implemented strategies to improve the Taylor Creek STA performance including: reducing the hydraulic loading during the dry season by limiting inflow pumping, preventing

[5] Dry conditions promote the rapid oxidation of soil organic matter and subsequent reflooding results in outflow phosphorus spikes due to the flux of mineralized soil phosphorus to the water column.

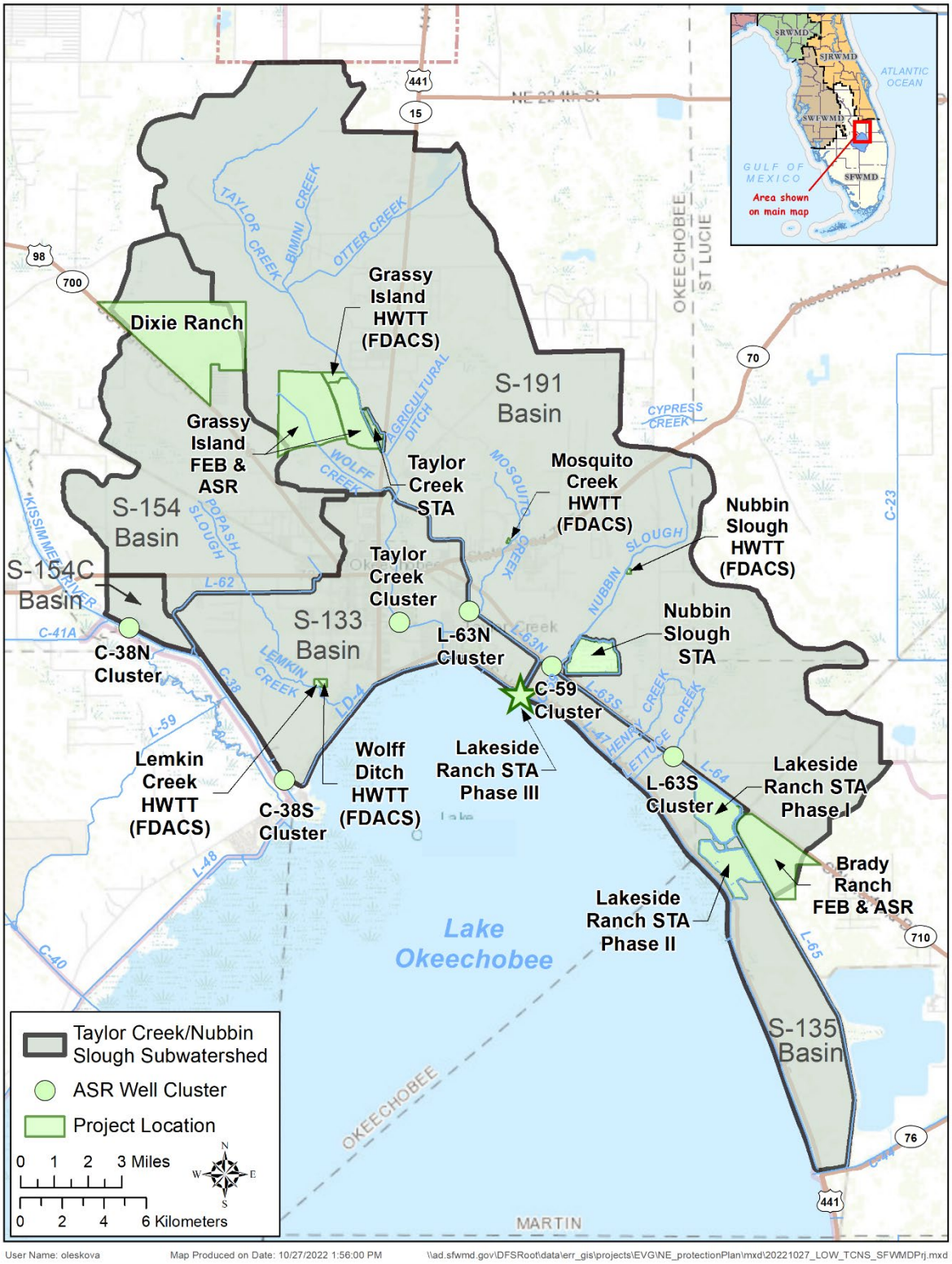

Figure 14. Locations of existing projects within the Taylor Creek/Nubbin Slough Subwatershed Note: ASR well clusters are planned components of the regional LOWRP. (Source Zhang et al. 2022).

Table 12. Current SFWMD and select Coordinating Agencies projects in the S-191 Basin, including long-term project estimates and WY2021 storage and nutrient retention (Source Zhang et al. 2022).

Project Name	Basin	Project Area (ac)	Project Status FY2021	Description	Estimated Storage (ac-ft/yr)	WY2021 Storage (ac-ft)	Estimated TP Removal (t/yr)	WY2021 TP Removed (t)	Estimated TN Removal (t/yr)	WY2021 TN Removed (t)
Lakeside Ranch STA (Phases 1-3)[a]	S-135 S-191	1,707	O&M	Eight cell STA diverts and treats runoff from the S-191 Basin before it enters Lake Okeechobee. Intakes from the L-64 canal and discharges to L-47 canal. Includes S-191A pump station.	N/A [b]	8,158	14.4[c]	18.1	N/A [b]	41.1
Nubbin Slough STA [a]	S-191	773	O&M	Two celled, STA diverts and treats runoff from Nubbin Slough before it enters Lake Okeechobee.	N/A [b]	-1,643	4.6[c]	-0.1	N/A [b]	-2.1
Taylor Creek STA [a]	S-191	118	O&M	Two celled STA diverts and treats runoff from Upper Taylor Creek before it enters Lake Okeechobee.	N/A [b]	760	1.0[c]	1.7	N/A [b]	8.9
Brady Ranch FEB and ASR	S-191	1,800	Design	Develop FEB and ASR projects at the Brady Ranch property.	7,200	N/A [d]	4.0	N/A [d]	TBD [e]	N/A [d]
Grassy Island FEB and ASR	S-191	984	Design	Develop FEB and ASR projects at the Grassy Island property.	3,200	N/A [d]	0.8	N/A [d]	TBD [e]	N/A [d]
Grassy Island HWTT (FDACS)	S-191	N/A	O&M	Grassy Island HWTT began operation in 2012 and has a treatment capacity of approximately 30 cfs (0.85 m^3/s).	N/A [b]	N/A [b]	N/A [b]	1.8	N/A [b]	4.3
Mosquito Creek HWTT (FDACS)	S-191	N/A	O&M	Mosquito Creek HWTT began operation in 2008 and has a treatment capacity of approximately 6 cfs (0.17 m^3/s).	N/A [b]	N/A [b]	N/A [b]	1.5	N/A [b]	5.6
Nubbin Slough HWTT (FDACS)	S-191	N/A	O&M	Lemkin Creek HWTT began operation in 2008 and has a treatment capacity of approximately 7.4 cfs (0.21 m^3/s).	N/A [b]	N/A [b]	N/A [b]	0.4	N/A [b]	1.1
				S-191 Basin (approximate totals) [f]	-	**7,275**	**24.8**	**23.4**	-	**58.9**

a. Calculated as the WY2021 project inflow minus project outflow as reported in Appendices 4-2, 4-3, and 4-4 of the SFER Volume III.

b. Benefit not associated with the project's primary objective. Actual performance may be calculated if data become available. N/A – not available

c. Estimated TP removal rates for STAs are calculated using existing monitoring data, observed project operations, and a first-order phosphorus removal model (Walker, 1995). These long-term annual averages are broad estimates for watershed planning purposes, and actual performance may vary according to regional system conditions and other factors inherent to the biological processes within an STA.

d. Project not in operation during WY2021.

e. Estimated project performance has not yet been established. TBD – to be determined.

f. Totals do not include projects where information is unavailable.

Table 13. Scenarios for estimates of long-term average annual TP load reductions and recommended estimates for Taylor Creek, Nubbin Slough and Lakeside Ranch STAs.

Scenarios	Average Annual TP (µg/L)	Average Annual Inflow Volume (ac-ft)	Estimated STA Phosphorus Settling Rate (m/yr)	Estimated Long-Term Average Annual TP Load Reduction (t/yr)	Recommended Long-Term Average Annual TP Load Reduction Estimate (t/yr)
Taylor Creek STA					
Original Design Values[1]	492	8,674	10.2	2	
Observed Data (WY11-WY21[2])	318	6,040	5	1	**1**
Nubbin Slough STA					
Original Design Values[3]	515	8,838	10.2	5.3	
Observed Data (WY16-WY22) and Observed Taylor Creek STA phosphorus Settling Rate	609[4]	7,770[5]	5	4.6	**4.6**
Observed Data (WY16-WY22) and Design Estimate phosphorus Settling Rate	609[2]	7,770[5]	10.2	5.6	
Lakeside Ranch STA					
Original Design Values[6]	268	113,000	10.2	15.2	
Observed Phase I Data (WY15-WY17[7])	483	30,000	9.1	14.4	**14.4**
Phase II using Observed Phase I Data (WY15-WY17[4]) plus additional estimated inflow volume	483	50,000	9.1	18.7	

1. Goforth 2005b.
2 Does not include WY2018 as the STA was off-line for rehabilitation.
3. Goforth 2005a.
4.Observed TP concentration data from the Nubbin Slough Tributary are not flow weighted.
5. Nubbin Slough tributary data were used to estimate a potential inflow volume
6. CDM 2007.
7. Does not include water years when cells were offline or when there were extended periods of dry-out.

dry-out by inflow pumping only as needed to maintain minimum states and suspending STA discharges, and completing vegetative enhancements. A future recommendation is to automate all of the STA structures to allow for a quicker response to changes in operations to enhance performance. For Taylor Creek STA, the observed creek and STA data were used in place of the original design values to develop an updated STA predicted long-term average annual TP load reduction of 1 t/yr (**Table 13**). The observed average annual inflow volume, and the TP FWMC were lower than the original assumptions which is why the updated long-term average annual estimated TP load reduction is lower than what was predicted from the original design. Due to the variability in rainfall, runoff (volumes and nutrient concentrations), and the inherent variability in the biological removal processes within an STA, individual water years will vary from long-term average annual predictions. For example, the WY2021 observed reduction was 1.7 t TP. The WY2021 reduction value may have been influenced by unusually high concentrations observed in

Taylor Creek in the spring of 2021. For additional information on the Taylor Creek STA see Appendix 4-2 of Volume III of the 2022 SFER (Gauthier and Iricanin, 2022).

For most of WY2021, Nubbin Slough STA was offline for levee repairs to correct seepage issues. Repairs were finalized in August of 2021 and it is anticipated that these repairs will allow the STA to be operated in a manner that will support improved nutrient reduction. A future recommendation for Nubbin Slough is to resize the STA inflow pump to ensure steady operation. Currently it shuts on and off during operation because the pump is so large. Another recommendation is to automate all of the STA structures to allow for a quicker response to operational changes to enhance performance of this STA. Like Taylor Creek STA and Lakeside Ranch STA, Nubbin Slough STA has experienced period of dry-out when basin runoff was low. A review of the original design values against the observed monitoring data (including an estimated potential inflow volume) from the Nubbin Slough tributary indicate a range of long-term average annual expected TP reduction from Nubbin Slough STA is from 4.6 t/yr to 5.6 t/yr (**Table 13**). The original design estimate was a long-term average annual TP removal of 5.3 t/yr. To be conservative, the 4.6 t/yr value is used in this report as the expected long-term average annual reduction from Nubbin Slough STA. For additional information on Nubbin Slough STA see Appendix 4-4 of Volume III of the 2022 SFER (Gauthier and Baldwin, 2022).

Table 13 presents expected long-term average annual TP reductions from Lakeside Ranch STA Phase I and II based on three scenarios; (1) the original design values; (2) using observed data from Phase I; and (3) using observed data from Phase I plus additional inflow volumes associated with the future operation of the S-191A pump station. The range of expected long-term average annual TP reductions for Lakeside Ranch STA is from 14.4 to 18.7 t. In WY2021, Lakeside Ranch STA Phase I and Phase II operated for its first full year and removed 18.1 t TP. To be conservative, the 14.4 t/yr value is used in this report as the expected future long-term average annual TP reduction from the Lakeside Ranch STA. The S-191A pump station, built under Phase III of Lakeside Ranch STA became operational in August of 2021. The S-191A pump station may under certain conditions allow water to be recirculated to Lakeside Ranch STA to prevent dry-out which in turn could improve treatment performance. As of the date of this report operational strategies for the pump station are being developed. Any potential effect of the S-191A pump station on Lakeside Ranch STA nutrient reductions will be observed in the coming years. SFWMD continues to investigate ways to improve Lakeside Ranch STA's nutrient reduction performance. A dry-out study as well as a topographic survey are planned in the STA to inform operational decision-making with the goal of improved treatment performance. For additional information on the Lakeside Ranch STA see Appendix 4-3 of Volume III of the 2022 SFER (Wakefield, 2022).

FDACS has three HWTT projects (Grassy Island, Mosquito Creek, and Nubbin Slough) that involve a combination of wetlands and chemical treatment (**Figure 13**). These projects draw water from the creek into a man-made wetland. The effluent of the wetland is then chemically treated in a separate holding pond before it is discharged back into the creek. HWTT can be tailored to site specific conditions and can be constructed with limited land availability (Watershed Technologies, 2020). All three projects combined removed about 3.7 t TP and 11 t TN in WY2021. None of the three projects are utilizing their full design capacity (**Table 14**) based on an analysis by Watershed Technologies, LLC. (Watershed Technologies, 2020), but they are reducing concentrations by about 80%. The Nubbin Slough HWTT facility was offline in June 2019 and June 2020 because of equipment damage by lightning strikes. The Watershed Technologies also reported times when equipment challenges interrupted the other two HWTT projects as well. Continued optimization of these projects may lead to additional nutrient reductions.

Table 14. HWTT period of record results (Source Watershed Technologies, 2020)

Site	HWTT Design Capacity (cfs)	HWTT % Capacity Utilization for July 1 2019 to June 30, 2020	HWTT TP Removed for July 1, 2019 to June 30, 2020 (lb)	HWTT % TP concentration Reduction
Grassy Island	30	21%	3,928	85%
Mosquito Creek	6	24%	3,329	81%
Nubbin Slough	7.4	8%	813	82%

Two FEB and ASR projects are planned in the S-191 Basin and initial modeling estimates a long-term average annual load reduction of 4.8 t/yr of TP for both projects combined (**Table 12**). Storage and nitrogen removal estimates have not yet been established as these projects are in the design phase. SFWMD is also working to develop an innovative technology project upstream of the S-191 structure. At this time, it is not known how much reduction that project may achieve. Additionally, the 2020 BMAP listed a proposed future project for a landowner operated STA in the S-191 Basin but the address for the proposed project places it in the north central part of the S-133 Basin so it is doubtful that it would provide treatment for the S-191 Basin.

Project location is an important consideration. Water storage projects can be put anywhere there is enough water for them to be effective. Regional nutrient reduction projects need to be located as close to the downstream receiving water body as possible to be most effective. While some of the existing projects are not adjacent to Lake Okeechobee, they are all located on major tributaries within the S-191 Basin providing regional treatment. The Grassy Island HWTT and Taylor Creek STA treat water from the headwaters of Taylor Creek. The Mosquito Creek HWTT treats water from Mosquito Creek. The Nubbin Slough HWTT and STA treats water from Nubbin Slough. Lakeside Ranch STA can receive water from Henry and Lettuce creeks. The proposed Grassy Island and Brady Ranch FEB and ASR will also help treat the water regionally from Taylor Creek; and Henry and Lettuce Creeks, respectively. Two major tributaries currently without water quality treatment projects are Agricultural Ditch and Wolff Creek. The SFWMD recently received a grant to develop a project on Agricultural Ditch (TCNS 214 Dispersed Storage and Treatment Project). The long-term annual average TP reduction from that project is estimated to be 1.02 t/yr. Ideally, the best location for a nutrient removal project is immediately upstream of the S-191 Structure since the water would be treated prior to it entering Lake Okeechobee. The upcoming innovative technology project will be located immediately upstream of the S-191 structure. It is not yet known how much reduction will be achieved from that project or if it can be scaled up and become a long-term project.

BMP ENROLLMENT AS OF NOVEMBER 2021

FDACS has enrolled 95,968 acres in the BMP program as of November 2021 (**Figure 15**) and 12,385 agricultural acres are identified as unenrolled. The remaining agricultural acreage that is not enrolled needs to be investigated to determine if it is enrollable acreage according to FDACS. Then the landowners need to be given the option to enroll or submit a monitoring plan to SFWMD per Chapter 40E-61 F.A.C. within 180 days of notification. The FDACS BMP program began in the S-191 Basin in 2003 and most of the agricultural acreage has been enrolled for quite some time. Because of the large amount of acreage already enrolled in the S-191 Basin and the length of implementation of the BMPs on properties already enrolled, there may not be a large TP load reduction from the enrollment of the remaining agricultural acreage. However, since S-191 Basin is 56 t over the planning target based on a 5-year moving average, further BMP implementation is an essential piece to restoration and the reduction of the input of nutrients into the basin.

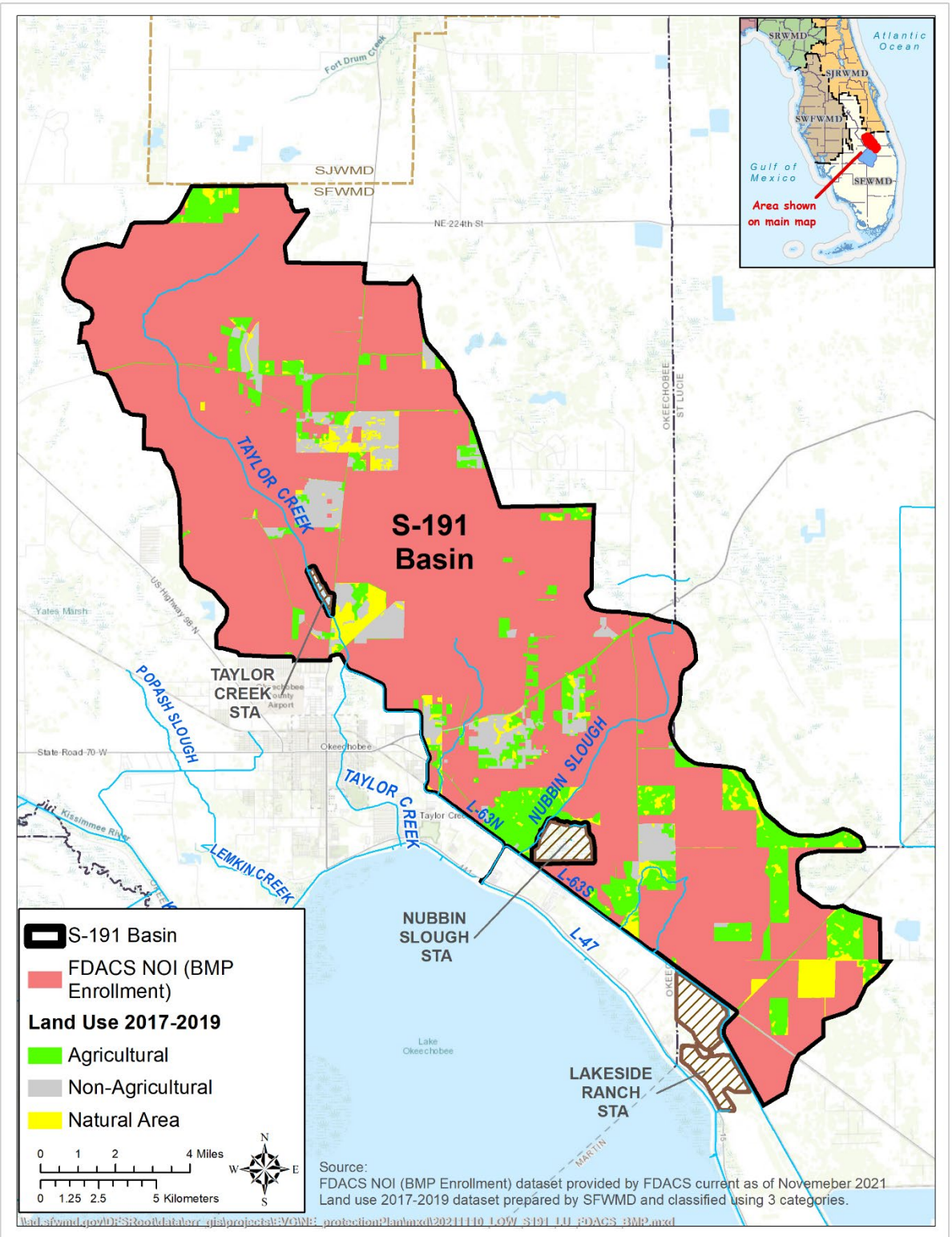

Figure 15. BMP enrollment and land use within the S-191 Basin as of November 2021.

ERP/SW PERMITS

The Environmental Resource Permit (ERP) program governs the following: construction, alteration, operation, maintenance, repair, abandonment, and removal of stormwater management (SWM) systems, dams, impoundments, reservoirs, appurtenant works, and works (including docks, piers, structures, dredging, and filling located in, on or over wetlands or other surface waters and requires that SWM systems be designed so they do not cause or contribute to violations of state water quality standards). Furthermore, ERPs issued for properties that discharge to impaired waters must include additional protective measures and provide 50% more water quality treatment volume than the amount required in Section 4.2.1. of ERP Applicant's Handbook Volume II (2016, SFWMD). ERPs require a construction phase pollution prevention plan and an operational phase pollution prevention plan. Three potential gaps regarding ERPs have been identified below:

1. Not every activity requires an ERP so there are areas within the S-191 basin that are not required to have a permit.
2. Older subdivisions and areas that have SWM systems which were constructed prior to the adoption of Chapter 373, Part IV, Florida Statutes in 1973, are not covered by ERPs.
3. Older permits (issued before 1995) do not meet the same level of water quality criteria as those permits issued after ERP rules were revised.

FDEP and the water management districts are currently in rulemaking to revise these rules per 373.4131(6) Florida Statutes to update them using the most recent scientific information available. Any additional requirements added to these rules will be applicable only to new permits or modifications. FDEP has held 13 public meetings with a Technical Advisory Committee which consists of various stakeholder groups that are providing input on the rulemaking.

Figure 16 depicts SFWMD ERPs, the surface water (SW) management permits and exemptions granted for the S-191 Basin as of February of 2021. Exemptions can be granted for a variety of projects, including water quality projects. When exemptions are issued for water quality structures or feature, they must be beneficial for water quality and must not have any offsite impacts. For information on FDEP permits see FDEP Permit section below.

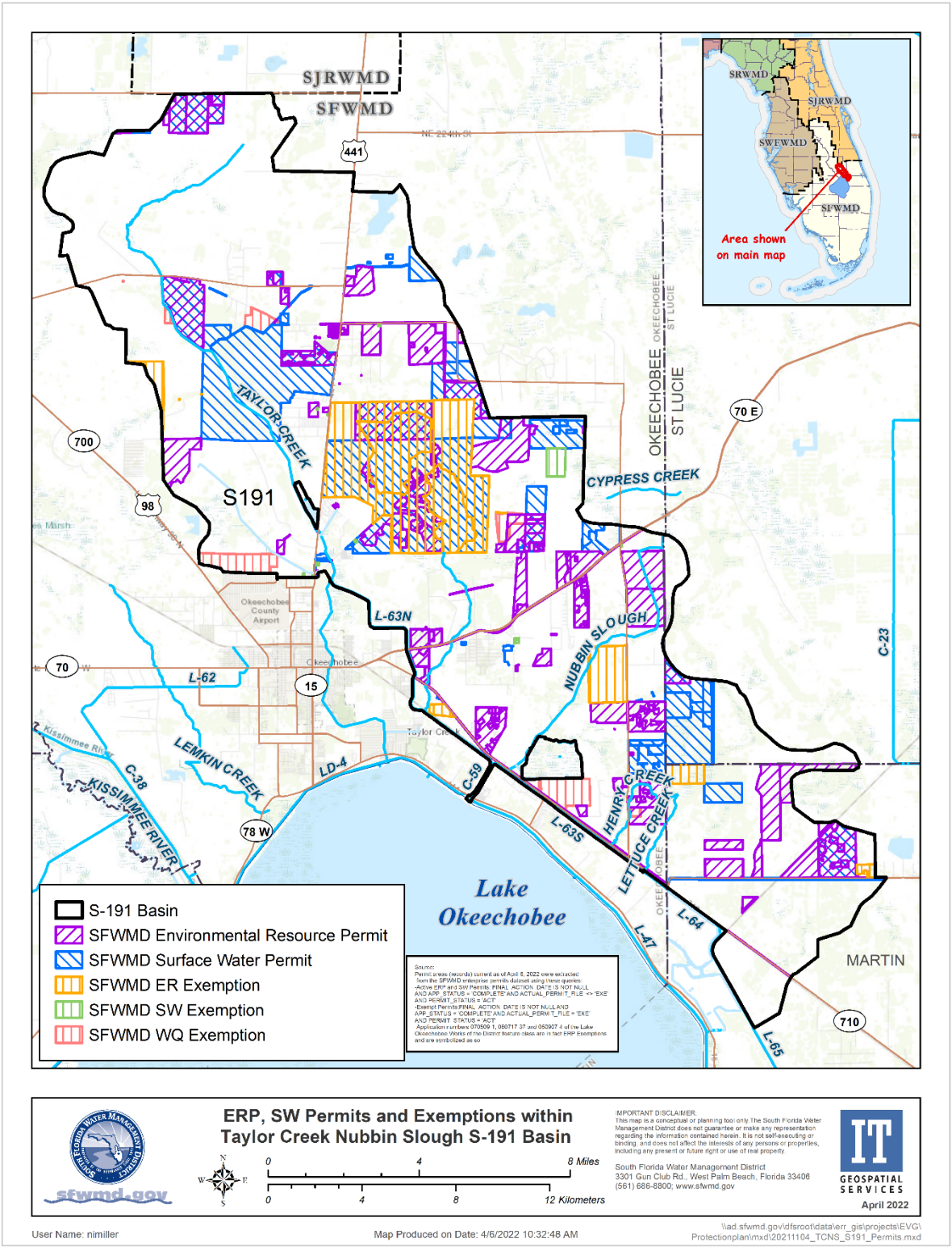

Figure 16. ERP, SW, and Exemptions within the S-191 Basin as of April 2022.

SEPTIC TANKS

There are multiple clusters of septic tanks within the S-191 Basin (**Figure 17**) but the contribution of nutrients from septic tanks to surface water in the basin is not known. A first step to determine the potential impact from septic tank clusters is to review upstream data sites with increasing trends and identify septic tank cluster within their contributing area.

Currently, DEP is working on a Bacteria TMDL for the Everglades West Coast Basin that will also serve as a pilot for a new consolidated approach that DEP will use in the future to address bacteria impairments throughout the state (more information can be found on the website here - https://floridadep.gov/dear/water-quality-evaluation-tmdl/content/bacteria-tmdls). DEP is also currently working through developing a new prioritization framework for TMDL development for the next 10 years and will use these procedures to develop TMDL workplans on a biennial basis. DEP held a public workshop to present the proposed framework for the TMDL prioritization process on May 24 2022, and will hold another workshop to present the proposed TMDL development work plan for the next two years later in 2022.

The Clean Waterways Act requires local governments to develop wastewater and onsite sewage treatment and disposal system (OSTDS) plans that will be adopted into nutrient BMAPs by July 1, 2025. These plans are expected to include, among many other components, any plans the local government may have to address septic tanks within their jurisdiction in the future.

SFWMD will notify FDEP where septic tank clusters are within or adjacent to contributing to the sites with increasing phosphorus trends. FDEP will review the information and these septic tank clusters may be addressed under future plan requirements under the Clean Waterways Act. This will be discussed further in the Upstream Level Analysis section of this report.

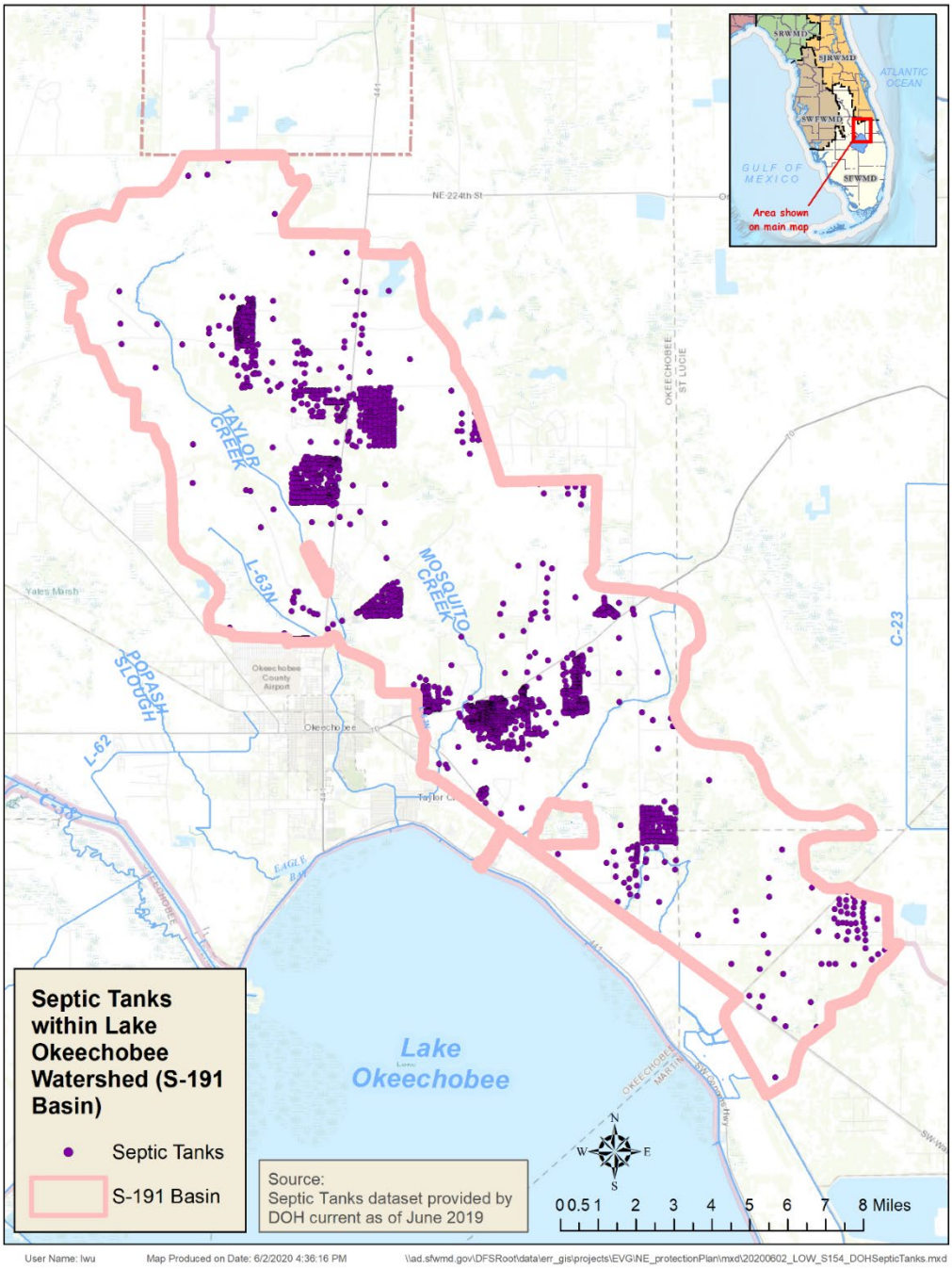

Figure 17. Septic tanks within the S-191 Basin as of June 2019.

FDEP PERMITS

The FDEP Feedlot and Dairy Wastewater treatment and management rules (62-670 F.A.C.) require BMPs and groundwater quality monitoring for Concentrated Animal Feeding Operations (CAFO) and for dairies in the Lake Okeechobee Drainage Area which is a subset of the NEEPP defined LOW. The FDEP Wastewater or CAFO permits within S-191 Basin are depicted in **Figure 18**.

The FDEP National Pollutant Discharge Elimination System (NPDES) Stormwater Program regulates point source discharges from construction activities, industrial activities, and municipal

stormwater. NPDES construction permits require BMPs for construction activities greater than 1 acre that discharge to waters of the state or municipal separate storm sewer systems (MS4). Any private or public entity may be issued one of these permits and implement construction BMPs, but once construction is over, the permit expires. The FDEP NPDES construction permits within S-191 Basin are depicted in **Figure 18**.

NPDES Industrial permits (also referred to as a multisector generic permits (MSGP) regulate operational facilities associated with industrial activities that are directly related to manufacturing, processing, or raw materials storage areas at an industrial plant) that discharge stormwater associated with those regulated "industrial activities" to surface waters of the state or to an MS4 system. Those regulated under NPDES Industrial permits must develop and maintain a stormwater pollution prevention plan (SWPP) and may be subject to water quality monitoring requirements and compliance inspections. FDEP's GIS information regarding NPDES Industrial permits within S-191 Basin indicate that none are centrally located within the S-191 Basin. It should be noted that FDEP uses only points to represent its permits which represent the center of the permitted activities, so it is possible that a portion of these permitted activities occur in the S-191 Basin.

Entities permitted under NPDES MS4 permits include municipalities, counties, community development districts, universities, military bases, or federal correctional facilities. The NPDES MS4 does not permit any privately-owned entities. Those regulated under MS4 permits must develop and implement a stormwater management plan to reduce pollutants. The S-191 Basin encompasses Okeechobee, Martin, and St. Lucie Counties and all three have FDEP Phase II MS4 permits.

The FDEP issued ERPs within the S-191 Basin are depicted in **Figure 18**.

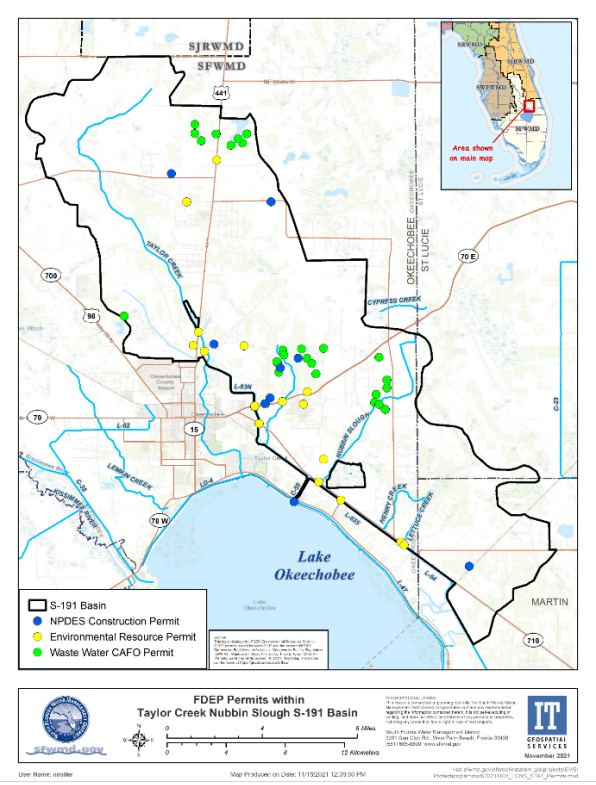

Figure 18. FDEP permits within the S-191 Basin as of November 2021.

ADDITIONAL NUTRIENT REDUCTIONS NEEDED

A review of recent 5-year average TP loading data compared to the basin target (**Table 15**) indicates that an additional 51 to 56 t average annual reduction is needed for the S-191 Basin, assuming that all existing projects operating for at least five years have achieved their TP reduction benefits. Brady Ranch and Grassy Island FEB and ASR are two upcoming projects with an expected long-term average annual TP reduction of 4.8 t/yr (long-term average annual model predictions). The long-term average annual TP reduction from the TCNS 214 Dispersed Storage and Treatment Project is estimated to be 1.0 t/yr. Nubbin Slough STA repairs should allow the project to achieve a long-term average annual TP reduction of 4.6 t/yr (based on observed inflow TP concentrations, potential inflow volume using tributary data and the TP settling rate observed for the Taylor Creek STA). Lakeside Ranch STA which just began operating Phase II is expected to achieve a 14.4 t/yr long-term average annual TP reduction (based on Phase I data, and projected inflow volume). The reductions from the other upcoming (Innovative Technology) or recently completed projects (S-191A pump station) are not known at this time. Thus, if the known reductions from upcoming and recently completed projects are considered (24.8 t/yr) an additional 26 to 31.2 t/yr average annual reduction of TP is still needed. To achieve the amount of TP load reduction needed, it will likely require additional projects or further optimization of existing projects, assuming the benefits from the source control programs in the S-191 Basin (**Table 9**) have been realized since most have been in place for many years.

Table 15. Planning targets for the S-191 Basin and the two most recent 5-year average TP loads and the long-term average annual reductions needed to achieve the planning targets.

	TP Planning Target (t)	WY2016 - WY2020 avg (t)	WY2017 - WY2021 avg (t)	Reduction Range Needed without Planned Projects Benefits (t)		Recently Completed and Planned Project Estimated Reductions (t)[a]	Reduction Range Needed assuming Planned Project Benefits (t)	
S-191 Basin	12.3	63.1	68.3	50.8	56.0	24.8	26	31.2

[a]Assumes that all projects operating for 5 years have realized their TP reductions. Includes reductions from recently completed and planned projects where load estimates were available.

TIMELINE TO ACHIEVE RECENTLY COMPLETED AND PLANNED PROJECT REDUCTIONS

To provide an estimate of the time it will take to achieve the 24.8 t/yr long-term average reductions from the recently operating and planned projects, the dates when operations would begin for each project were estimated (**Table 16**). It should be noted that the exact timeline for achieving reductions is not known. The TP load reductions are long-term average annual estimates and individual water years will vary due to changes in rainfall, runoff, and biological removal processes. Also, assumptions were made as to when project would be completed and begin operations which presumed that funding would be available. The timeline for all of the planned projects to be in the operations phase is 2025 (when Brady Ranch FEB and ASR begin operation). Allowing 5 years for the projects long-term average reductions to take effect, the S-191 basin should begin seeing the 24.8 t/yr long-term average annual reduction around 2030. That is assuming that there are no project delays and that the long-term estimated reductions are realized over a 5-year period.

Table 16. Operational Dates and expectations for reductions for recently completed and planned projects in the S-191 Basin

Project	Long-term Average Annual TP Reduction	Year When Operation begins	Year TP Long-Term TP Reductions may be Realized[a]
Nubbin Slough STA	4.6	2021	2026
Lakeside Ranch STA	14.4	2021	2026
TCNS 214 Project	1	2024	2029
Grassy Island FEB and ASR	0.8	2024	2029
Brady Ranch FEB and ASR	4	2025	2030
Totals	**24.8**		**2030**

[a]Assuming no project delays and estimates for long-term reductions are realized over a 5-year period.

UPSTREAM LEVEL ANALYSIS

To better understand the source of nutrients within the watershed and to better define where additional projects or program adjustments are needed, data from the upstream monitoring sites were reviewed to identify areas of interest. Currently there are 23 upstream monitoring locations in the S-191 Basin where TP, TN, OPO_4, NH_4, and NO_x are collected (**Figure 19, Tables 17-19**). The current frequency of monitoring at most of the upstream monitoring sites is bi-weekly when flowing, but some are monitored weekly. At most upstream monitoring locations there is no measurement of flow.

The 5-year average annual concentrations were greater than the BMAP (FDEP, 2020) benchmarks for TP (120 µg/L) at all 23 sites and for TN (1,540 µg/L) at 21 of the sites (**Figure 19**, **Tables 17-18**). With so many sites having high TP concentrations, it was decided to review three recently completed trend analyses (FDEP, 2020, Zhang et.al, 2021, and SFWMD unpublished see **Appendix A4**) and focus on sites with statistically significant increasing TP trends. These studies indicated that there were 5 sites within the S-191 Basin with increasing trends (TCNS 214, TCNS 220, TCNS 209, OT34353513, and LB 29353513; **Figure 20**). These sites were selected as areas of interest to be further investigated. All of these trend analyses used a monthly SKT test but each reviewed different time periods. The Zhang et. al, 2021 analysis only included upstream sites which also had a measurement of flow. FDEP's analysis and SFWMD analysis reviewed all upstream data but only sites that indicated statistically significant differences with 50% or greater of monthly data available to analyze were considered. Note only one site had a statistically significant decreasing TP concentration trend and that was TCNS 222 from WY2005-WY2018 (SFWMD unpublished see **Appendix A4**).

Note that in WY2016, monitoring at the upstream sites was reduced from biweekly when flowing to monthly. This resulted in a loss of data that made it difficult to determine monthly trends. The full impact of the data reduction is not known. The monitoring frequency was restored during WY2020 and WY2021 is the first full water year with the restored frequency. Also, February of 2020 is when SFWMD began monitoring for TP, TN, OPO_4, NH_4, and NO_x at all upstream sites in the Northern Everglades. Additional information on the sites in this network can be found in Volume I, Appendix 8B-1 of the 2022 SFER (Junod et al., 2022).

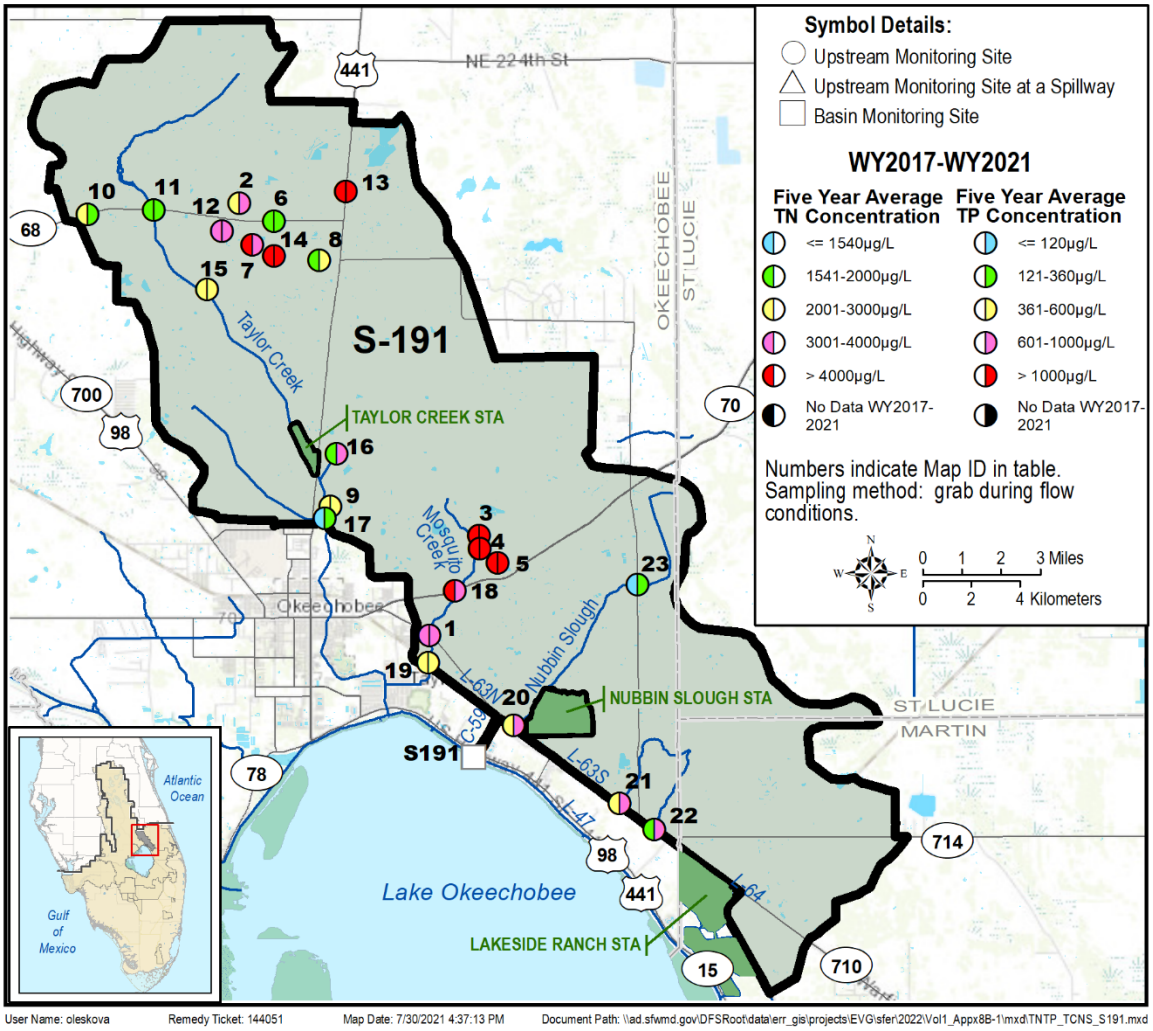

Figure 19. Most recent 5-year average TP and TN concentrations (WY2017–WY2021) for upstream monitoring sites within the Taylor Creek/Nubbin Slough Subwatershed, S-191 Basin (Source Junod and Olson 2022).

Table 17. Most recent 5-year TP concentration data (WY2017–WY2021) for upstream monitoring sites within the Taylor Creek/Nubbin Slough Subwatershed, S-191 Basin. The 5-year average TP concentration is presented on the previous figure. (Source Junod and Olson 2022). (Note: Avg. – Average, Conc. – Concentration, ID – Identifier, Max. – Maximum, Min. – Minimum, and No. – Number of Samples.)

S-191		WY2017 [a]				WY2018 [a]				WY2019 [a]				WY2020 [a]				WY2021				5-Year Avg. TP Conc. (µg/L) [b]
		No.	TP Conc. (µg/L)			No.	TP Conc. (µg/L)			No.	TP Conc. (µg/L)			No.	TP Conc. (µg/L)			No.	TP Conc. (µg/L)			
Map ID	Site		Avg.	Min.	Max.		Avg.	Min.	Max.		Avg.	Min.	Max.		Avg.	Min.	Max.		Avg.	Min.	Max.	
1	02275197[c]	5	626	165	906	7	523	190	1,341	5	362	143	552	5	1,492	182	4,755	16	761	197	2,570	753
2	LB29353513	5	764	80	1,557	9	783	230	3,198	3	609	582	624	5	800	512	992	10	1,537	1,169	1,981	899
3	MS05373613	1	3,170	3,170	3,170	5	1,882	856	3,120	1	1,566	1,566	1,566	0	-	-	-	10	3,875	1,488	10,245	2,623
4	MS08373611	5	1,263	243	2,226	9	890	111	3,005	4	1,186	76	3,363	0	-	-	-	12	1,817	340	7,966	1,289
5	MS08373624	1	2,372	2,372	2,372	3	1,839	1,174	2,579	0	-	-	-	2	8,189	2,808	13,570	6	2,686	1,560	4,570	3,772
6	OT29353514	3	587	452	761	4	288	143	403	0	-	-	-	1	115	115	115	3	203	45	297	298
7	OT32353511	3	1,320	1,190	1,449	7	716	245	1,320	3	624	358	1,053	1	979	979	979	13	943	357	1,888	916
8	OT34353513	4	368	140	756	4	725	147	2,207	2	164	118	209	5	420	86	1,621	15	464	47	1,408	428
9	TC03373511	4	570	201	966	5	571	200	1,102	5	391	216	570	5	408	237	727	7	724	286	2,367	533
10	TC27353413	1	267	267	267	6	356	256	444	4	241	195	282	2	575	395	754	11	327	213	863	353
11	TCNS 201	2	717	676	758	8	293	123	608	4	287	226	390	6	168	114	271	17	196	91	324	332
12	TCNS 204	6	1,002	456	1,574	7	788	303	1,277	4	740	658	901	6	640	396	840	15	784	508	1,106	791
13	TCNS 207[d]	6	797	403	1,301	6	381	164	646	1	2,011	2,011	2,011	4	1,227	444	2,647	12	1,639	345	5,196	1,211
14	TCNS 209[c]	3	845	567	1,217	7	459	131	1,108	5	518	114	1,196	6	560	225	919	3	8,896	2,491	13,823	2,256
15	TCNS 213[c]	6	653	504	901	6	434	211	639	11	324	142	562	10	351	182	639	23	549	62	3,847	462
16	TCNS 214[c]	8	706	339	1,334	4	856	600	1,018	8	519	376	844	5	557	300	1,065	18	742	384	1,186	676
17	TCNS 217[c]	8	329	187	744	10	262	114	541	4	228	184	323	7	311	67	784	16	262	122	437	278
18	TCNS 220	5	668	193	1,041	7	582	215	1,249	4	383	150	917	4	2,335	212	5,870	15	934	228	2,552	980
19	TCNS 222	9	473	189	878	5	617	189	1,085	10	303	152	588	11	597	111	2,382	23	601	147	2,466	518
20	TCNS 228[e]	1	800	800	800	3	1,063	894	1,239	2	500	200	800	0	-	-	-	7	718	528	944	770
21	TCNS 230	3	656	546	716	3	821	537	995	1	626	626	626	0	-	-	-	6	579	400	756	671
22	TCNS 233	4	772	418	1,136	3	975	651	1,158	4	432	325	582	0	-	-	-	15	531	297	895	678
23	TCNS 249	3	226	167	267	3	442	91	640	3	189	107	233	2	47	32	61	11	271	99	665	235

a. During WY2016, the sampling frequency of the majority of the upstream ambient/tributary sites was reduced from biweekly to monthly because of SFWMD resource constraints but was restored to biweekly in February 2020 (WY2020).

b. 5-Year Avg. is the 5-year arithmetic mean of annual average concentration data.

c. Flow data were collected by the United States Geological Survey funded by the Florida Department of Agriculture and Consumer Services at associated flow stations. The flow data are available in the SFWMD's DBHYDRO database accessible at https://www.sfwmd.gov/science-data/dbhydro.

d. Additional data were found for WY2019 that were not reported in previous South Florida Environmental Reports.

e. Flow data were collected by SFWMD at an associated flow station. The flow data are available in SFWMD's DBHYDRO database accessible at https://www.sfwmd.gov/science-data/dbhydro. Note that there may be other flow monitoring sites in this basin that can be found in the database.

Table 18. Most recent 5-year TN concentration data (WY2017–WY2021) for upstream monitoring sites within the Taylor Creek/Nubbin Slough Subwatershed, S-191 Basin. The 5-year average TP concentration is presented on the previous figure. (Source Junod and Olson 2022). (Note: Avg. – Average, Conc. – Concentration, ID – Identifier, Max. – Maximum, Min. – Minimum, and No. – Number of Samples.

S-191		WY2017 [a]				WY2018 [a]				WY2019 [a]				WY2020 [a]				WY2021				5-Year Avg. TN Conc. (µg/L) [b]
			TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)			
Map ID	Site	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	
1	02275197[c]	5	2,144	1,630	2,590	7	2,163	1,460	2,670	5	2,134	1,790	2,410	5	8,224	1,440	31,500	16	3,888	1,690	15,600	3,711
2	LB29353513	0	-	-	-	0	-	-	-	0	-	-	-	1	2,620	2,620	2,620	10	2,760	2,350	3,410	2,690
3	MS05373613	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	10	14,492	2,380	46,500	14,492
4	MS08373611	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	12	8,825	2,670	48,700	8,825
5	MS08373624	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	6	7,265	1,970	14,600	7,265
6	OT29353514	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	3	1,723	1,410	1,900	1,723
7	OT32353511	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	13	6,822	3,080	13,200	6,822
8	OT34353513	0	-	-	-	0	-	-	-	0	-	-	-	2	1,475	1,310	1,640	15	2,403	1,480	3,050	1,939
9	TC03373511	0	-	-	-	0	-	-	-	0	-	-	-	2	1,090	1,070	1,110	7	4,156	1,680	17,400	2,623
10	TC27353413	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	11	2,932	1,970	3,670	2,932
11	TCNS 201	2	2,175	2,140	2,210	8	1,452	578	2,240	4	1,858	1,660	2,020	6	1,517	783	2,320	17	1,523	835	2,080	1,705
12	TCNS 204	6	3,165	2,460	4,180	7	2,673	2,060	3,340	4	3,338	3,300	3,410	6	2,790	2,150	3,870	15	3,626	2,630	5,810	3,118
13	TCNS 207[d]	6	3,393	1,710	5,630	6	4,017	2,130	6,340	1	13,500	13,500	13,500	4	7,758	3,970	16,700	12	9,844	2,650	29,200	7,702
14	TCNS 209[c]	3	3,243	2,120	4,610	7	2,504	1,850	3,070	5	3,280	1,470	5,090	6	3,900	1,670	5,820	3	64,133	18,700	116,000	15,412
15	TCNS 213[c]	5	2,496	1,870	3,350	6	2,335	1,040	3,480	11	1,512	719	2,470	10	1,927	1,140	3,150	23	3,626	1,090	23,600	2,379
16	TCNS 214[c]	8	1,692	963	2,540	4	2,338	1,820	2,850	8	1,409	738	2,170	5	1,583	894	2,220	18	2,429	1,020	4,920	1,890
17	TCNS 217[c]	8	1,549	809	2,850	10	1,493	821	2,230	4	1,018	643	1,680	7	1,340	525	2,830	16	1,719	846	2,540	1,424
18	TCNS 220	5	2,512	1,970	3,050	7	2,573	1,650	3,550	4	2,540	1,460	3,170	4	12,743	1,870	41,700	15	3,543	1,430	15,300	4,782
19	TCNS 222	9	1,746	1,240	2,330	5	2,002	1,160	2,560	10	1,677	1,090	2,880	11	4,114	1,100	16,800	23	3,496	1,430	17,300	2,607
20	TCNS 228[e]	1	2,530	2,530	2,530	3	2,817	2,700	2,970	2	2,320	2,000	2,640	0	-	-	-	7	2,413	2,050	2,760	2,520
21	TCNS 230	3	2,080	1,920	2,170	3	2,263	1,850	2,520	1	2,250	2,250	2,250	0	-	-	-	6	1,913	1,150	2,430	2,127
22	TCNS 233	4	1,988	1,790	2,260	3	2,167	1,800	2,560	4	1,843	1,540	2,060	0	-	-	-	15	1,857	1,530	2,200	1,964
23	TCNS 249	3	1,660	1,450	1,860	3	1,882	855	2,980	3	1,359	967	1,670	2	838	823	852	11	1,536	809	2,620	1,455

a. During WY2016, the sampling frequency of the majority of the upstream ambient/tributary sites was reduced from biweekly to monthly because of SFWMD resource constraints but was restored to biweekly in February 2020 (WY2020). Note that TN monitoring began at many of the upstream monitoring locations in February 2020 as part of SFWMD expanded monitoring.

b. 5-Year Avg. is the 5-year arithmetic mean of annual average concentration data.

c. Flow data were collected by the United States Geological Survey funded by the Florida Department of Agriculture and Consumer Services at associated flow stations. The flow data are available in the SFWMD's DBHYDRO database accessible at https://www.sfwmd.gov/science-data/dbhydro.

d. Additional data were found for WY2019 that were not reported in previous South Florida Environmental Reports.

e. Flow data were collected by SFWMD at an associated flow station. The flow data are available in SFWMD's DBHYDRO database accessible at https://www.sfwmd.gov/science-data/dbhydro. Note that there may be other flow monitoring sites in this basin that can be found in the database.

Table 19. Number of samples and averages for additional water quality parameters collected in WY2021 for the Taylor Creek/Nubbin Slough Subwatershed, S-191 Basin. (Source Junod and Olson 2022).

WY2021								
S-191	OPO_4 (µg/L)		NH_4 (µg/L)		NO_x (µg/L)		Specific Conductance (µS/cm) [a]	
Site	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.
02275197	15	582	13	884	15	736	15	759
LB29353513	1	1,646	1	171	1	5	1	267
MS05373613	2	1,916	2	2,372	2	195	2	1,228
MS08373611	4	1,964	4	139	4	1,398	1	228
MS08373624	6	2,023	6	3,541	6	174	2	853
OT29353514	2	201	3	67	3	64	3	202
OT32353511	8	1,063	8	2,510	7	550	8	389
OT34353513	12	477	13	618	12	100	13	283
TC03373511	7	484	7	2,402	6	146	7	392
TC27353413	8	195	8	261	7	89	8	180
TCNS 201	16	133	17	84	16	150	15	321
TCNS 204	14	690	15	309	13	1,213	15	535
TCNS 207	0	-	0	-	0	-	0	-
TCNS 209	2	4,673	2	9,975	2	2,796	3	1,812
TCNS 213	22	430	23	1,405	20	654	22	478
TCNS 214	17	613	17	697	16	167	17	571
TCNS 217	15	190	14	106	14	120	15	181
TCNS 220	14	756	14	1,324	12	363	14	380
TCNS 222	23	416	21	1,037	22	603	23	826
TCNS 228	7	610	7	187	6	188	7	201
TCNS 230	6	478	5	141	5	91	6	357
TCNS 233	15	451	14	141	14	110	15	266
TCNS 249	2	504	1	289	2	8	3	90

a. µS/cm – microsiemens per centimeter.

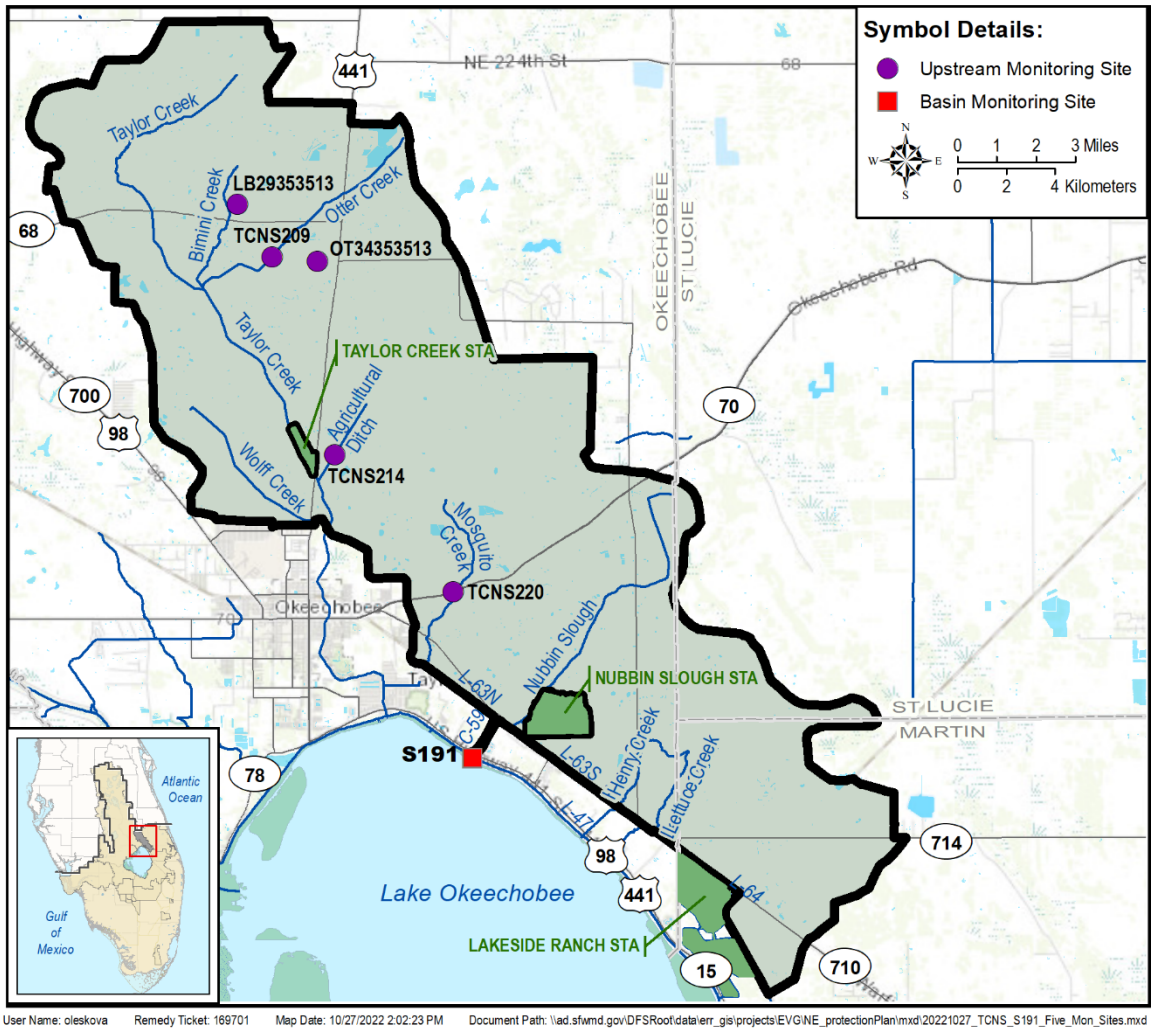

Figure 20. Five upstream monitoring sites with statistically significant increasing trends.

TCNS 214

TCNS 214 is located on Agricultural Ditch (**Figure 20**) and is approximately 10.5 miles upstream of the S-191 structure. This site was identified as having statistically significant increasing trends in three separate SKT studies. FDEP found increasing trends from the period of WY2009-WY2018 (FDEP, 2020). SFWMD found increasing trends for the period of WY2005-WY2018 (SFWMD unpublished - see **Appendix A4**). Zhang et. al. found increasing trends in FWMC for both TP and TN (Zhang et al. 2021) for the period of WY2006-WY2019.

Figures 21 and **22** depict the average TP and TN concentration data, respectively from this site along with the rainfall in inches for the S-191 Basin. The average annual TP concentrations appear to be increasing and since WY2010 have been above 400 µg/L with one exception WY2012 (395 µg/L). The average TP annual concentrations at this site have greater than the BMAP (FDEP, 2020) TP benchmark of 120 µg/L every year it has been monitored. The average annual TN concentrations were greater than the BMAP (FDEP, 2020) TN benchmark of 1,540 µg/L for four out of the last five water years.

The contributing area (**Figure 23**) for this upstream site is approximately 20,000 acres and includes agriculture (83.2%), non-agriculture (4.8%), and natural areas (12%). **Figure 24** depicts the land use and the septic tanks within the contributing area. A cluster of septic tanks for a residential area is located in the northwest corner of the contributing area. The TCNS 214 site has measurement of flows as well as concentrations and it is estimated that the drainage area contributes 14 t TP and 44 t TN annually (Zhang et al. 2021) to Williamson Ditch. The estimated UAL for this area is 1.49 lb/ac for TP and 4.80 lb/ac of TN (Zhang et a., 2021). As of November 2021, 17,504 acres within the contributing area are enrolled in the FDACS BMP program (**Figure 25)**. However, 700 acres are labelled as agriculture lands that are not enrolled which need to be reviewed with FDACS. Note the area labelled as agriculture that is immediately upstream of the TCNS 214 monitoring location is not agriculture, but a natural area on state owned property. Landowners of any applicable unenrolled lands need to be notified of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C. There are state-owned lands available for an additional project on Agricultural Ditch and SFWMD recently received a grant for a project on these lands (**Figure 26**). This is an ideal location as it could be used to treat water from Agricultural Ditch prior to it entering Taylor Creek.

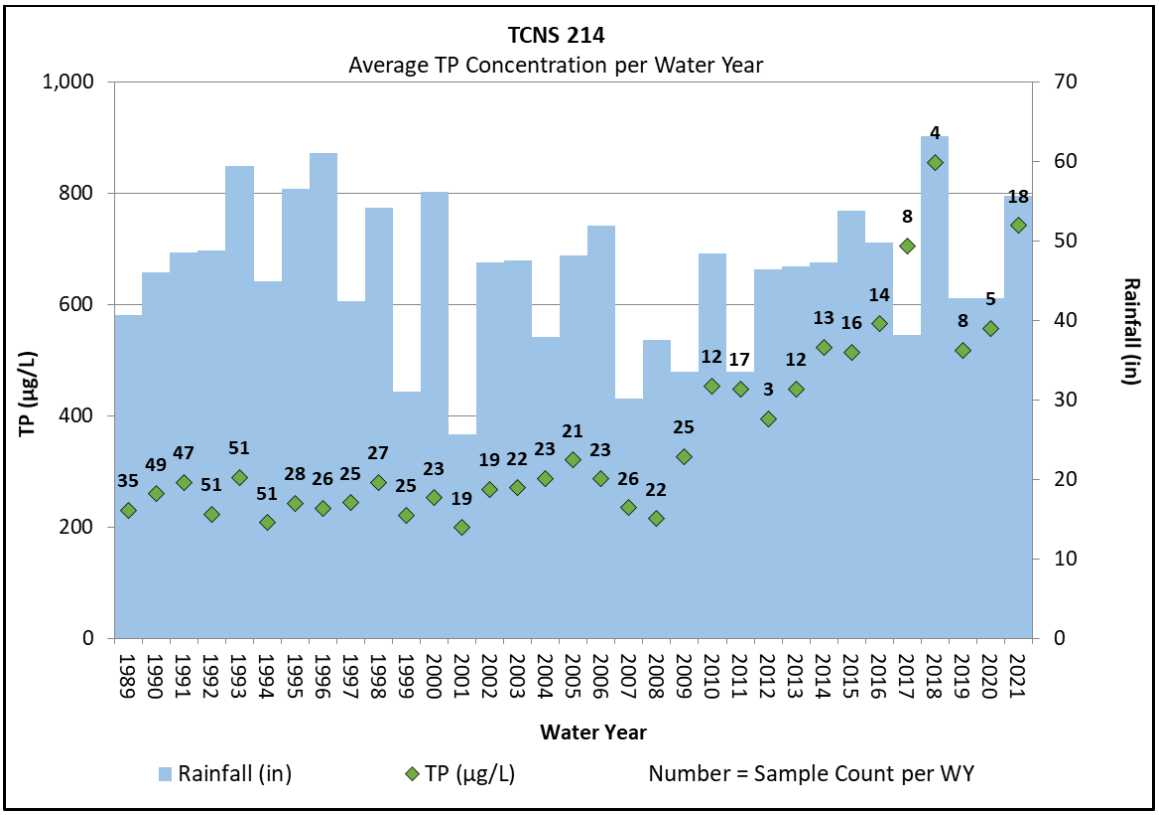

Figure 21. Average TP Concentration per Water Year for Site TCNS 214.

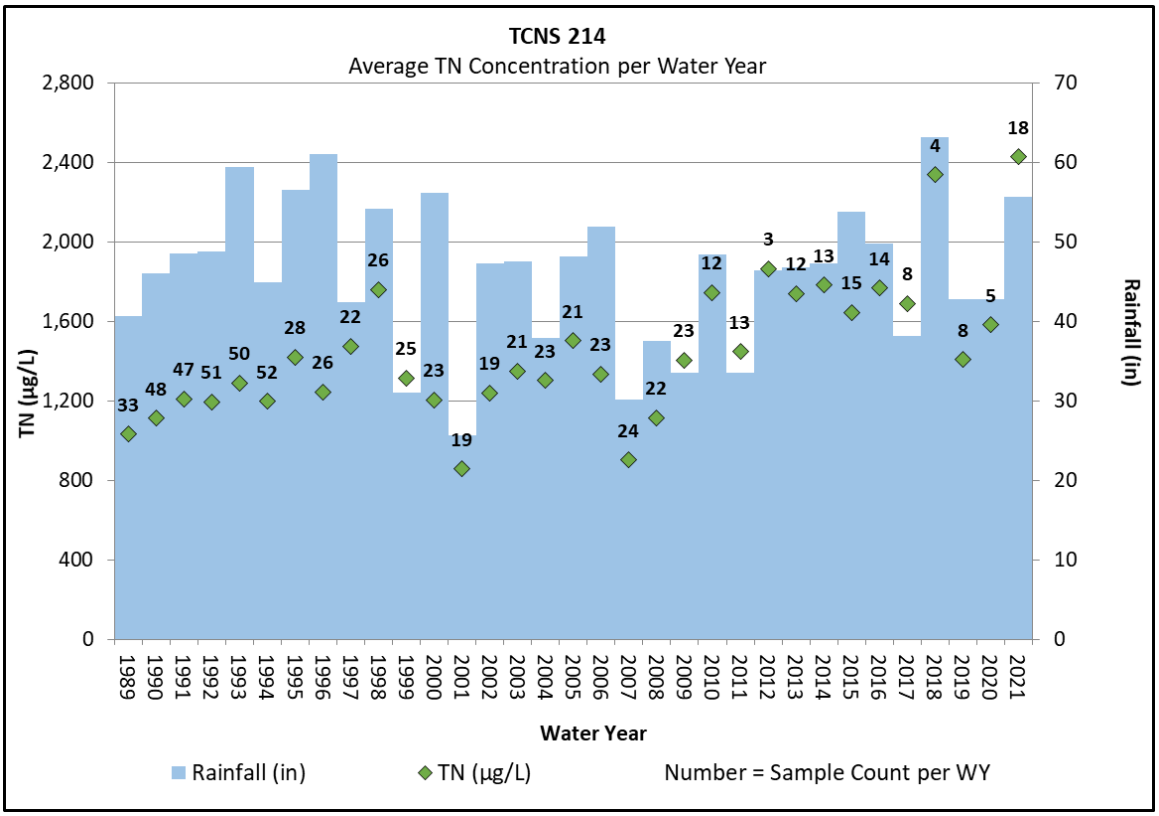

Figure 22. Average TN Concentration per Water Year for Site TCNS 214.

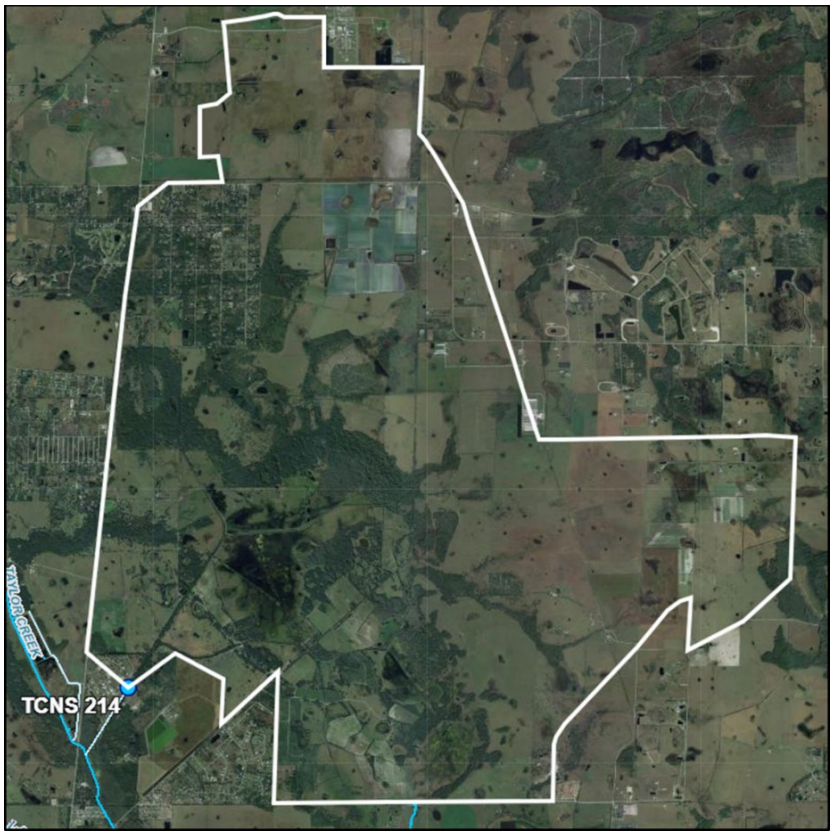

Figure 23. Contributing area of TCNS 214.

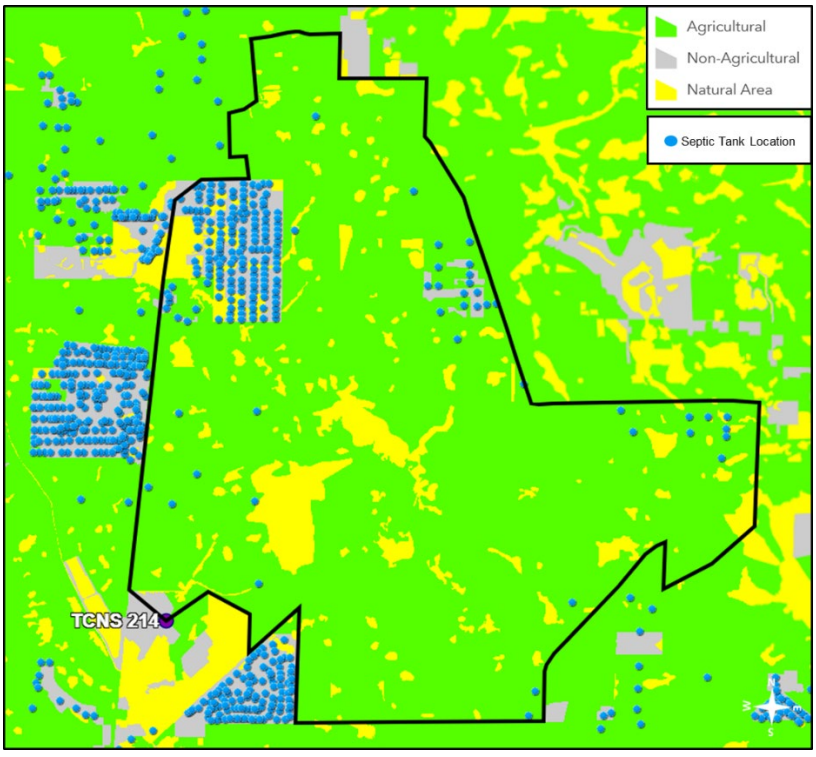

Figure 24. Land use and septic tanks in the Contributing area of TCNS 214.

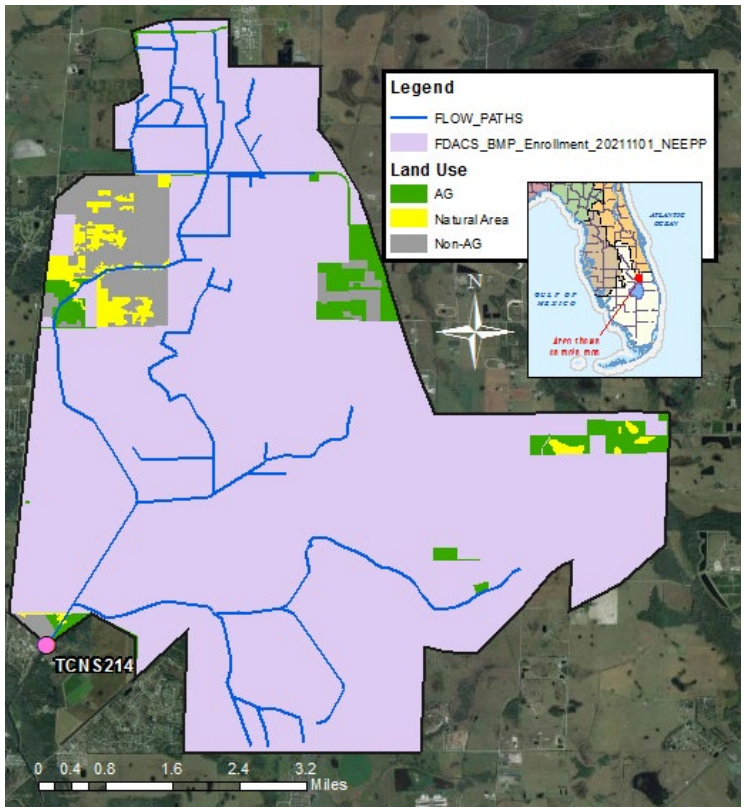

Figure 25. FDACS enrollment within the TNCS 214 Contributing area as of November 2021.

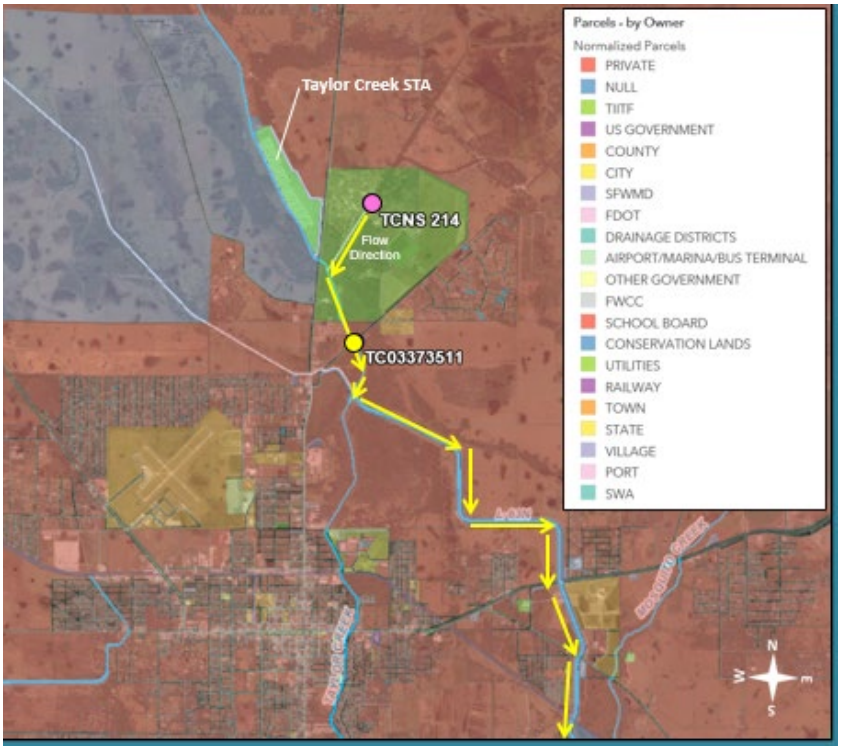

Figure 26. Land ownership in the vicinity of TCNS 214.

SFWMD ERPs issued within the contributing area for TCNS 214 are presented in **Figure 27**. To determine if any significant changes had been made within the contributing area that may have impacted water quality at this site Environmental Resource Permits (ERP), Surface Water Management permits (SWM), and exemptions issued since 2007 were reviewed (**Table 20**). Two permits were issued for wetland reserve projects. Three were issued for a poultry farm located in the eastern portion of the contributing area. Nine were related to a subdivision located in the eastern portion of the contributing area. One was for aquaculture and one was for a mine located in the eastern portion of the contributing area. One was for a vegetable farm located in the north central portion of the contributing area. One was for a storage and RV lot on the northwest corner of the contributing area. Of these permitted changes, the poultry farm and the row crop areas appear to be the most intensive land use types in terms of nutrients and both appear to be enrolled in the FDACS BMP program based on a review of the FDACS enrollment map (**Figure 25**). The change in water quality occurred around WY2010 (**Figure 21**). The poultry farm permit was issued in 2013. The row crop area has been farmed since circa 2004 and the recent permit actions were for a permit transfer and modifications. Since both facilities were issued ERPs which provide a certain level of water quality treatment in addition their FDACS enrollment, there is no obvious cause for the water quality issues within the contributing area for TCNS 214 based on a review of the ERPs.

Similar to the TP and Ortho P analysis completed at the basin level, an analysis was done for TCNS 214 (**Figure 28, Table 21**). On average the samples are 79% Ortho P which indicates that BMPs upstream should focus on soluble P. A review of the sample comments for this site indicates there have been times that the site was too heavily vegetated to be able to collect a sample but did not reveal any changes that occurred around WY2010.

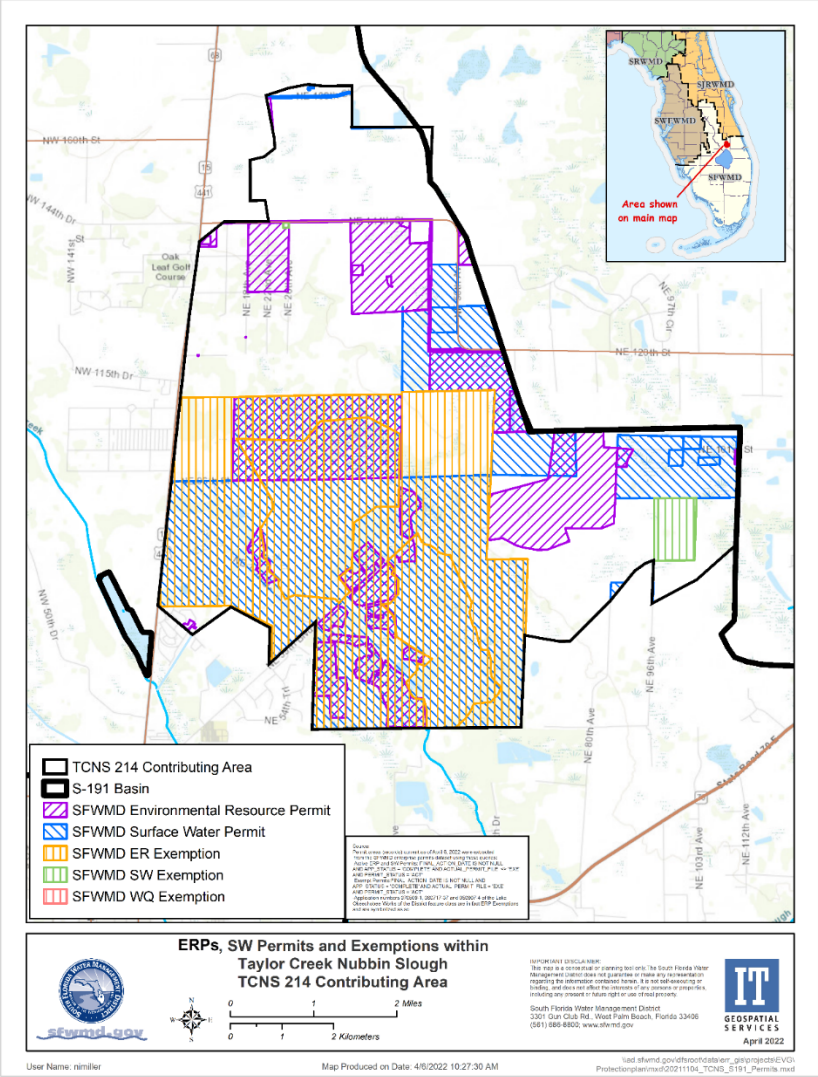

Figure 27. SFWMD permits and exemptions in the Contributing area of TCNS 214.

Table 20. SFWMD ERP and exemptions within the Contributing area of TCNS 214.

Site TCNS 214			
Permit Number	**Application Number**	**Final Action Date**	**Description**
47-00068-S	140807-7	9/4/2014	Exemption – The objective of this project was for a Wetland Reserve Project to restore or enhance wetlands and wet prairie onsite.
47-00081-S	111209-14	2/22/2012	Transfer construction and operation of a surface water management system serving 470 acres of agricultural lands discharging via unnamed ditch into Taylor Creek.
	131107-23	12/30/2013	Construction and operation of a 561-acre agricultural facility (poultry and cattle farm)
47-00456-P	111209-12	2/22/2012	Transfer permit for egg farm.
47-106022-P	211010-31289	11/5/2021	Authorizes the replacement of structures at layer facility and addition of a structure at the pullet facility. No modifications to the stormwater management system were proposed as the existing system (under permit 47-00081-S) provided the required water quality treatment volume and attenuation.
47-00182-S	061031-19	2/23/2007	Transfer – Construction and operation of a surface water management system serving a 20.09-acre residential site (facilities on Lot 7 Pine Island Subdivision).
47-00182-S-04	150814-9	8/31/2015	Modification of the previously permitted surface water management system to reflect current ownership and operation of a SWMS serving a 27.39-acre aquaculture project.
47-00182-S-06	091027-8	12/1/2009	Minor Modification – Construction of the facilities (600 ft long pervious driveway; residence with adjacent pool, shed, and decks, and a small pond) on Lot 3 Pine Island Subdivision.
47-00182-S-07	100303-13	4/1/2010	Minor Modification – Construction of the facilities (pervious driveway, residence, two pole barns, patio, and a ½ acre pond) on Lot 12 Pine Island Subdivision.
47-00182-S-07	200716-3891	8/19/2020	Permit Transfer for Pine Island Subdivision Lot 12.
47-00182-S-08	110308-13	4/12/2011	Minor Modification – Construction of the facilities (pervious driveway, residence, paver patio and walkway, and two small ponds) on Lot 4 Pine Island Phase 1.
47-00182-S-09	110228-18	4/20/2011	Minor Modification – Construction of the facilities (driveway, residence, barn, dog kennel, miscellaneous sheds, and a pond) on Lot 16 Pine Phase 1.

47-00182-S-10	110726-20	8/30/2011	Minor Mod – Construction of the facilities (concrete driveway, residence, barn, shop, and two ponds) on Lot 18 Pine Island Subdivision.
47-00182-S-11	110720-12	9/2/2011	Minor Modification – Construction of the facilities (pervious driveway, residence, pole barn, and shed) on Lot 21 Pine Island Phase 1.
47-00182-S-12	150717-1	7/23/2015	Transfer to reflect the current ownership and operation of a surface water management system serving a 31.98-acre mining project.
47-00182-S-13	160125-21	2/9/2016	Modification to reflect the current ownership and operation of a surface water management system serving a 10-acre agricultural project known as Pine Island Borrow Pit 2 – Lot 1.
47-00674-P	070507-31	11/9/2007	Minor Modification – Relocation of the outfall structure from the second stage of the eastern reservoir for the vegetable farm.
	090818-13	1/26/2012	Minor Modification – Relocating the West Basin reservoir pump from the northeast corner of the first cell to the south end of the first cell.
	140127-4	2/13/2014	Permit Transfer to Campbell Farms Florida.
	151112-22	1/11/2016	Modification – Construction of a vegetable packing house. The surface water management system includes a dry detention area and control structure to provide pre-treatment prior to discharging to the master system.
	160630-2	7/31/2017	Modification – Construction and operation of a 11.03-acre wetland mitigation project.
	180301-31	3/13/2018	Accepted as built system for water quality pretreatment system for a packing house and parking area discharging to the master stormwater management system.
47-00723-P	080325-8	5/8/2008	Minor Modification – Construction of a new swale to convey runoff from off-site properties around the project for surface water management system for storage and RV lot.
47-01097-P	120228-10	4/23/2012	Construction and operation of a surface water management system to serve an 870-acre project Wetland Reserve Project

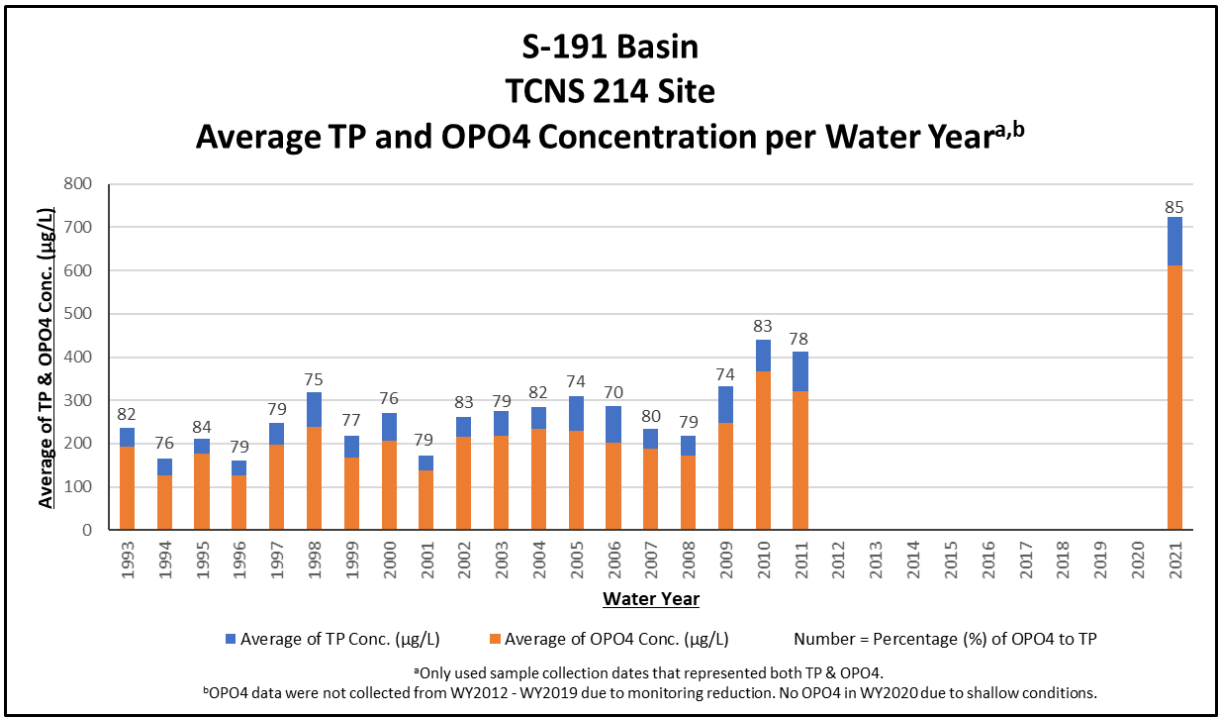

Figure 28. Average TP and OPO_4 concentrations per water year at the TCNS 214 site.

Table 21. Speciation Information per Water Year at the TCNS 214 site.

TCNS214 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
1993	236	194	82%	7
1994	167	127	76%	2
1995	211	177	84%	1
1996	161	127	79%	2
1997	249	197	79%	19
1998	319	239	75%	16
1999	218	168	77%	20
2000	271	207	76%	12
2001	173	137	79%	12
2002	262	216	83%	18
2003	275	218	79%	20
2004	286	234	82%	21
2005	310	230	74%	20
2006	287	202	70%	23
2007	235	187	80%	26
2008	218	172	79%	20
2009	333	247	74%	15
2010	440	366	83%	10
2011	413	321	78%	11
2012[b]	-	-	-	-
2013[b]	-	-	-	-
2014[b]	-	-	-	-
2015[b]	-	-	-	-
2016[b]	-	-	-	-
2017[b]	-	-	-	-
2018[b]	-	-	-	-
2019[b]	-	-	-	-
2020[b]	-	-	-	-
2021	723	613	85%	17
Minimum	**161**	**127**	**70%**	**1**
Maximum	**723**	**613**	**85%**	**26**
Average	**289**	**229**	**79%**	**15**

[a]Only used sample collection dates that represented both TP & OPO4.

[b]OPO4 data were not collected from WY2012 - WY2019 due to monitoring reduction. No OPO4 in WY2020 due to shallow conditions.

Recommendations for TCNS 214 include:

- Continuing to investigate the potential causes of increasing concentration trends with FDEP and FDACS.
- SFWMD to notify FDEP who will review the septic tank cluster within the TCNS 214 contributing area. These septic tank clusters may be addressed under future plan requirements under the Clean Waterways Act.
- Notifying landowners of any applicable unenrolled lands within the TCNS 214 contributing area of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Continue the development of a project on the state-owned lands surrounding the TCNS 214 (**Figure 26**) as this is an ideal location to treat the water from Agricultural Ditch.
- Ensure that BMPs and projects upstream of this location address soluble P based on the level of Ortho P.
- Consider a re-evaluation of the BMPs in the TCNS 214 contributing area due to the increasing trends in TP concentrations.

TCNS 220

Located on Mosquito Creek, TCNS 220 (**Figure 20**) is approximately 5.63 miles upstream of the S-191 structure. The site had statistically significant increasing trends in TP concentrations for the period of WY2009-WY2018 based on a monthly SKT (FDEP, 2020). **Figures 29** and **30** depict the average annual TP and TN concentration data, respectively from this site along with the rainfall in inches for the S-191 Basin. The average annual TP concentrations for WY2020 were unusually high, although only four samples were collected. The TP average annual concentration for WY2021 was lower than WY2020 but still at the higher range compared to previous average concentrations collected at this location. The average annual concentrations at this site were greater than the BMAP (FDEP, 2020) TP benchmark of 120 µg/L every year it has been monitored. The average annual TN concentrations have been greater than the TN (1,540 µg/L) benchmark every year that SFWMD collected data, except in WY2011.

The contributing area (**Figure 31**) for this upstream site is approximately 6,500 acres and includes agriculture (90.9%), non-agriculture (4.2%), and natural areas (4.9%). **Figure 32** depicts the land use and the septic tanks within the contributing area. A cluster of septic tanks is located on the far eastern side of the contributing area. As of November 2021, 5,959 acres within the contributing area are enrolled in the FDACS BMP program (**Figure 33)**. However, 467 acres are labelled as agriculture lands that are not currently enrolled which should be reviewed with FDACS. Landowners of any applicable unenrolled lands need to be notified of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C. There is no state-owned land available for an additional project on Mosquito Creek, but the County owns property along the creek that is heavily vegetated (**Figure 34**). Further investigation is needed to determine if the area would be suitable for a project.

SFWMD ERPs issued within the contributing area for TCNS 220 are presented in **Figure 35**. To determine if any significant changes had been made within the contributing area that may have impacted water quality at this site Environmental Resource Permits (ERP), Surface Water Management permits (SWM), and exemptions issued since 2009 were reviewed (**Table 22**). Two were issued for mud bogging events, one was issued for the development of a gun club and one was issued for an expansion of State Road (SR) 70. The impact from the mud bogging events is unknown. The location for one of the mud bogging permits is on the eastern portion of the contributing area and is approximately three miles from the monitoring location. The location for the second mud bogging permit, which expired in 2015, was in the north central portion of the contributing area and was also approximately three miles from the TCNS 220

monitoring site. The SR 70 road expansion involved replacing the bridge where the samples are collected and occurred between 2014 and 2017. The increasing trends based on the monthly SKT were between WY2009 and WY2018 and all of these actions had ERPs which provide a certain level of water quality treatment. Thus, there is no obvious cause for the water quality issues within the contributing area for TCNS 220 based on a review of the ERPs.

Similar to the TP and Ortho P analysis completed at the basin level, an analysis was done for TCNS 220 (**Figure 36, Table 23**). On average the samples are 83% Ortho P. Note the percentage of Ortho P appears to be decreasing over time but there is a large gap in Ortho-P collection. A review of the sample comments for this site for WY2017 to WY2021 indicates there were only three times that the samples appeared to contain particulates.

Just upstream of TCNS 220 is a HWTT project funded by FDACS but operated on private property. A review of WY2020 data from the HWTT indicates that large amount of TP was observed at the project inflow in August, September and January that coincided with high TP concentrations collected at TNCS 220. This indicates that something upstream of the HWTT was causing the high concentrations. FDACS reports that the HWTT on Mosquito Creek is designed to treat 6 cfs, the average daily flow through the project is 1.5 cfs (from 7/1/2019-6/30/2020), and the average daily flow at Mosquito Creek is 9.3 cfs at USGS 02275197. This project is constrained by intermittent flows from the creek and the project footprint. A water storage project was suggested to assist with the intermittent flows, but the landowner has a limited amount of space that can be dedicated to the project. It was suggested that other locations along Mosquito Creek might be used for an additional nutrient reduction project.

Two dairy barns are located within the contributing area that have FDEP wastewater permits. The barns were last inspected in 2019 and at that time no violations were observed. No discharges from the wastewater ponds were reported between May of 2015 to July of 2021. FDEP reported that TP concentrations at one of the compliance monitoring wells was above the background monitoring well concentration by 572% for one barn and that two compliance monitoring wells from the other barn had TP concentrations 100% and 4,865% above the background. FDEP also reported that the spray-field effluent from one barn was 10,490 µg/L for TP and 43,550 µg/L for TN for the period between September 2009 and June of 2021. FDEP has committed to investigating groundwater limits and spray-field discharges related to dairy permitting at this site.

There are three monitoring sites located on the dairy within the contributing area of the TCNS 220 monitoring location (**Figure 31**) that flow to TCNS 220, MS05373613, MS08373611, and MS08373624. None of these sites have measurement of flow and were not considered under the Zhang et al. 2021 study. MS08373611 was reviewed under the FDEP and SFWMD study but no significant trend was found. The other two sites did not have enough data to be considered. **Table 24** provides the TP and TN data from these sites for the last five water years. The high concentrations observed at these sites may be a contributing to the high concentrations observed at TCNS 220. It should also be noted that a June 2015 helicopter flight documented dairy cattle in Mosquito Creek just upstream of the monitoring sites.

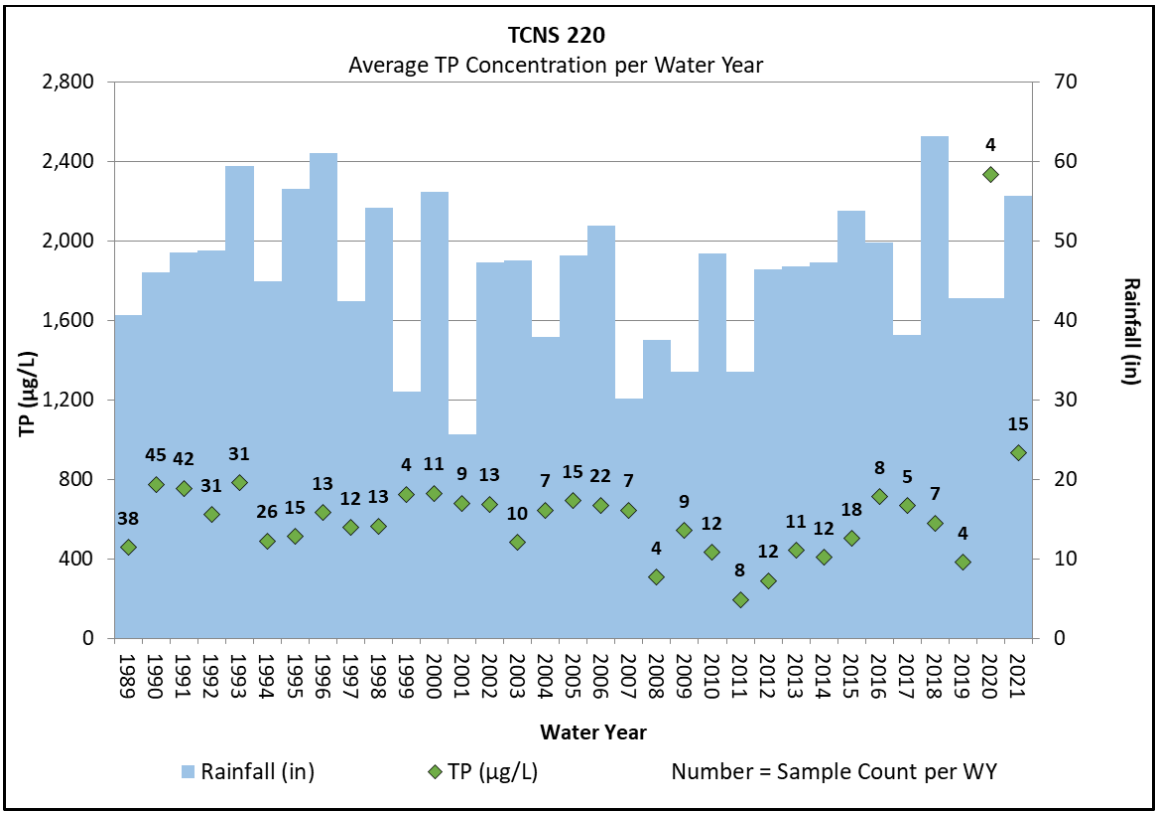

Figure 29. Average TP Concentration per Water Year for Site TCNS 220.

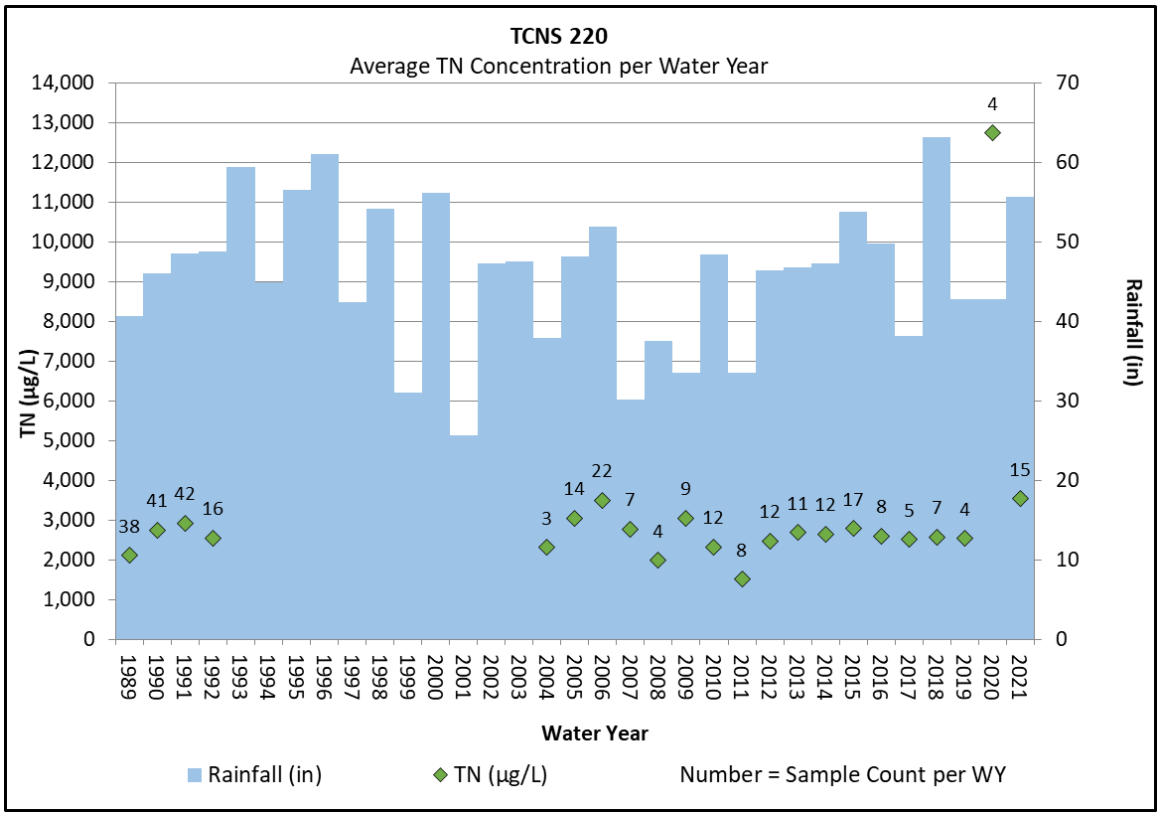

Figure 30. Average TN Concentration per Water Year for Site TCNS 220.

Figure 31. Contributing Area of Site TCNS 220 (6,500 acres), including 3 additional upstream sites (1,000 acres).

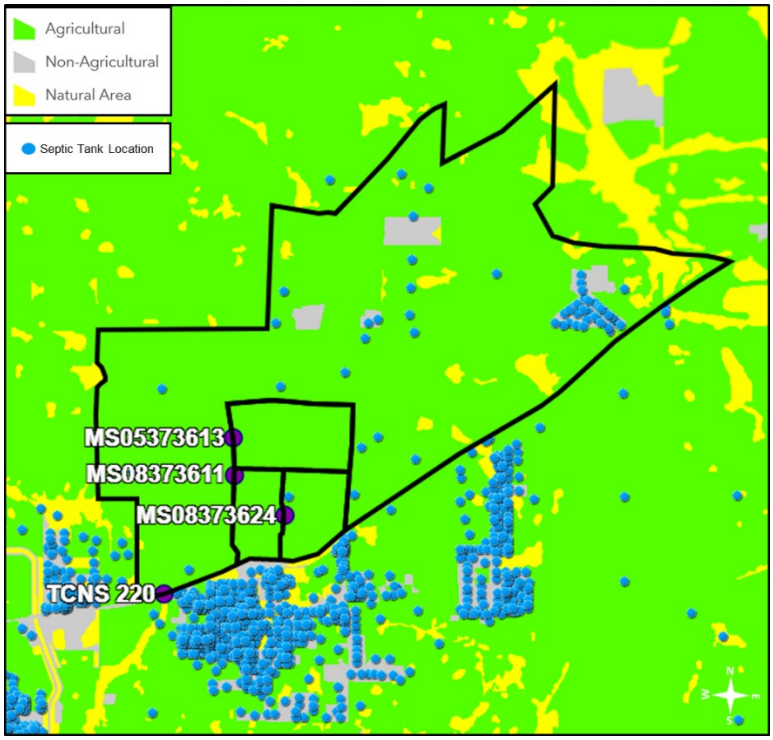

Figure 32. Land use and septic tanks in the Contributing area of TCNS 220 and the 3 additional upstream sites.

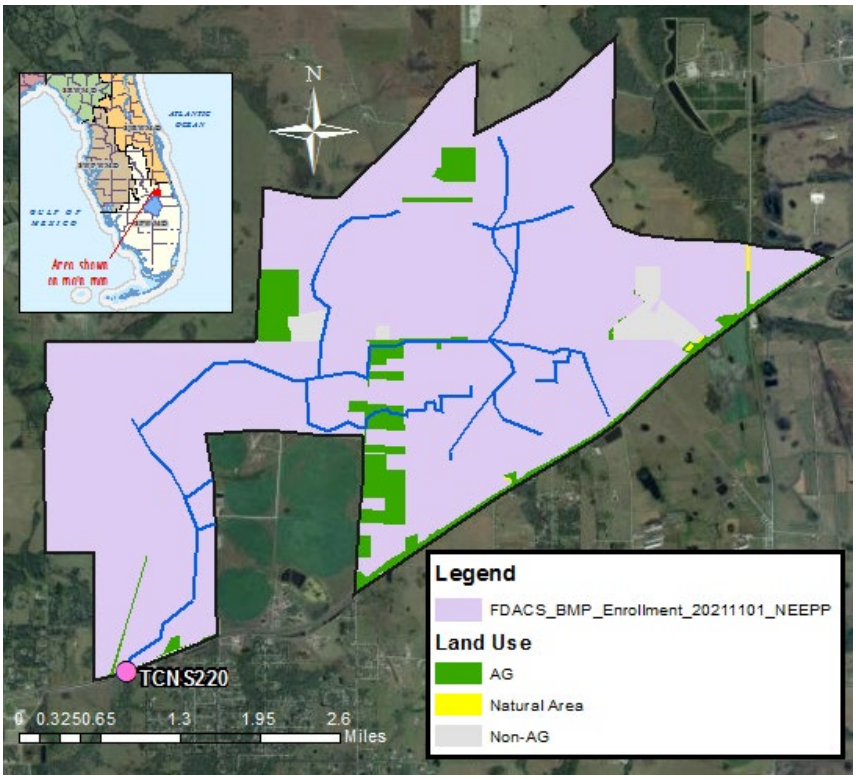

Figure 33. FDACS enrollment within the TNCS 220 Contributing area as of November 2021.

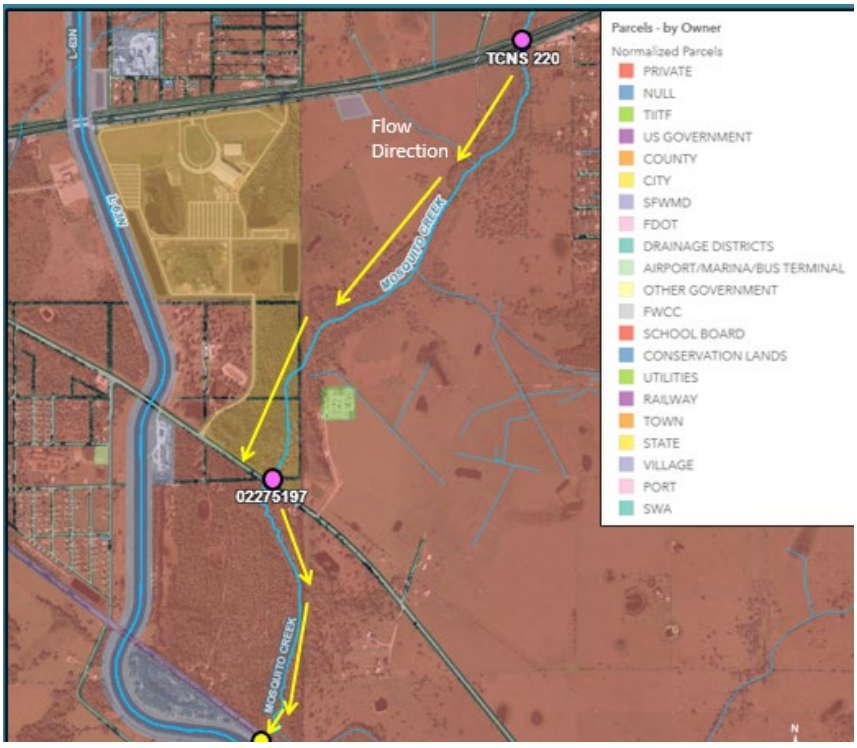

Figure 34. Land ownership in the vicinity of TCNS 220.

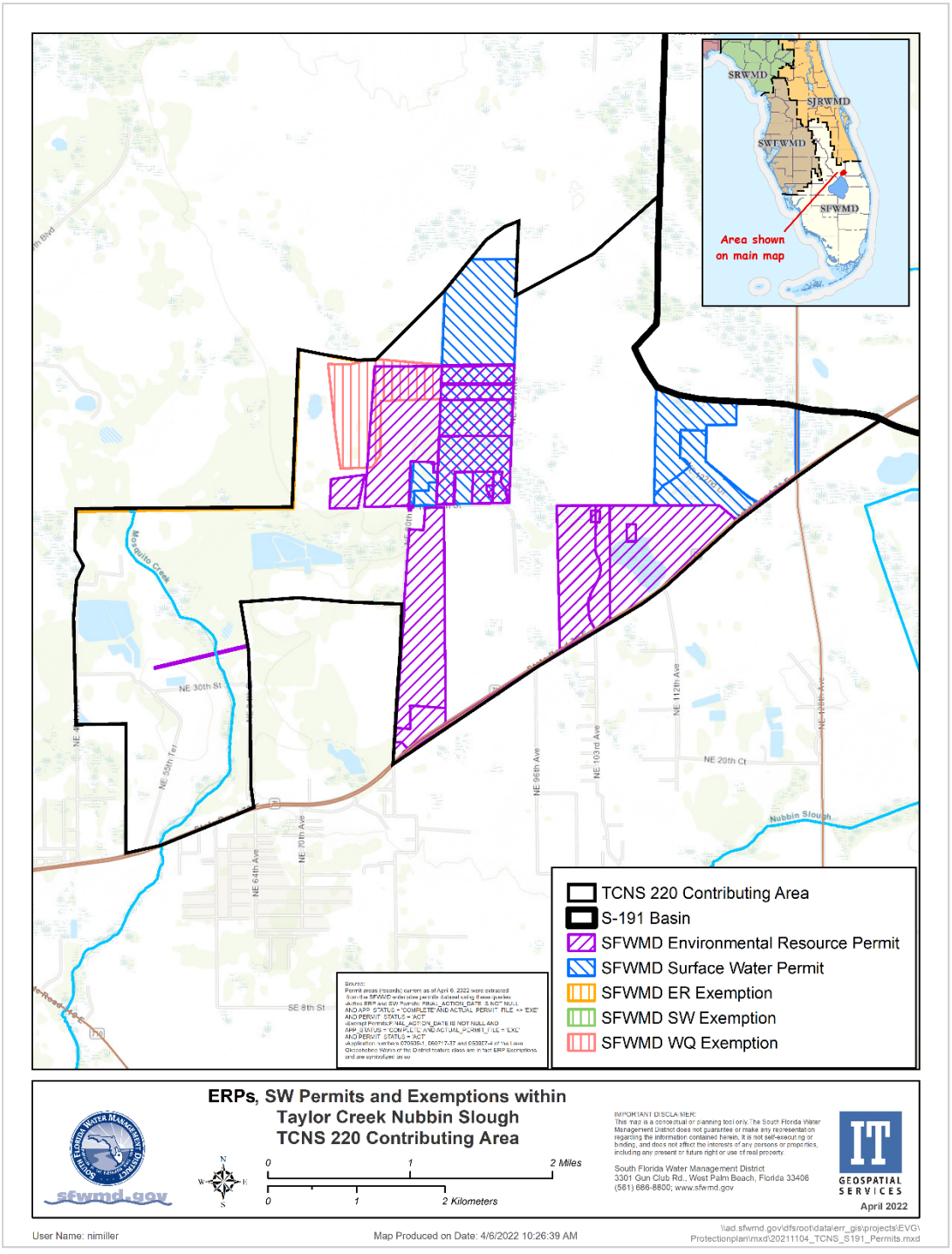

Figure 35. SFWMD permits and exemptions in the contributing area of TCNS 220.

Table 22. SFWMD permits and exemptions within the contributing area of TCNS 220 since 2009

Site TCNS 220			
Permit Number	**Application Number**	**Final Action Date**	**Description**
47-00651-P	090106-10	6/21/2010	Modification of the existing authorization to include holding airboat racing events up to a maximum of six times a year resulting in temporary impacts to the onsite 54.81-acre wetland.
	120106-8	2/15/2012	Modifications to the Mud Fest project, in accordance with Consent Order No. SFWMD 2012-002-CO-ERP, to reduce the amount of frequency of monitoring; modify the conditions under which future events can occur; and require smoothing of ruts during the dry season if water levels and conditions allow.
47-00715-P	081010-6	12/2/2008	Construction and operation of a surface water management system to serve a 317.74-acre project known as Holley Mud Hole.
	110803-7	10/21/2011	Permit Extension Hb7207) - Original Expiration Date (December 2, 2013) changed to New Expiration Date (December 2, 2015).
47-01041-P	100722-16	12/2/2010	Construction and operation of a surface water management system to serve a 40.0-acre project known as Private Gun Club.
	110408-5	5/23/2011	Construction and operation of a surface water management system to serve a 80.0-acre project known as O K Corral Gun Club.
	120719-6	7/31/2012	Minor Modification - Proposed construction of a banquet hall at the gun club facility which includes construction of a proposed building and vehicular use. The proposed improvements are located within the master storm water system previously permitted.
	121016-7	1/4/2013	Modification - Construction and operation of a surface water management system to serve a 14.5-acre project known as O K Corral Access Road.
	121113-1	1/4/2013	Modification - Construction and operation of a surface water management system to serve a 279.07-acre project

			known as O K Corral Gun Club 200 Acre Site Expansion.
	150122-12	2/4/2015	Modification of Work Schedule.
	150413-17	7/27/2015	Modification - Construction and operation modifications to an existing 279.07 acre recreational/commercial development, totaling 6.8 acres.
	160504-14	6/13/2016	Adjustments in site grading.
	180816-2	8/29/2018	Modification - Construction and operation modifications to a 319.07 acre recreational and commercial development, totaling 3.82 acres, known as O K Corral RV Parking (Basin C).
47-01151-P	121210-2	11/18/2013	Construction and operation of a 120.36-acre roadway project known as SR 70 (NE 31st Street to East of NE 80th Avenue).
	131212-9	1/31/2014	Modification to add 1.511 acres of right of way and to offset the deduction of a 0.083-acre area of conservation easement through the purchase of a 0.05 forested wetland credits from Bluefield Ranch Mitigation Bank.

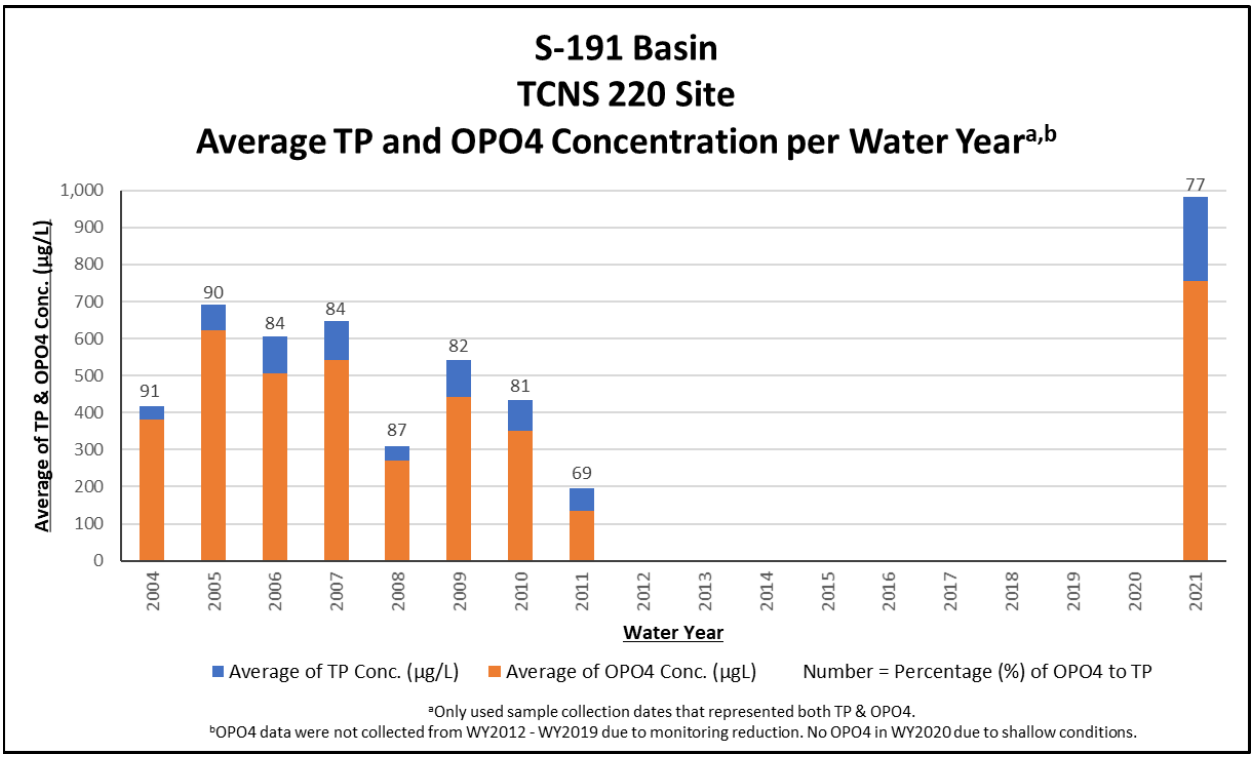

Figure 36. Average TP and OPO_4 concentrations per water year at the TCNS 220 site.

Table 23. Speciation Information per Water Year at the TCNS 220 site.

TCNS220 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
2004	419	380	91%	3
2005	692	622	90%	15
2006	606	507	84%	21
2007	646	543	84%	7
2008	309	270	87%	4
2009	543	443	82%	9
2010	434	352	81%	12
2011	194	134	69%	8
2012[b]	-	-	-	-
2013[b]	-	-	-	-
2014[b]	-	-	-	-
2015[b]	-	-	-	-
2016[b]	-	-	-	-
2017[b]	-	-	-	-
2018[b]	-	-	-	-
2019[b]	-	-	-	-
2020[b]	-	-	-	-
2021	984	756	77%	14
Minimum	**194**	**134**	**69%**	**3**
Maximum	**984**	**756**	**91%**	**21**
Average	**536**	**445**	**83%**	**10**

[a]Only used sample collection dates that represented both TP & OPO4.

[b]OPO4 data were not collected from WY2012 - WY2019 due to monitoring reduction. No OPO4 in WY2020 due to shallow conditions.

Table 24. Most recent 5-year TP and TN concentration data (WY2017–WY2021) for Site TCNS 220 and the three upstream monitoring sites (MS05373613, MS08373611, and MS08373624).

S-191		WY2017 [a]				WY2018 [a]				WY2019 [a]				WY2020 [a]				WY2021				5-Year Avg. TP Conc. (µg/L) [b]
			TP Conc. (µg/L)				TP Conc. (µg/L)				TP Conc. (µg/L)				TP Conc. (µg/L)				TP Conc. (µg/L)			
Map ID	Site	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	
3	MS05373613	1	3,170	3,170	3,170	5	1,882	856	3,120	1	1,566	1,566	1,566	0	-	-	-	10	3,875	1,488	10,245	2,623
4	MS08373611	5	1,263	243	2,226	9	890	111	3,005	4	1,186	76	3,363	0	-	-	-	12	1,817	340	7,966	1,289
5	MS08373624	1	2,372	2,372	2,372	3	1,839	1,174	2,579	0	-	-	-	2	8,189	2,808	13,570	6	2,686	1,560	4,570	3,772
18	TCNS 220	5	668	193	1,041	7	582	215	1,249	4	383	150	917	4	2,335	212	5,870	15	934	228	2,552	980

S-191		WY2017 [a]				WY2018 [a]				WY2019 [a]				WY2020 [a]				WY2021				5-Year Avg. TN Conc. (µg/L) [b]
			TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)				TN Conc. (µg/L)			
Map ID	Site	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	
3	MS05373613	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	10	14,492	2,380	46,500	14,492
4	MS08373611	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	12	8,825	2,670	48,700	8,825
5	MS08373624	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	6	7,265	1,970	14,600	7,265
18	TCNS 220	5	2,512	1,970	3,050	7	2,573	1,650	3,550	4	2,540	1,460	3,170	4	12,743	1,870	41,700	15	3,543	1,430	15,300	4,782

a. During WY2016, the sampling frequency of the majority of the upstream ambient/tributary sites was reduced from biweekly to monthly because of SFWMD resource constraints but was restored to biweekly in February 2020 (WY2020). Note that TN monitoring began at many of the upstream monitoring locations in February 2020, as part of SFWMD expanded monitoring.
b. 5-Year Avg. is the five-year arithmetic mean of annual average concentration data.

Recommendations for TCNS 220 include:

- Continuing to investigate the potential causes of the increasing concentrations trends with FDEP and FDACS.
- FDEP should continue to follow up with the dairy permitting program and reviewing groundwater/surface water interactions with SFWMD.
- SFWMD should investigate working with Okeechobee County, dependent upon site conditions, to see if an additional project could be developed along Mosquito Creek on county owned lands.
- Notifying landowners of any applicable unenrolled lands within the TCNS 220 contributing area of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Ensure that BMPs and projects upstream of this location address soluble P based on the level of Ortho P and sediments based on the sample comments.
- Consider a re-evaluation of the BMPs in the TCNS 220 contributing area due to the increasing trends in TP concentrations.
- SFWMD to notify FDEP who will review the septic tank cluster within the TCNS 220 contributing area. These septic tank clusters may be addressed under future plan requirements under the Clean Waterways Act.

TCNS 209

Located on Otter Creek, TCNS 209 (**Figure 20**) is approximately 18 miles upstream of the S-191 structure. The site had statistically significant increasing trends in flows, TP and TN FWMC and TP and TN loads for the period of WY2006-WY2019 based on the monthly SKT analysis (Zhang et al., 2021). **Figures 37** and **38** depict the average TP and TN concentration data, respectively from this site along with the rainfall in inches for the S-191 Basin. The average annual TP concentrations for WY2021 were unusually high for both TP and TN although only 3 samples were collected. There had been an issue with vegetation at this site that did not allow collectors to gather samples for most of the water year. SFWMD notified FDEP in May when unusually high concentrations were observed in Taylor Creek and were impacting the FDACS HWTT (operations were paused) and the Taylor Creek STA (operations were reduced) which are downstream of TCNS 209. It was determined that the high concentrations observed at TCNS 209 in WY2021, and on May 11, 2021, were impacted from concentrations upstream of TCNS 207

which is upstream of TCNS 209 (**Table 25**, **Figures 39 – 40**). When data without WY2021 are reviewed it appears that the concentrations at TCNS 209 may be influenced by TCNS 207 (**Figure 41**) as the TP concentrations data follow a similar pattern for certain periods and the concentrations at TCNS 207 are usually higher than those at TCNS 209. Unfortunately, no samples were collected at TCNS 207 in April of 2021 when high concentrations were observed at TCNS 209 (13,823 µg/L on April 13 and 10,373 µg/L on April 21) although the site was flowing.[6] TCNS 207 was not included in the Zhang et al. 2021 study which only reviewed upstream sites with flow measurements so it is unknown if there was also an increasing trend at that location between WY2006-WY2019. The average annual TN concentrations at both TCNS 209 and TCNS 207 were greater than the BMAP (FDEP, 2020) benchmarks for TN (1,540 µg/L) for the five most recent water years and the TP average annual TP concentrations have never achieved the BMAP (FDEP, 2020) benchmarks for TP (120 µg/L) during the period both sites have been monitored.

Table 25. TP and TN concentrations collected at TCNS 207 and TCNS 209 on May 11 ,2021.

May 11, 2021		
	TP µg/L	TN µg/L
TCNS 207	34,500	249,000
TCNS 209	17,640	125,000

After being notified of the unusually high TP concentrations, FDEP completed a dairy inspection for two barns located upstream on May 21, 2021 and notified FDACS. FDEP reported that there was minimal groundwater flow from a ditch on McArthur Farms upstream of TCNS 207. They also indicated that the there was no discharge from the wastewater storage ponds and that no problems were identified with the spray-field. FDEP and SFWMD worked together to collect additional samples along Taylor and Otter Creeks and SFWMD performed an aerial reconnaissance of the area. Despite these efforts no direct causes of the extremely high concentrations were found but they did cease. During a Coordinating Agencies technical team discussion of the May 11, 2021 sampling event, the agencies agreed to develop a rapid assessment notification process in an effort to be more proactive when unusually high concentrations are observed.

The contributing area (**Figure 42**) for TCNS 209 is 3,464 acres and for TCNS 207 it is 3,736 acres. The land use for TCNS 209 includes agriculture (97.1%), non-agriculture (0.9%), and natural areas (2%) and for TCNS 207 it includes agriculture (93.0%), non-agriculture (4.5%), and natural areas (2.5%). The TCNS 209 location has both flow and concentration measurements. It is estimated that the drainage area contributes 2 t TP and 11 t TN annually (Zhang et al. 2021) to Otter Creek. **Figure 43** depicts the land use and the septic tanks within the contributing area for both sites. There are septic tanks within the contributing area for both TCNS 207 and TCNS 209 but there are no large clusters. As of November 2021, 3,193 acres within the contributing area for TCNS 209 and 3,229 acres within the contributing area for TCNS 207 are enrolled in the FDACS BMP program (**Figures 44-45**). However, there are 230 acres in the contributing area for TCNS 209 and 255 acres in the contributing area for TCNS 207 that are labelled as agriculture lands that are not enrolled and should be reviewed with FDACS. Landowners of any applicable unenrolled lands need to be notified of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to the SFWMD per Chapter 40E-61, F.A.C. All of the agricultural lands within the TCNS 207 lands appear to be enrolled as the remaining portion of land depicted as agriculture is state owned lands for the Okeechobee Correctional Facility (**Figure 45**). However, FDACS has reported that they may be

[6] Staff had training on flow direction for the TCNS 207 site on 7/29/2021. All samples collected at TCNS 207 when flowing were included in Figures 38-40.

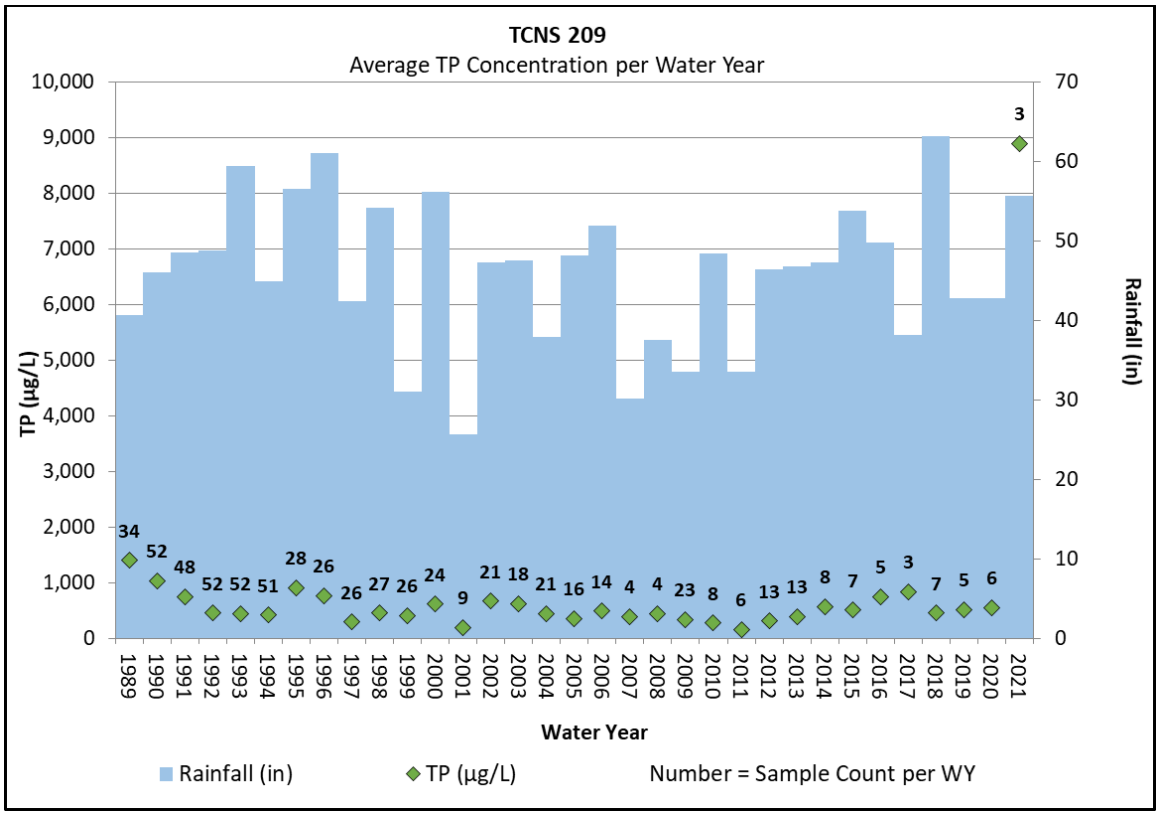

Figure 37. Average TP Concentration per Water Year for Site TCNS 209.

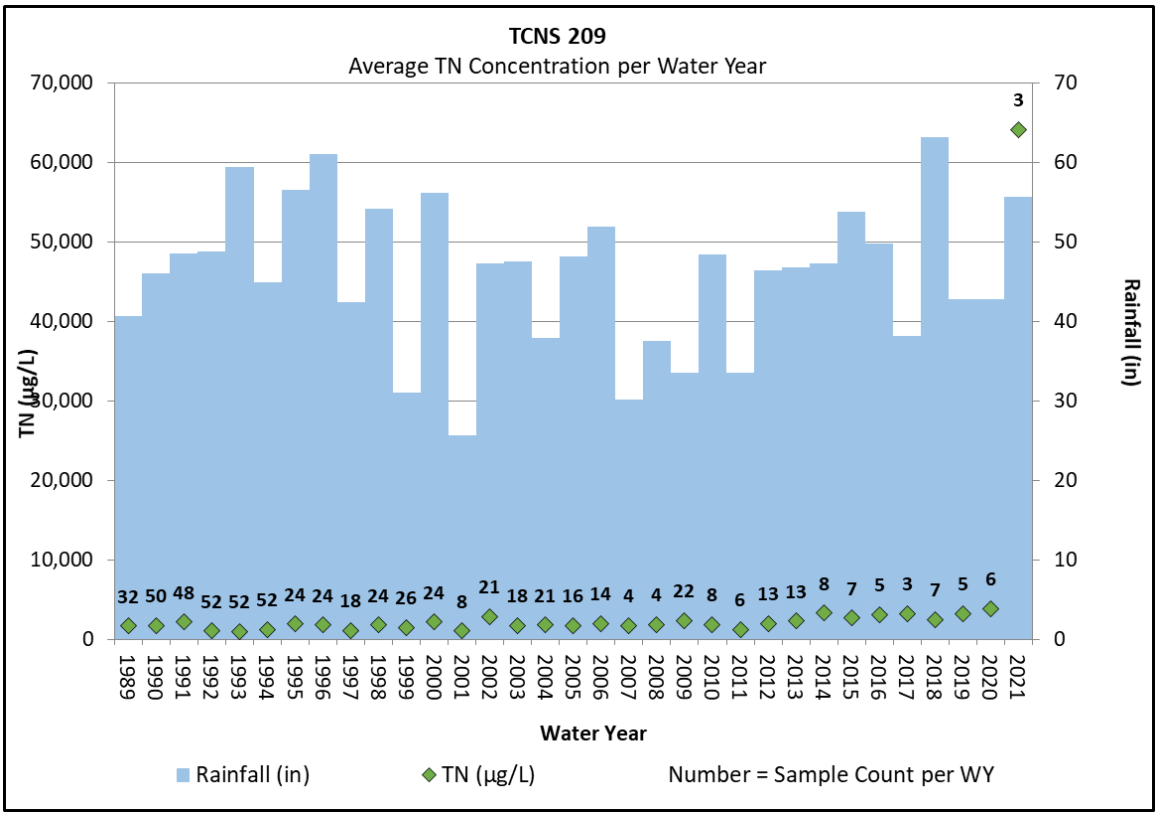

Figure 38. Average TN Concentration per Water Year for Site TCNS 209.

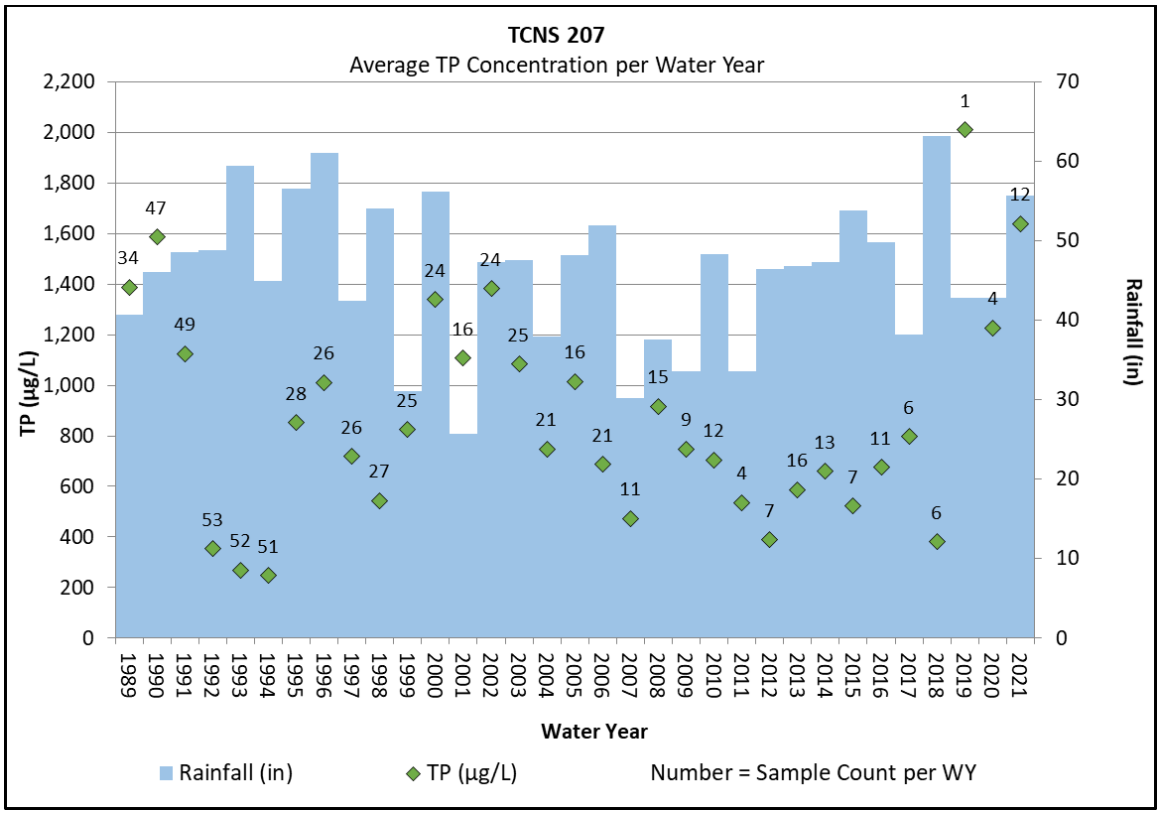

Figure 39. Average TP Concentration per Water Year for Site TCNS 207.

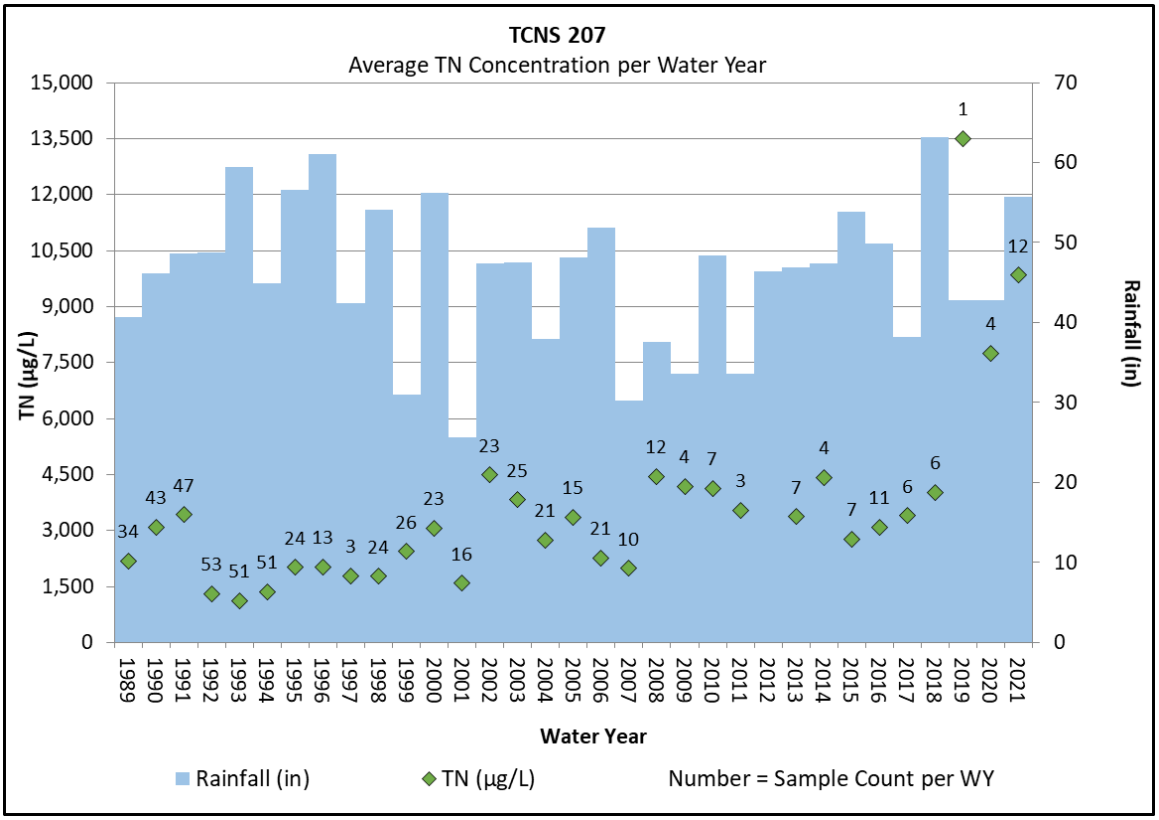

Figure 40. Average TN Concentration per Water Year for Site TCNS 207.

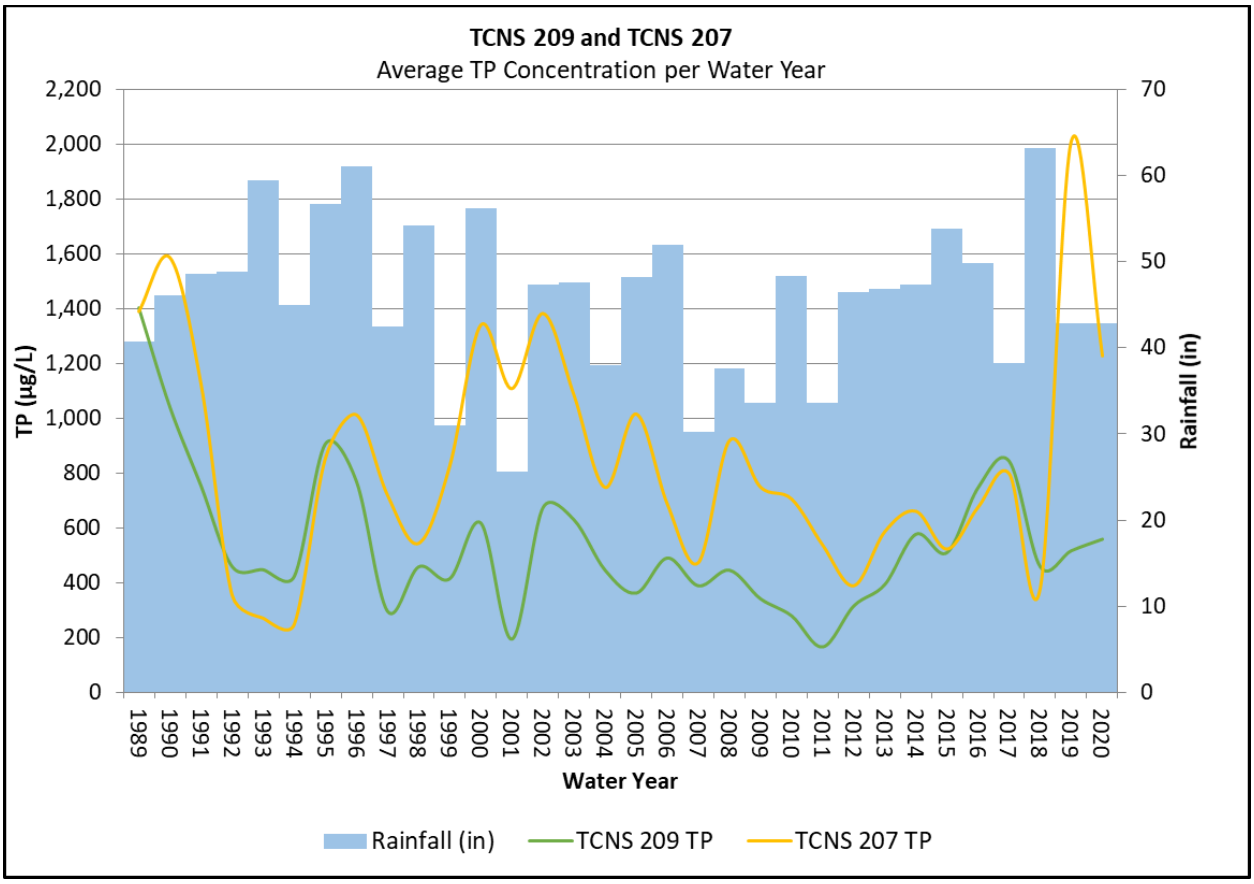

Figure 41. Average TP Concentration per Water Year for Sites TCNS 209 and TCNS 207 excluding WY2021.

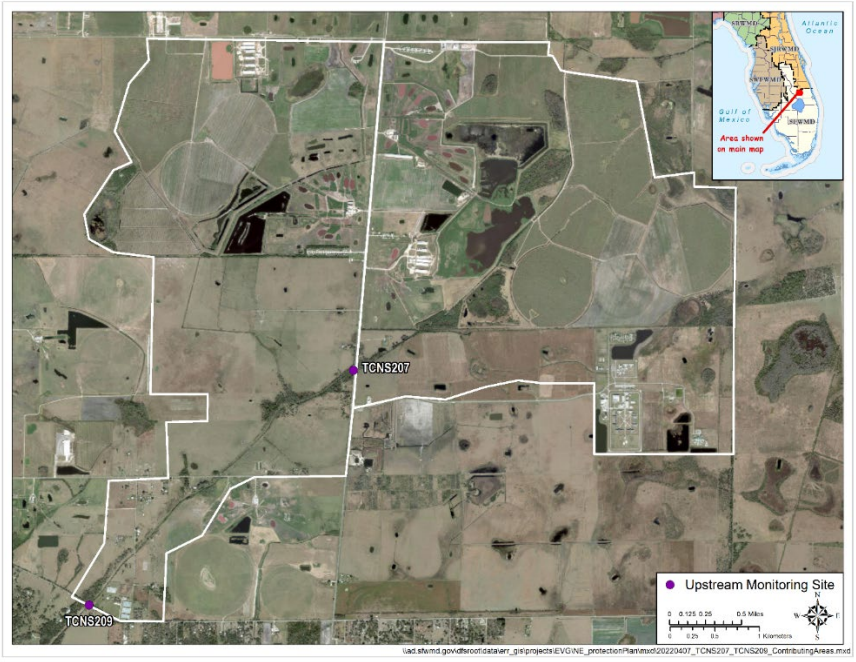

Figure 42. Contributing Area of Priority Site TCNS 209 and TCNS 207.

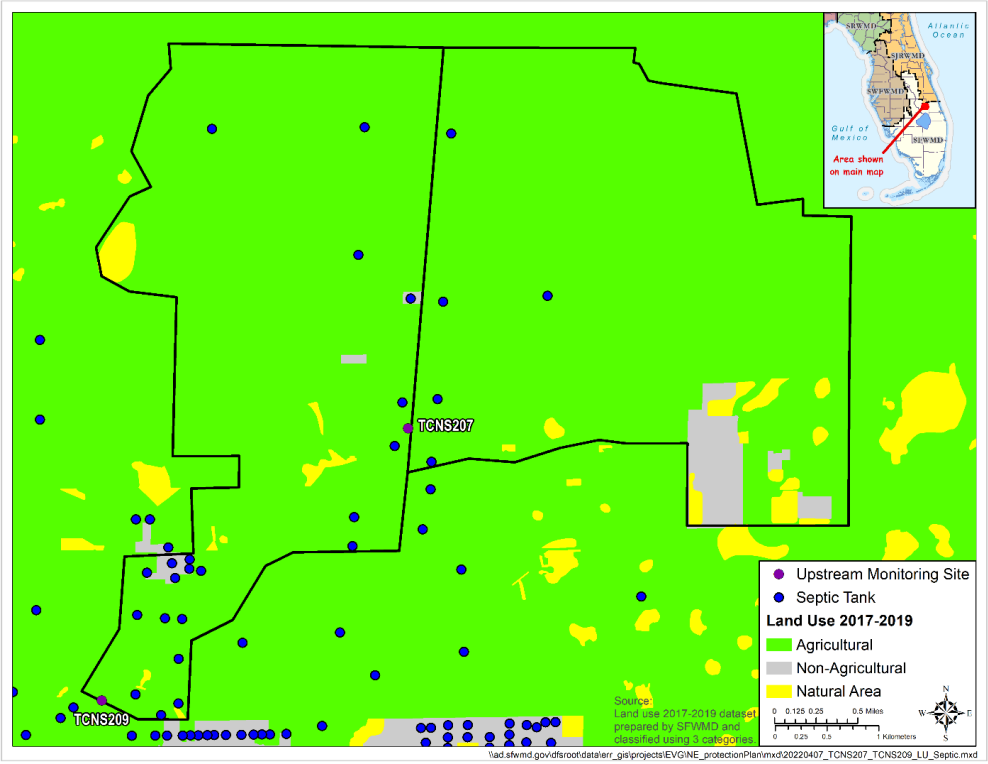

Figure 43. Land use and septic tanks in the Contributing area of TCNS 209 and TCNS 207.

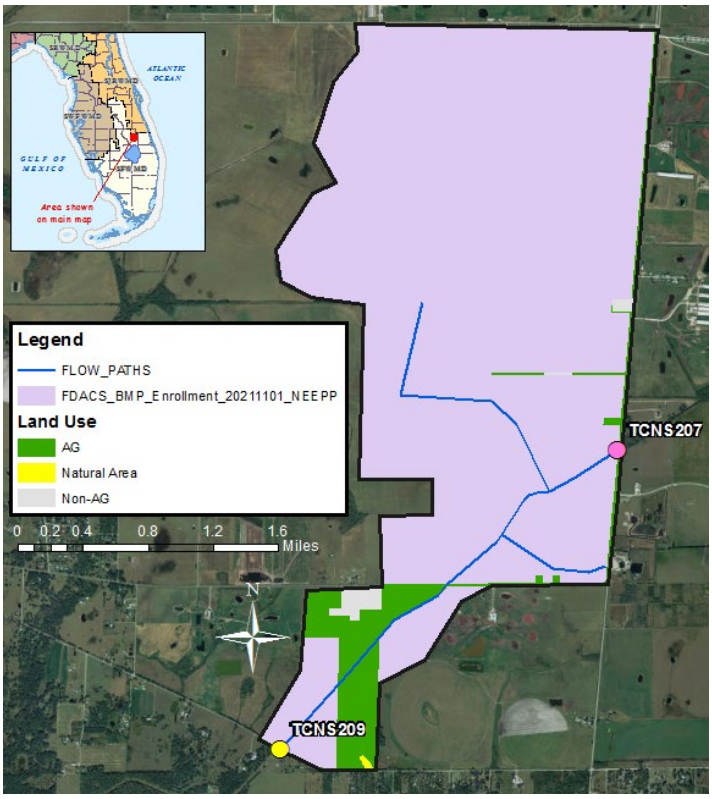

Figure 44. FDACS enrollment within the TNCS 209 Contributing area as of November 2021.

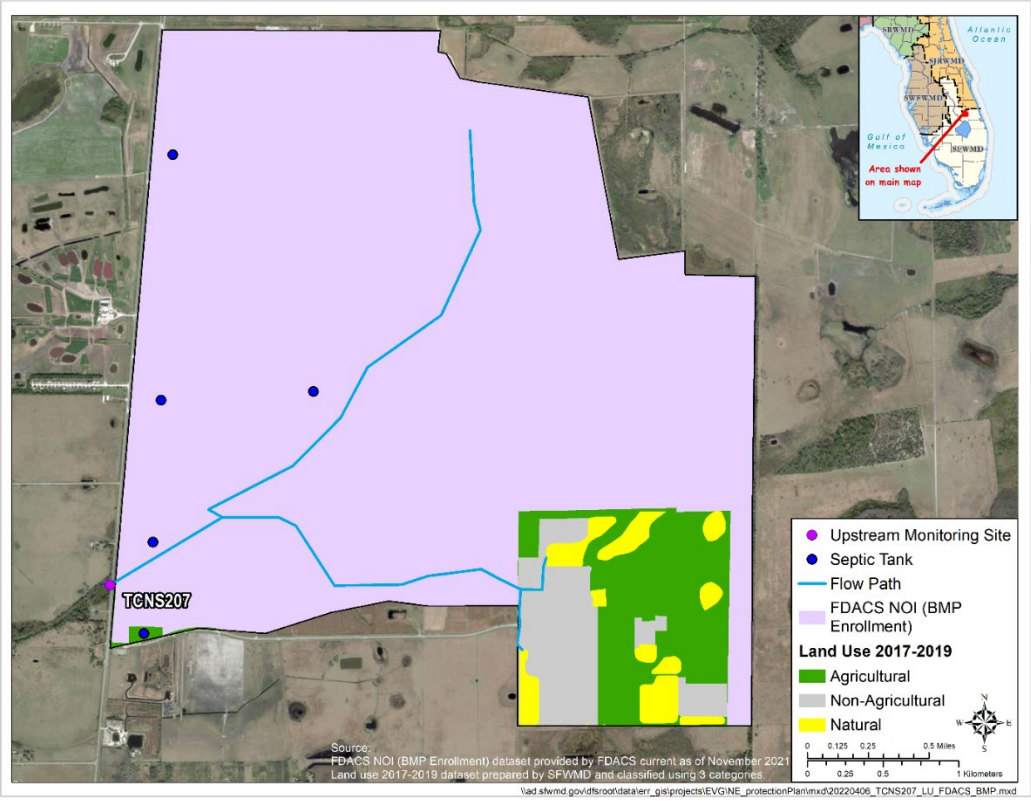

Figure 45. FDACS enrollment within the TNCS 207 Contributing area as of November 2021.

growing hay at the facility so it may also need to be contacted about BMP enrollment or monitoring under 40E-61, F.A.C. There is no state-owned land available for an additional project within this contributing area.

The SFWMD ERPs issued within the contributing area for TCNS 209 and TCNS 207 are presented in **Figure 46**. To determine if any significant changes had been made within the contributing area that may have impacted water quality at this site Environmental Resource Permits (ERP), Surface Water Management permits (SWM), and exemptions were reviewed There are five ERPs within the TCNS 209 contributing area. One was issued for a subdivision surface water management system. Another was issued for a surface water management system for agriculture and a greenhouse. The other three were issued for placing culverts under the roadways. There are three ERPs within the TCNS 207 contributing area and they are all related to the Okeechobee County Correctional Facility. The two most recent applications for each of the contributing areas for these sites include replacement of the culverts under Potter Road and a modification to the Okeechobee County Correctional Facility permit (**Tables 26-27**). The construction of the culverts at Potter Road at the TCNS 209 site occurred in late 2018 early 2019 timeframe. Ongoing construction was documented on the February 2019 helicopter flight but was finished when the site was flown in October of 2019. Thus, there is no obvious cause for the water quality issues within the contributing area for TCNS 209 and TCNS 207 based on a review of the ERPs.

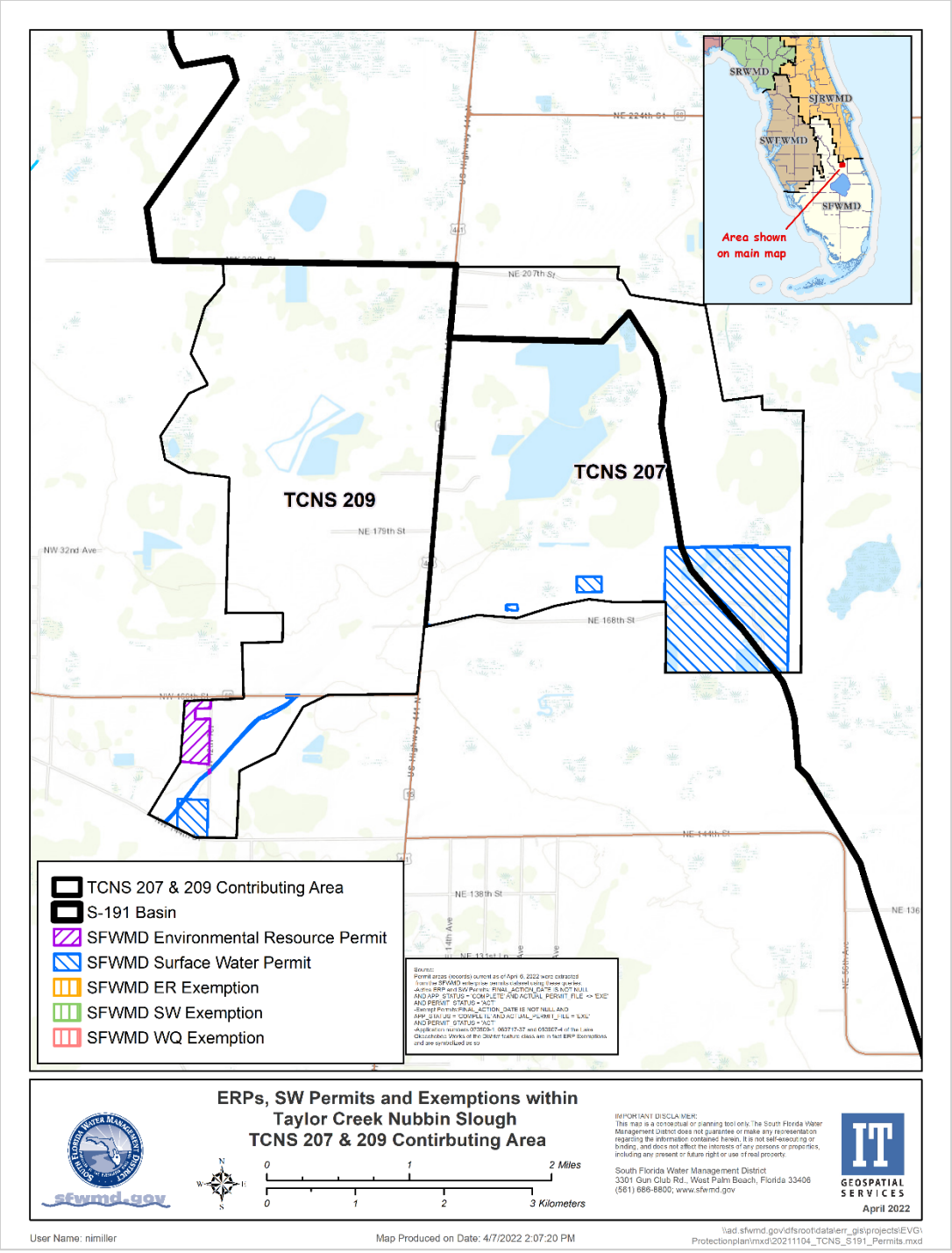

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Figure 46. SFWMD permits and exemptions in the contributing areas of TCNS 209 and TCNS 207.

Table 26. SFWMD ERPs issued since 2012 within the contributing area of TCNS 209.

Site TCNS 209			
Permit Number	**Application Number**	**Final Action Date**	**Description**
47-100519-P	180809-753	8/20/2018	Replacement of existing structures within Otter Creek in the vicinity of Potter Road. The existing dual 96" culverts under Potter Road will be replaced by dual 84" culverts, and the metal sheet pile weir within Otter Creek downstream of the road crossing will be replaced by a steel sheet and pipe piling of identical width and elevation. The applicant has demonstrated that the proposed structures will have no adverse offsite impacts.

Table 27. SFWMD ERPs issued since 2012 within the contributing area of TCNS 207

Site TCNS 207			
Permit Number	**Application Number**	**Final Action Date**	**Description**
47-00421-S	121030-14	11/19/2012	Modification for a 16' x 20' Proposed Building Okeechobee Correctional Institute. Permitted is a three-pond system, interconnected by storm pipes and ditches.

Similar to the TP and Ortho P analysis completed at the basin level, an analysis was done for the TCNS 209 and TCNS 207 (**Figures 47-48, Tables 28 - 29**). On average the samples are 74% Ortho P at TCNS 209 and 85% at TCNS 207, however no Ortho P samples have been collected at TCNS 207 since WY2011 since the site is often too shallow to collect filtered samples. A review of the sample comments for TCNS 209 from WY2021 indicates that for most of the water year the site was clogged with vegetation and no sample could be collected. Comments for the samples collected indicated the filters used to collect the Ortho samples were filled with particulates indicating that sediments may have been an issue.

Within the contributing areas for TNCS 209 and TCNS 207 are four dairy barns that have FDEP wastewater permits. The barns were last inspected in 2021 and at that time no violations were observed. No discharges from the wastewater ponds were reported between June of 2014 to July of 2021. FDEP reported that TP concentrations at four of the compliance monitoring wells from two of the barns were 10% to 227% above the concentrations at the background monitoring wells. FDEP also reported that the spray-field effluent from one barn was 15,270 µg/L for TP and 109,160 µg/L for TN for the period between March 2009 and June of 2021 for one barn. And FDEP spray-field effluent from a second barn was 7,940 µg/L for TP and 34,510 µg/L for TN for the period between March 2017 and June of 2021. FDEP has committed to investigating groundwater limits and spray-field discharges related to dairy permitting at this site.

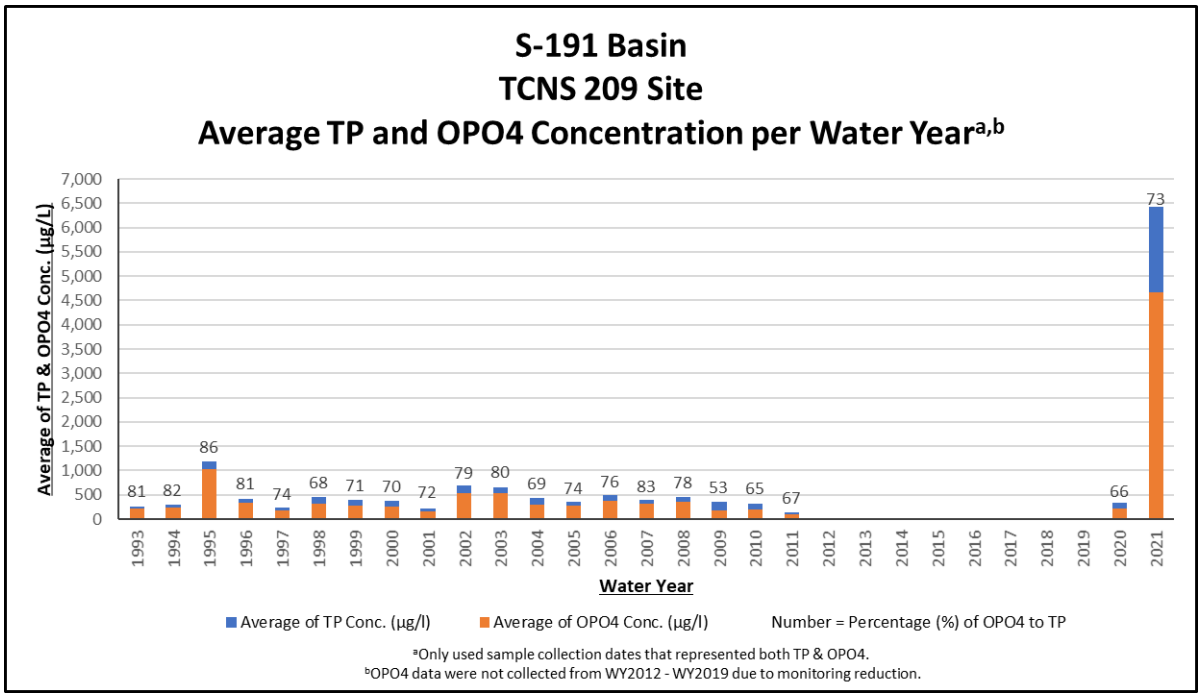

Figure 47. Average TP and OPO_4 concentrations per water year at the TCNS 209 site.

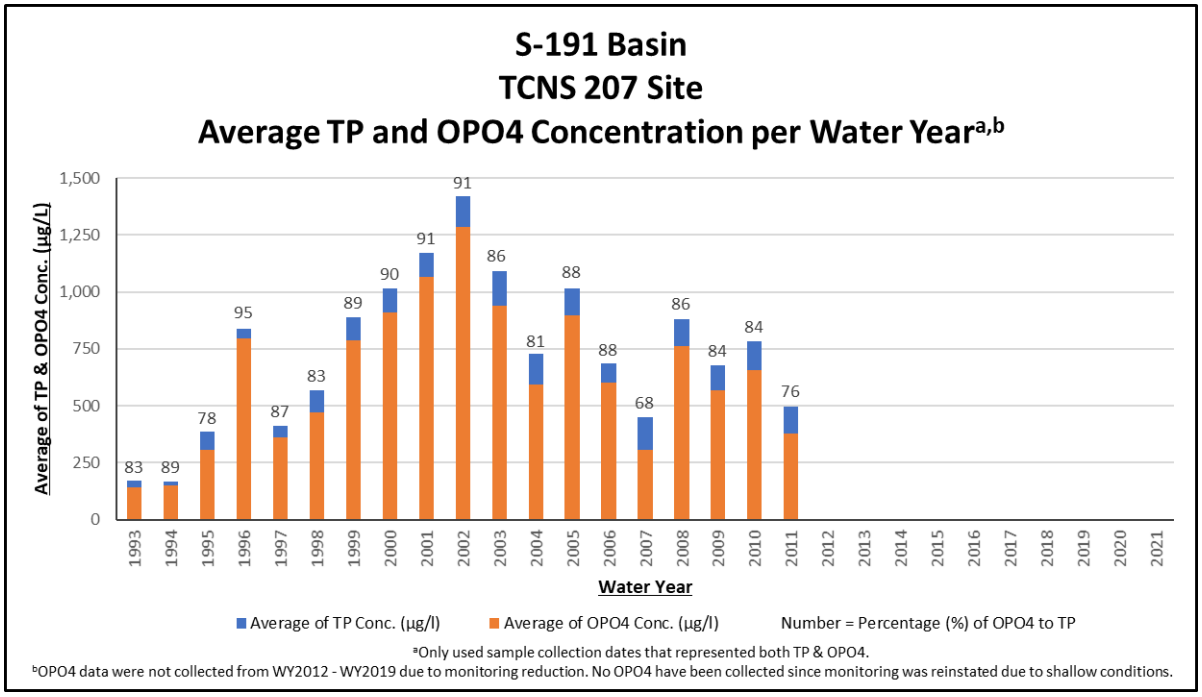

Figure 48. Average TP and OPO_4 concentrations per water year at the TCNS 207 site.

Table 28. Speciation Information per Water Year at the TCNS 209 site.

TCNS209 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
1993	258	216	84%	9
1994	289	237	82%	2
1995	1,179	1,018	86%	1
1996	416	338	81%	2
1997	245	181	74%	13
1998	461	315	68%	15
1999	401	285	71%	21
2000	368	257	70%	13
2001	217	157	72%	6
2002	682	542	79%	20
2003	658	529	80%	16
2004	430	296	69%	19
2005	364	268	74%	16
2006	492	373	76%	14
2007	391	325	83%	4
2008	447	350	78%	4
2009	352	187	53%	14
2010	307	199	65%	7
2011	133	89	67%	5
2012[b]	-	-	-	-
2013[b]	-	-	-	-
2014[b]	-	-	-	-
2015[b]	-	-	-	-
2016[b]	-	-	-	-
2017[b]	-	-	-	-
2018[b]	-	-	-	-
2019[b]	-	-	-	-
2020	331	220	66%	2
2021	6,432	4,673	73%	2
Minimum	**133**	**89**	**53%**	**1**
Maximum	**6,432**	**4,673**	**86%**	**21**
Average	**707**	**526**	**74%**	**10**

[a]Only used sample collection dates that represented both TP & OPO4.

[b]OPO4 data were not collected from WY2012 - WY2019 due to monitoring reduction.

Table 29. Speciation Information per Water Year at the TCNS 207 site.

TCNS207 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
1993	170	140	83%	11
1994	168	150	89%	2
1995	388	304	78%	1
1996	839	795	95%	1
1997	414	359	87%	2
1998	567	470	83%	17
1999	888	789	89%	20
2000	1,016	909	90%	12
2001	1,173	1,067	91%	10
2002	1,419	1,286	91%	23
2003	1,089	937	86%	23
2004	728	592	81%	20
2005	1,015	896	88%	16
2006	686	603	88%	21
2007	451	306	68%	10
2008	882	760	86%	14
2009	677	568	84%	5
2010	783	656	84%	6
2011	496	379	76%	3
2012[b]	-	-	-	-
2013[b]	-	-	-	-
2014[b]	-		-	-
2015[b]	-	-	-	-
2016[b]	-	-	-	-
2017[b]	-	-	-	-
2018[b]	-	-	-	-
2019[b]	-	-	-	-
2020[b]	-	-	-	-
2021[b]	-	-	-	-
Minimum	**168**	**140**	**68%**	**1**
Maximum	**1,419**	**1,286**	**95%**	**23**
Average	**729**	**630**	**85%**	**11**

[a]Only used sample collection dates that represented both TP & OPO4.

[b]OPO4 data were not collected from WY2012 - WY2019 due to monitoring reduction. No OPO4 have been collected since monitoring was reinstated due to shallow conditions.

Recommendations for TCNS 209 and TCNS 207 include:

- Continuing to investigate the potential causes of the increasing concentrations trends with FDEP and FDACS.
- FDEP should continue to follow up with the dairy permitting program and reviewing groundwater/surface water interactions with SFWMD.
- Ensure that BMPs and projects upstream of this location address soluble P based on the level of Ortho P and sediments based on the sample comments.
- Notifying landowners of any applicable unenrolled lands within the TCNS 209 and TCNS 207 contributing areas of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Consider a re-evaluation of the BMPs in the TCNS 209 and TCNS 207 contributing areas due to the increasing trends in TP concentrations for TCNS 209 and high TP concentrations at TCNS 207.
- Continue to develop a Coordinating Agency rapid assessment process to proactively manage specific water quality issues such as the one observed in Taylor and Otter Creek in the spring of 2021.

OT34353513

Located on a tributary which flows to Otter Creek, OT34353513 (**Figure 20**) is approximately 19 miles upstream of the S-191 structure. The site had statistically significant increasing trends in TP concentrations for the period of WY2005-WY2018 (SFWMD unpublished – See **Appendix A4**). **Figures 49** and **50** depict the average TP and TN concentration data, respectively from this site along with the rainfall in inches for the S-191 Basin. Note that TN data collection at the site did not begin until February of 2020 (WY2021). Since WY2013 the average annual TP concentrations have been above 400 µg/L with only two exceptions (WY2017 368 µg/L and WY2019 164 µg/L). Prior to WY2013 the average annual TP concentration was only above 400 µg/L in WY1991 (441 µg/L). The average annual TP concentrations were greater than the BMAP (FDEP, 2020) TP benchmark of 120 µg/L for the last five water years. The average annual TN concentration was greater than the BMAP (FDEP, 2020) TN benchmark of 1,540 µg/L in WY 2021.

The contributing area (**Figure 51**) for OT34353513 is 1,024 acres and the land use is 100% agriculture. **Figure 52** depicts the land use and the septic tanks within the contributing area for the site. There are septic tanks within the contributing area but no large clusters of tanks. As of November 2021, 908 acres within the contributing area are enrolled in the FDACS BMP program (**Figure 53)**. However, there are 104 acres that are labelled as agriculture lands that are not enrolled which need to be reviewed with FDACS. Also, there is a small portion of the land not enrolled that appears to be a single-family residence. The agricultural land uses for the acreage enrolled in the FDACS program includes a dairy, ornamentals, and cow calf. Landowners of any applicable unenrolled lands need to be notified of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to the SFWMD per Chapter 40E-61, F.A.C. There is no state-owned land available for an additional project within this contributing area.

To determine if any significant changes had been made within the contributing area that may have impacted water quality at this site Environmental Resource Permits (ERP), Surface Water Management permits (SWM), and exemptions were reviewed. There are only two SFWMD ERPs within the contributing area (**Figure 54, Table 30**). One was for the construction of a surface water management system for a 117-acre tree farm with water quality treatment in excess of 1-inch is provided in a wet detention pond prior to discharge which was issued in July of 2000. The second one was issued in 2005 and was for the construction and operation of a surface water management system to serve a 40-acre agricultural development know as Tree Locators. The surface water management system consists of an above ground

impoundment which provides water quality treatment before discharging off-site. There was a minor modification to the Tree Locators permit issued in 2007. Based on the dates of issuance for these permits, it does not appear that these changes caused the average annual concentration increases that began in WY2013.

Similar to the TP and Ortho P analysis completed at the basin level, an analysis was done for OT34353513 (**Table 31**). The SFWMD only had Ortho P data for WY2021 and on average the samples are 91% Ortho P at OT34353513. A review of the sample comments for OT34353513 for WY2021 indicates that at times particulates are observed in the samples.

Within the contributing areas for OT34353513 is one dairy barn that had FDEP wastewater permit. FDEP reported that this barn ceased operations in December of 2020 and the permit has expired. Prior to closing, the last inspection was completed in 2019. FDEP reported that TP concentrations at two of the compliance monitoring wells were 46% and 311% above the concentrations at the background monitoring well. There are no requirements for closing out wastewater ponds and these have been retained by the producer so they may resume operations in the future.

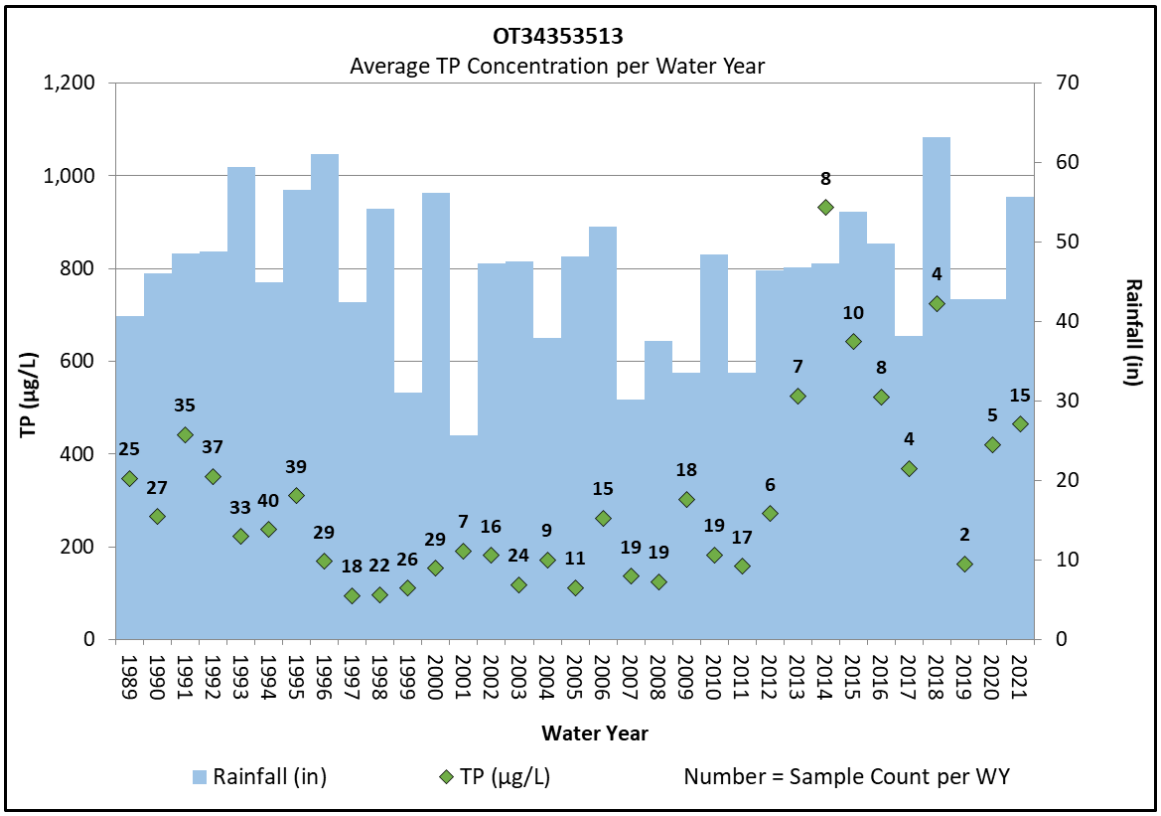

Figure 49. Average TP Concentration per Water Year for Site OT34353513.

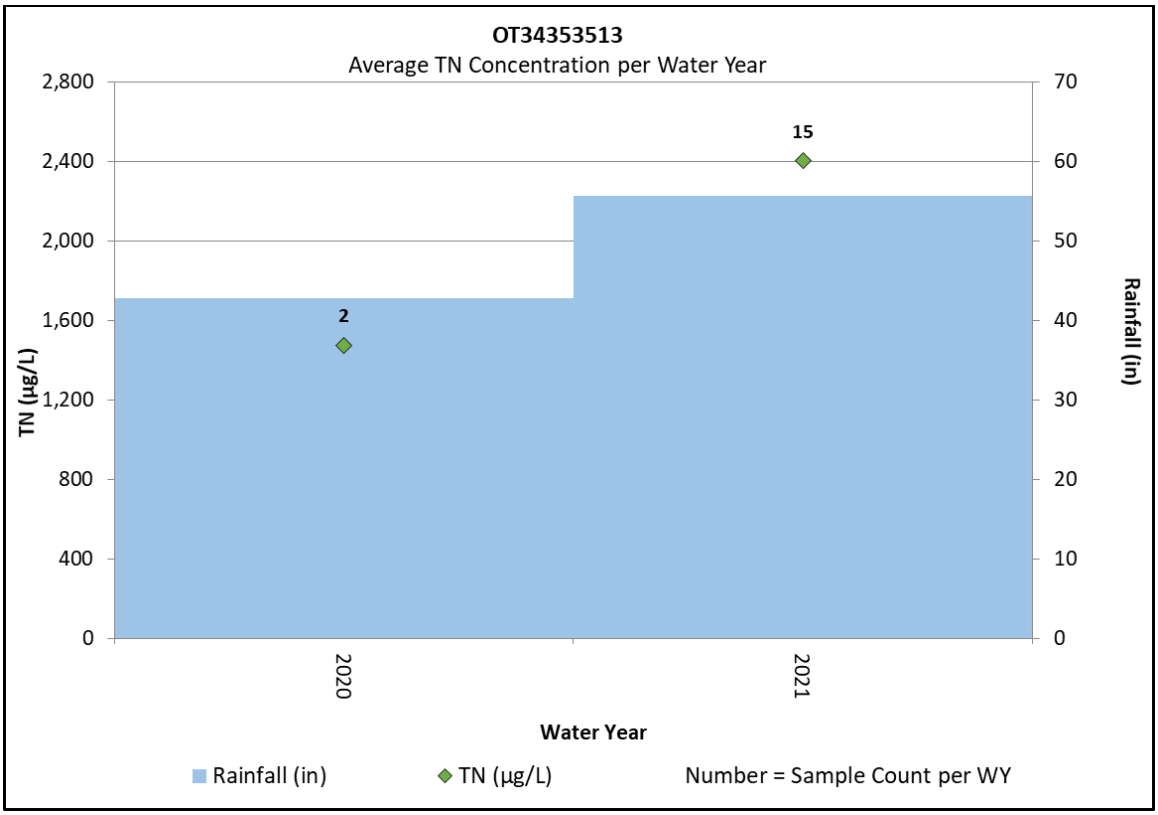

Figure 50. Average TN Concentration per Water Year for Site OT34353513.

Figure 51. Contributing Area of Priority Site OT34353513.

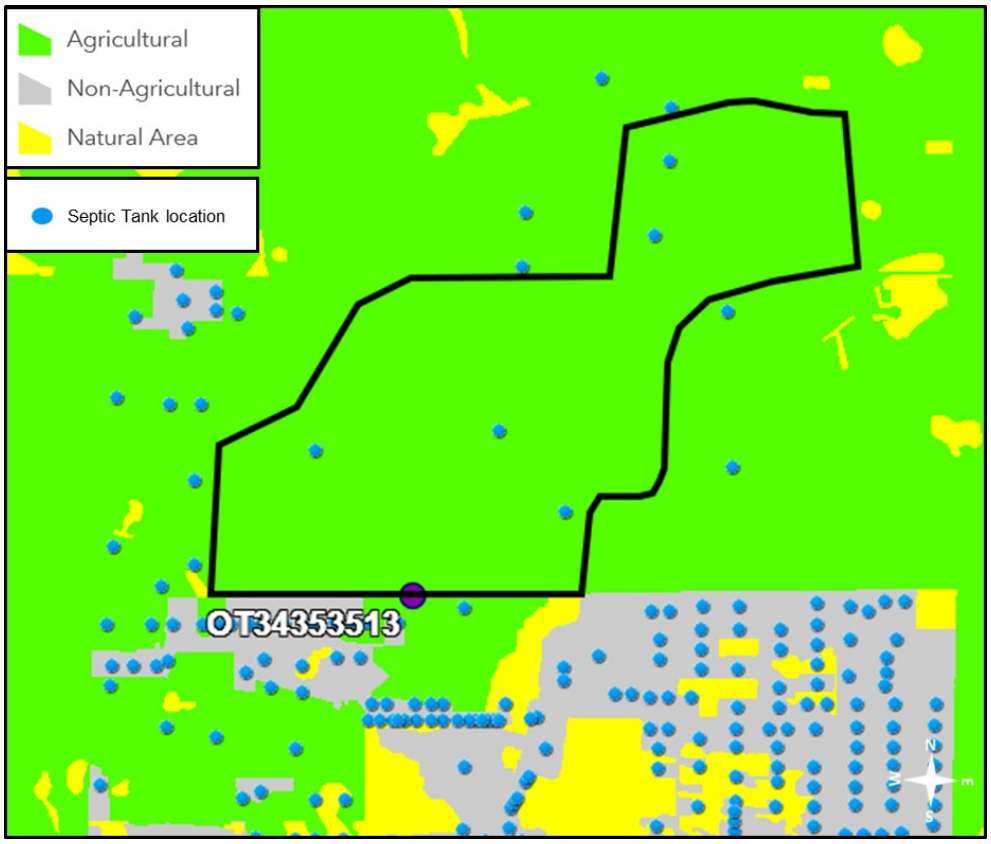

Figure 52. Land use and septic tanks in the Contributing area for 0T34353513.

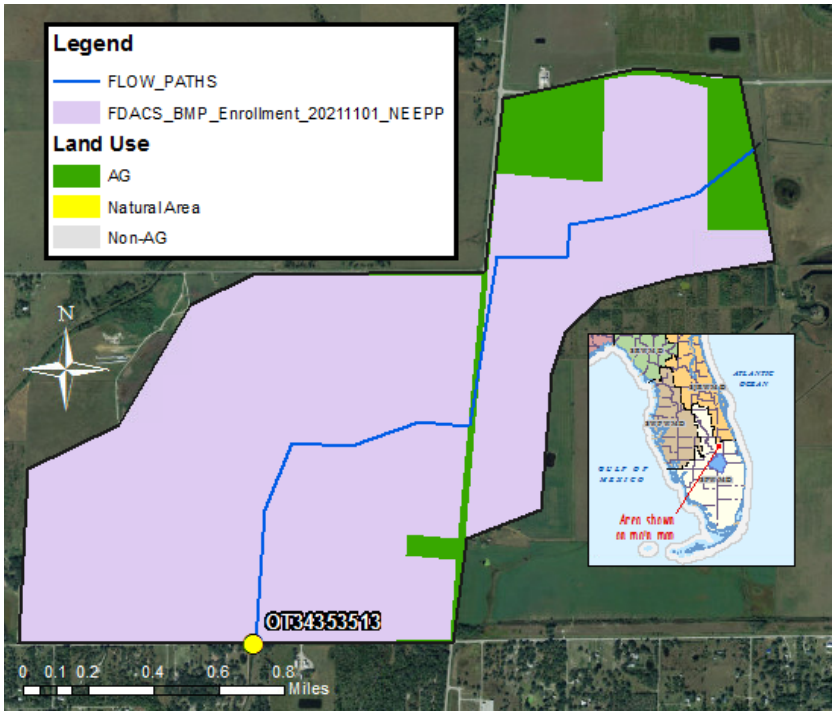

Figure 53. FDACS enrollment within the TNCS 209 Contributing area as of November 2021.

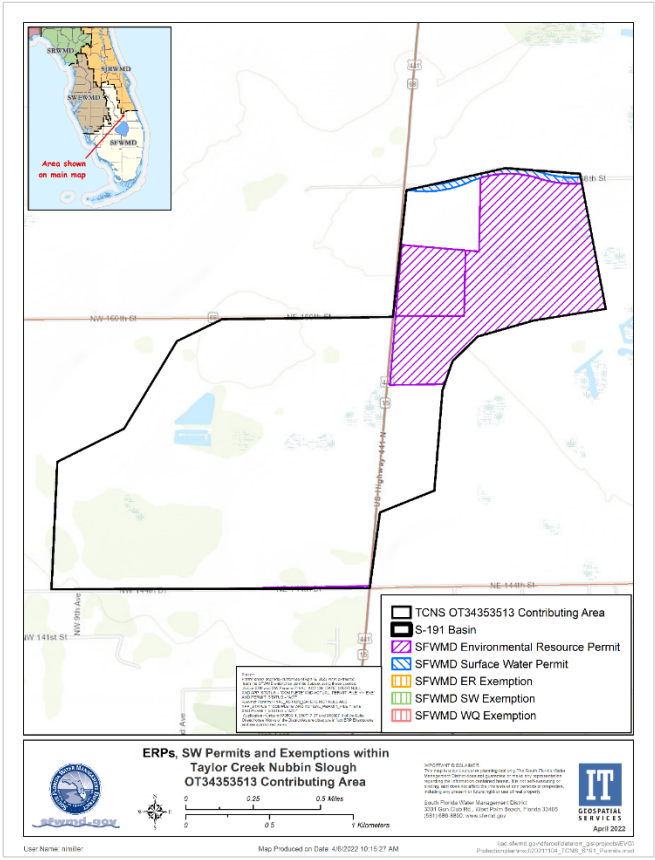

Figure 54. SFWMD permits and exemptions in the contributing area of OT34353513.

Table 30. SFWMD ERP and exemptions within the contributing area of OT34353513

Site OT34353513			
Permit Number	**Application Number**	**Final Action Date**	**Description**
47-00526-P	000330-19	7/13/2000	For the construction and operation of a surface water management system for a 117-acre tree farm with water quality treatment in excess of 1-inch is provided in a wet detention pond prior to discharge.
47-00704-P	050718-16	10/20/2005	For the construction and operation of a surface water management system to serve a 40-acre agricultural development know as Tree Locators. The surface water management system consists of an above ground improvement which provides water quality treatment before discharging off-site.
	070216-1	6/29/2007	There was a minor modification to the Tree Locators permit issued in 2007.

Table 31. Speciation Information per Water Year at the OT34353513 site.

OT34353513 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
2021	524	477	91%	12
[a]Only used sample collection dates that represented both TP & OPO4.				

Recommendations for OT34353513 include:

- Continuing to investigate the potential causes of the increasing concentrations trends with FDEP and FDACS.
- FDEP should continue to follow up with the dairy permitting program and reviewing groundwater/surface water interactions with SFWMD.
- Notifying landowners of any applicable unenrolled lands within the OT34353513 contributing area of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Ensure that BMPs and projects upstream of this location address soluble P based on the level of Ortho P and sediments based on the sample comments.
- Consider a re-evaluation of the BMPs in the OT34353513 contributing area due to the increasing trends in TP concentrations. It should be noted, thus far in WY2022 there have been only two samples collected thus far at this location and the TP concentrations were below the BMAP (FDEP, 2020) TP benchmark of 120 µg/L, but the TN concentrations were greater than the BMAP (FDEP, 2020) TN benchmark of 1,540 µg/L in WY 2021.

LB29353513

Located on a tributary which flows to Little Bimini Creek, LB29353513 (**Figure 20**) is approximately 18.5 miles upstream of the S-191 structure. The site had statistically significant increasing trends in TP concentrations for the period of WY2005-WY2018 (SFWMD unpublished – **See Appendix A4**). **Figures 55** and **56** depict the average annual TP and TN concentration data, respectively from this site along with the rainfall in inches for the S-191 Basin. Note that TN data collection at the site did not begin until February of 2020 (WY2021). The average annual TP concentrations appear to be increasing and since WY2011 have been above 600 µg/L with one exception WY2012 (537 µg/L). The average annual TP concentrations at this site have been greater than the BMAP (FDEP, 2020) TP benchmark of 120 µg/L every year it has been monitored. The average annual TN concentrations were greater than the TN (1,540 µg/L) benchmark in WY2020 and WY2021.

The contributing area (**Figure 57**) for LB29353513 is 1,085 acres and includes agriculture (97.5%), non-agriculture (0.1%), and natural areas (2.4%). **Figure 58** depicts the land use and the septic tanks within the contributing area the site. There are septic tanks within the contributing area but no large clusters of tanks. There is a cluster of septic tanks just downstream of the monitoring site. As of November 2021, 1,025 acres within the contributing area are enrolled in the FDACS BMP program (**Figure 59)**. However, there are 51 acres that are labelled as agriculture lands that are not enrolled which need to be reviewed with FDACS. Landowners of any applicable unenrolled lands need to be notified of the need to enroll in the

FDACS BMP program or submit a water quality monitoring plan to the SFWMD per Chapter 40E-61, F.A.C.

There are no SFWMD ERPs within the contributing area for LB29353513. There is no state-owned land available for an additional project within this contributing area.

Similar to the TP and Ortho P analysis completed at the basin level, an analysis was done for the LB29353513 (**Figure 60, Table 32**). On average the samples are 84% Ortho P at LB29353513 based on two water years. Comments for the samples collected indicated notations of particulates in the samples beginning in WY2008 - WY2011 and WY2013 – WY2014. There have been no recent notations of particulates in the sample comments.

Within the contributing areas for LB293353513 is one dairy barn that had an FDEP wastewater permit. FDEP reported that this barn ceased operations in December of 2020 and the permit has expired. Prior to closing, the last inspection was completed in 2020. FDEP reported that TP concentrations at two of the compliance monitoring wells were 26% and 811% above the concentrations at the background monitoring well. There are no requirements for closing out wastewater ponds and these have been retained by the producer so they may resume operations in the future.

In 2016, FDACS provided cost share to the dairy owner to complete an edge of farm reservoir and water reuse system. The purpose of the project was to capture stormwater and use it on the dairy. The intent was to increase storage and provide a nutrient reduction benefit. Construction was completed in 2018. The wetland immediately upstream of the monitoring location is now a part of that system and FDACS reports that the project is still being used even though the dairy has closed.

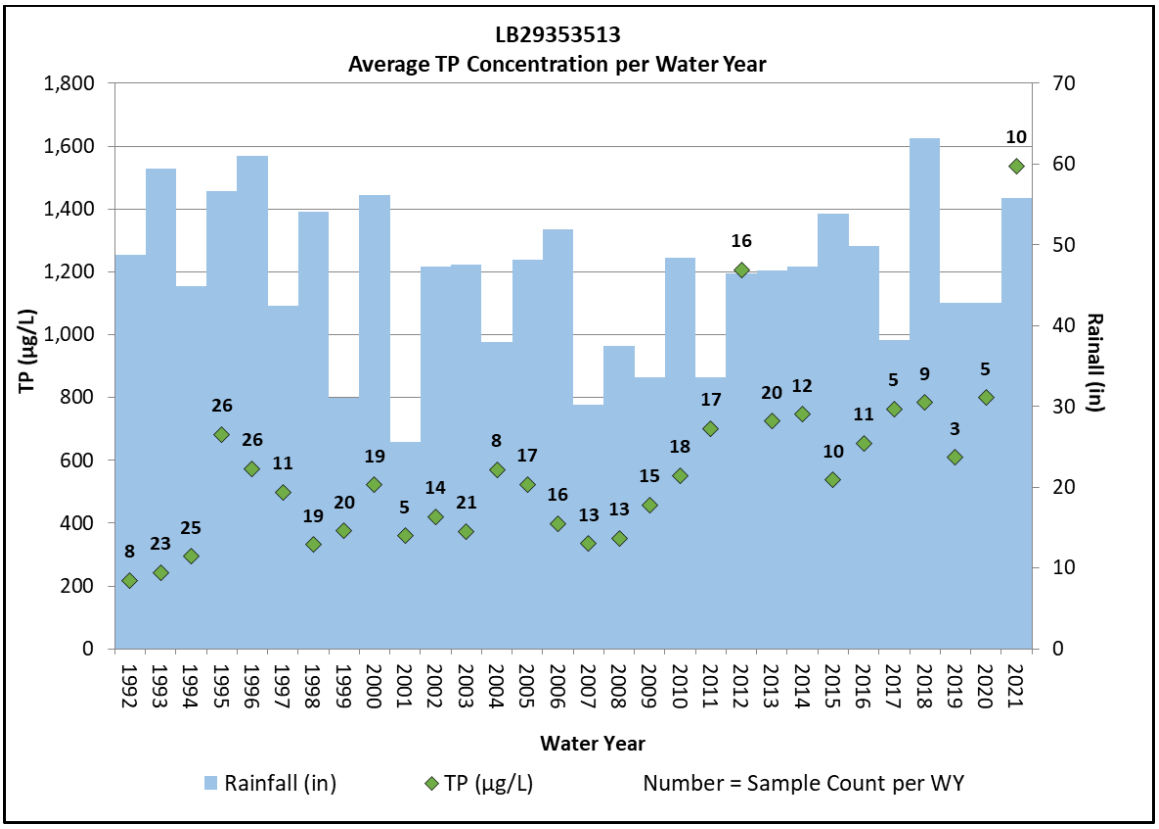

Figure 55. Average TP Concentration per Water Year for Site LB293535

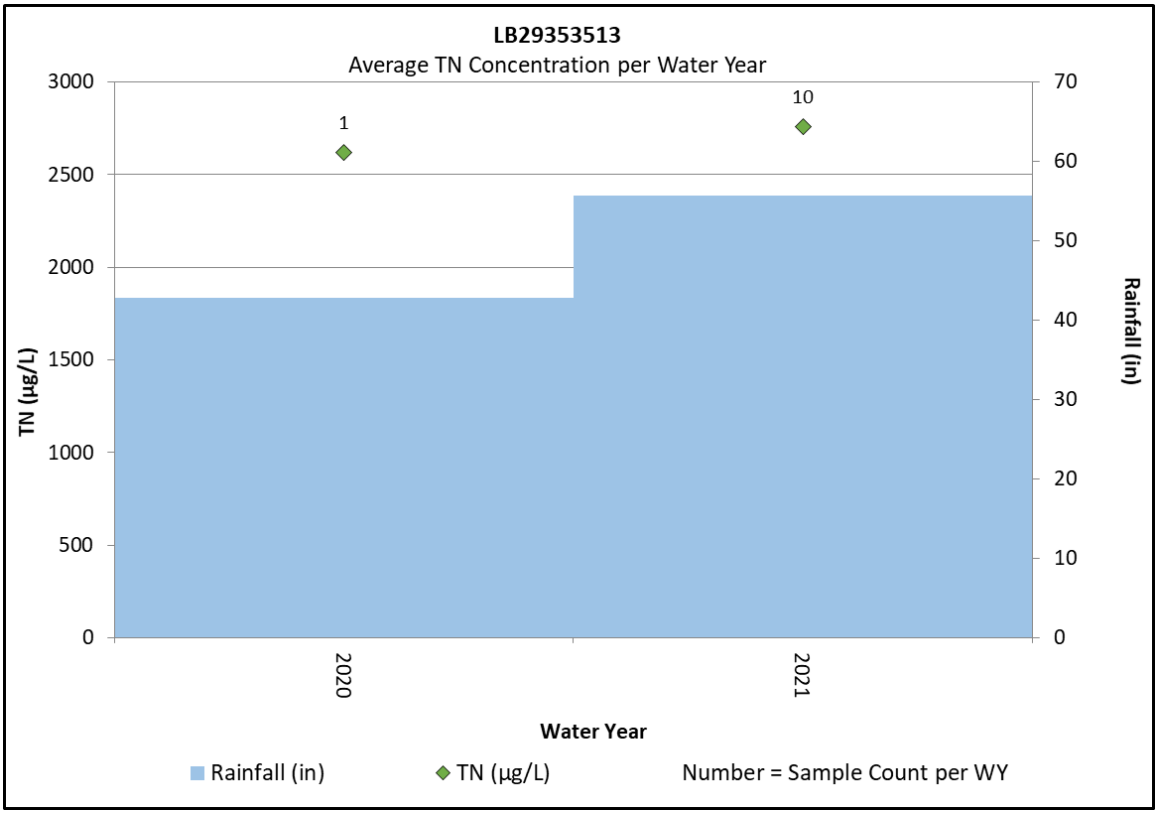

Figure 56. Average TN Concentration per Water Year for Site LB29353513.

Figure 57. Contributing Area of Priority Site LB29353513.

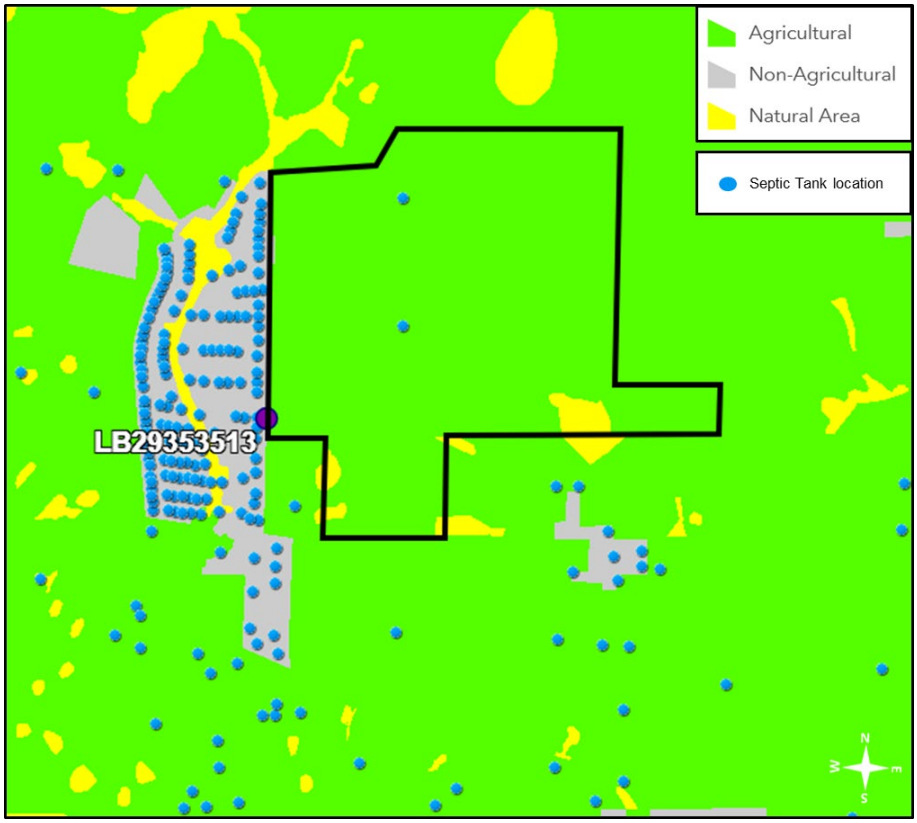

Figure 58. Land use and septic tanks in the Contributing area of LB29353513.

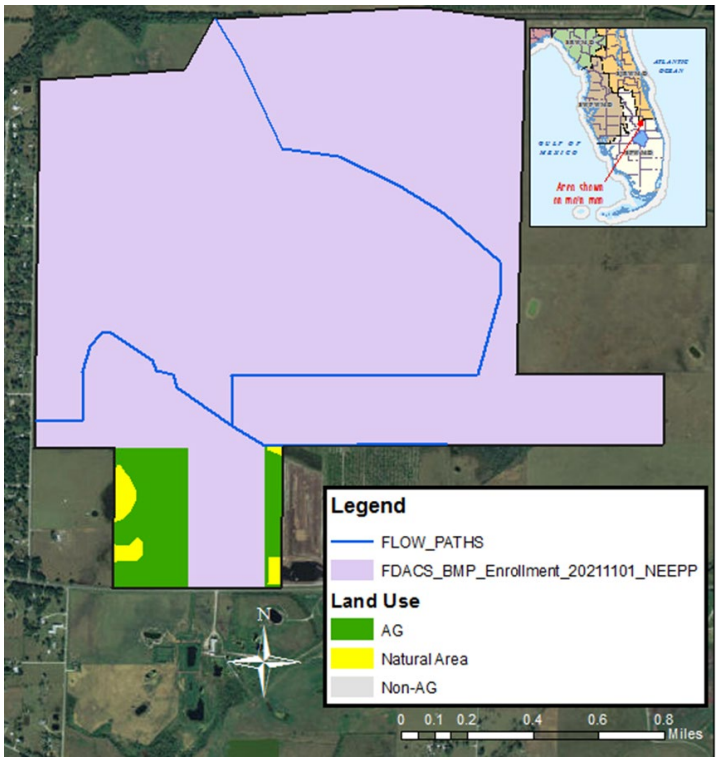

Figure 59. FDACS enrollment within the LB29353513 Contributing area as of June 2021.

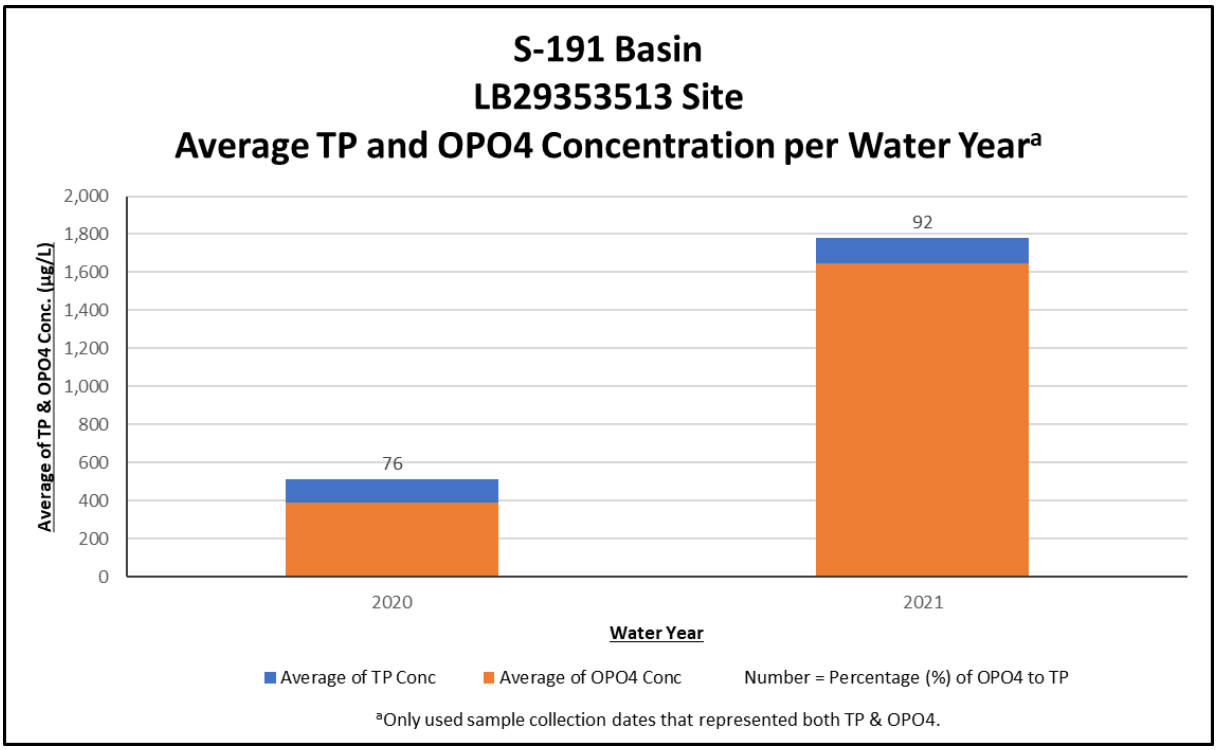

Figure 60. Average TP and OPO_4 concentrations per water year at the LB29353513 site.

Table 32. Speciation Information per Water Year at the LB29353513 site.

LB29353513 Speciation Information per Water Year (WY)				
Water Year	Average of TP Conc. (µg/L)	Average of OPO4 Conc. (µg/L)	Percentage of OPO4 to TP	Number of Samples[a]
2020	512	388	76%	1
2021	1,780	1,646	92%	1
Minimum	**512**	**388**	**76%**	**1**
Maximum	**1,780**	**1,646**	**92%**	**1**
Average	**1,146**	**1,017**	**84%**	**1**
[a]Only used sample collection dates that represented both TP & OPO4.				

Recommendations for LB29353513 include the following:

- Continuing to investigate the potential causes of the increasing concentrations trends with FDEP and FDACS.
- FDEP should continue to follow up with the dairy permitting program and reviewing groundwater/surface water interactions with SFWMD.
- Notifying landowners of any applicable unenrolled lands within the LB 29353513 contributing area of the need to enroll in the FDACS BMP program or submit a water quality monitoring plan to SFWMD per Chapter 40E-61, F.A.C.
- Ensure that BMPs and projects upstream of LB 29353513 address soluble P based on the level of Ortho P and sediments based on the sample comments.
- Consider a re-evaluation of the BMPs in the LB 29353513 contributing area due to the increasing trends in TP concentrations.
- SFWMD to notify FDEP who will review the septic tank cluster immediately downstream of LB29353513 contributing area. These septic tank clusters may be addressed under future plan requirements under the Clean Waterways Act.

WATER AVAILABILITY

Water availability refers to both the quantity and timing of flows relative to watershed objectives and project operations. The following water availability analysis reviewed six flow monitoring locations in the S-191 Basin (**Figure 61**).

In general, all the monitoring stations reviewed had 'flashy' hydrographs characterized by short duration, high intensity flows (**Figures 62, 64, 66, 68, 70,** and **72** below). These conditions can present unique challenges when evaluating projects and other improvements to the water management system. To aid in the evaluation, the following sections summarize water availability analyses for each of the six stations. Specifically, two metrics (flow exceedance and available flow) are introduced here.

The flow exceedance charts (**Figures 63, 65, 67, 69, 71,** and **73** below) illustrate the frequency that the observed flow exceeded a given rate and can be used as a general assessment regarding how 'available' water may be to existing and planned projects (Example: flow exceeds 500 cfs during only 2% of the year).

Available flow is defined for this purpose as the 90th percentile flow observed during the evaluation period. This criterion was selected to omit rare and extreme flow events and better define 'normal' conditions under which water might be available to existing and planned projects. Flows exceeding the 90th percentile are not readily captured by project inflow pumps, because extreme events in these systems occurred over a wide range of flows and for short durations. Instead, volumes exceeding the available flow might be addressed through stormwater detention, wetland restoration, and other passive methods.

Based on this water availability review the following actions are recommended:

- Re-evaluate project operation plans (existing and planned) basin-wide for comprehensive management and to ensure that they are coordinated, synchronized, and operate synergistically for maximum nutrient reduction and storage;
- Ensure all inflow pumps are automated and can start quickly when high flow events occur to limit response lag and minimize flow bypass;
- Operate planned FEBs and ASRs to moderate high intensity flow events by reserving storage capacity and increasing baseflow;
- Consider additional passive stormwater detention and wetland restoration projects throughout the basin to decrease peak flow and increase baseflow.

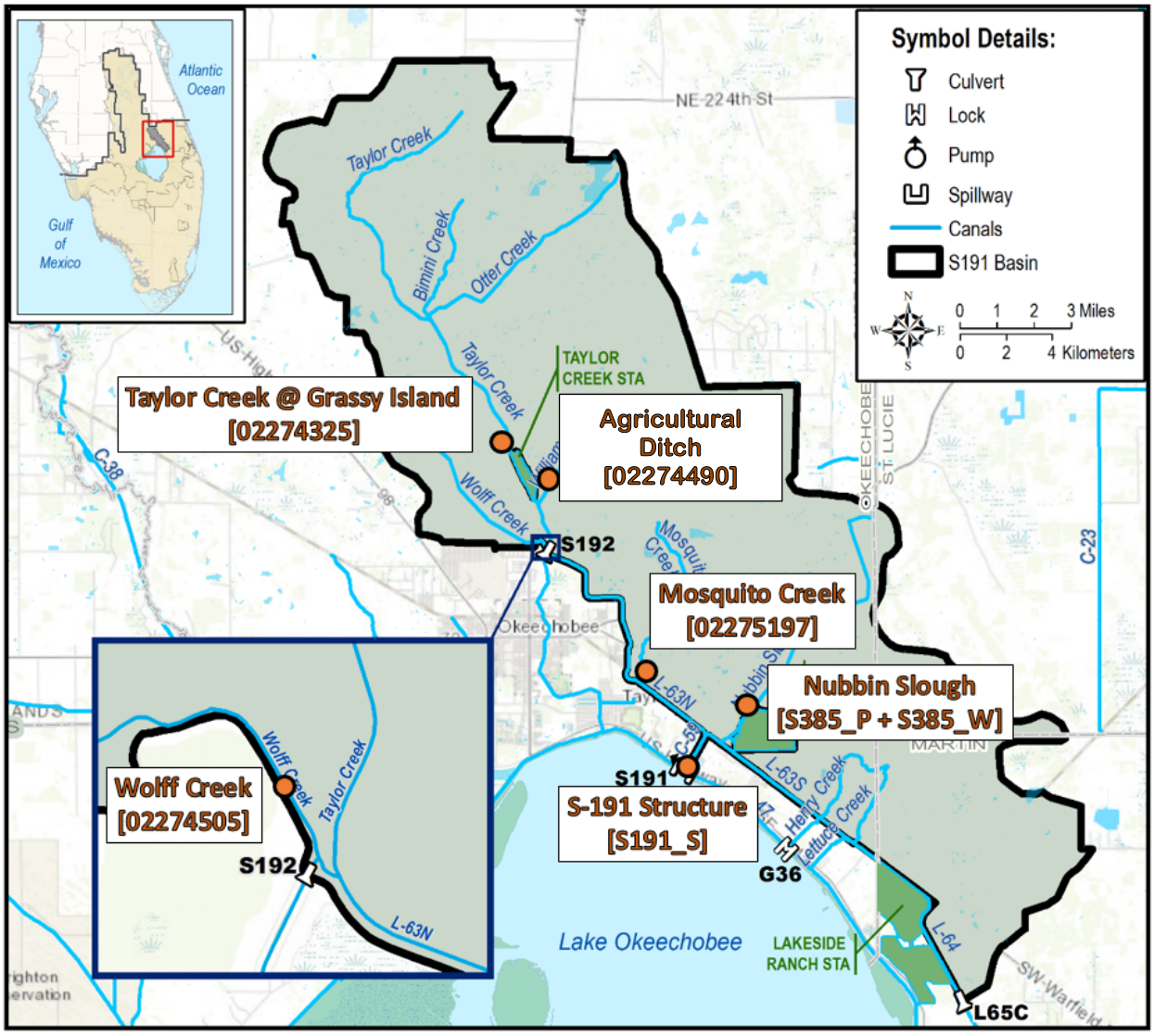

Figure 61. Location of the five monitoring stations evaluated for the water availability analyses.

S-191 STRUCTURE

Flow at the S-191 structure (**Figure 62**) averaged 82,514 ac-ft/yr during the evaluation period (2012-2021). No flow was present approximately 65% of the time, and the maximum observed flow rate was nearly 5,000 cfs. Available flow (90th percentile) was approximately 327 cfs (**Figure 63**). Approximately 44% of the total volume occurred at extreme flows, i.e. greater than the available flow (90th percentile). Pump capacities for newly completed and planned projects (**Table 33**) in the S-191 Basin exceed the available flow (90th percentile). Therefore, an evaluation should be conducted before additional projects are planned for this basin based on this initial water availability analysis. While the pump capacities exceed the available flow, dependent upon operating and weather conditions, not all of the pumps may be used at the same time. Since S-191 is the major discharge point into Lake Okeechobee, an evaluation could quantify the inflow and discharge for potential projects upstream to determine net impact on S-191 water availability.

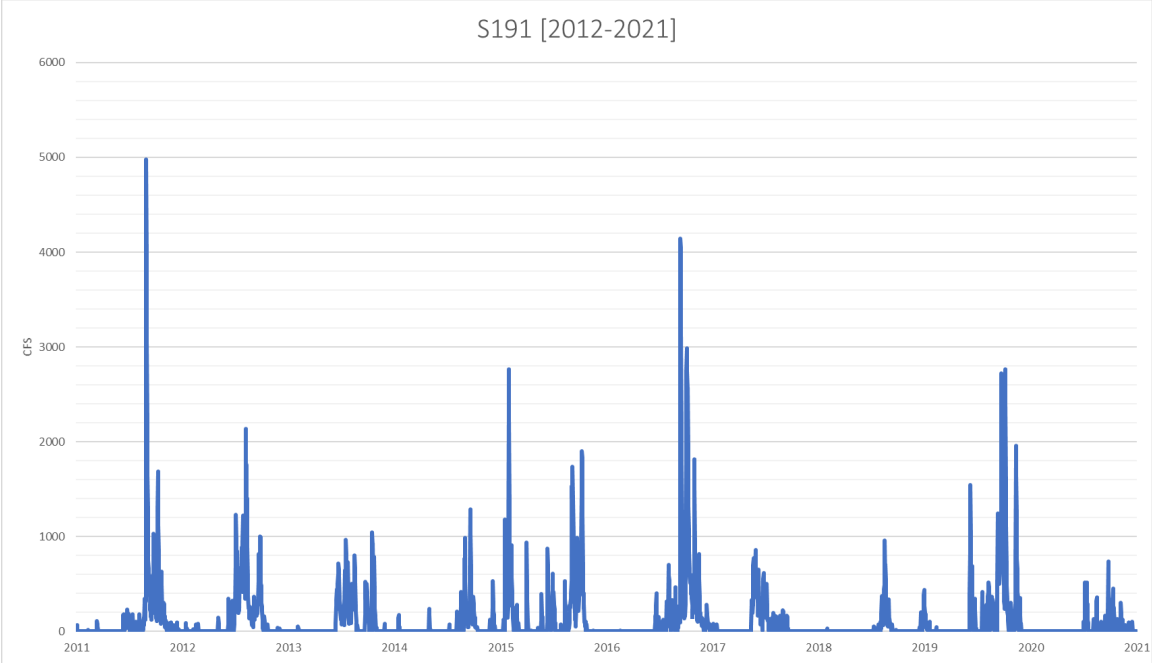

Figure 62. Flow hydrograph for the S-191 structure [S191_S].

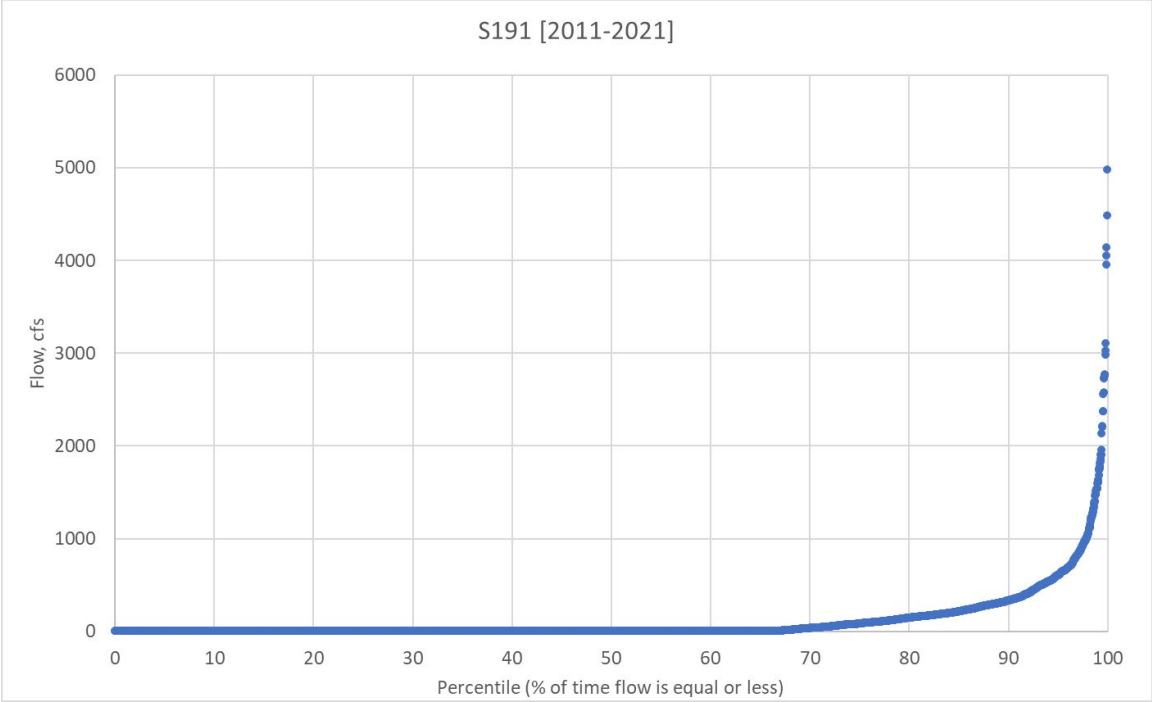

Figure 63. Flow exceedance for the S-191 structure [S191_S].

Table 33. Pumping Capacity for Newly Completed and Planned Projects in the S-191 Basin.

Project	Status	Pump Capacity [cfs]
214 Project	Planned	20 (estimated)
Brady Ranch FEB	Planned	150 (estimated)
Brady Ranch ASR	Planned	8 (estimated)
Grassy Island FEB	Planned	100 (estimated)
Grassy Island ASR	Planned	8 (estimated)
13 LOWRP ASR Wells	Planned	100 (estimated)
Lakeside Ranch STA	Newly Completed	250
Nubbin Slough STA	Newly Repaired	144

NUBBIN SLOUGH

To evaluate a theoretical point upstream of the STA, station S385_W (bypass weir) and S385_P (pump at STA) were combined to determine the amount of flow at Nubbin Slough (**Figure 64**) which averaged 12,462 ac-ft/yr during the evaluation period (2011-2021)[7]. No flow was present approximately 6% of the time, and the maximum observed flow rate was nearly 1,250 cfs. Available flow (90^{th} percentile) was approximately 29 cfs (**Figure 65**). Approximately 58% of the total volume occurred at extreme flows, i.e. greater than the available flow (90^{th} percentile). Existing projects in the Nubbin Slough basin have a 144 cfs pump capacity which is the 97^{th} percentile flow. Based on this preliminary information, it appears there is enough pump capacity in the Nubbin Slough STA for the available water observed in the creek. There may be an excess volume that occurs in peak events that exceed the pump capacity, and that volume should be addressed through a different approach (i.e., other than pumping).

[7] This assumes the flow in Nubbin Slough tributary is equal to the flow south (bypass flows) plus what is pumped to the STA. Also, the Nubbin Slough HWTT project is already operating upstream so water from this analysis is what is available after water has been taken out for that project.

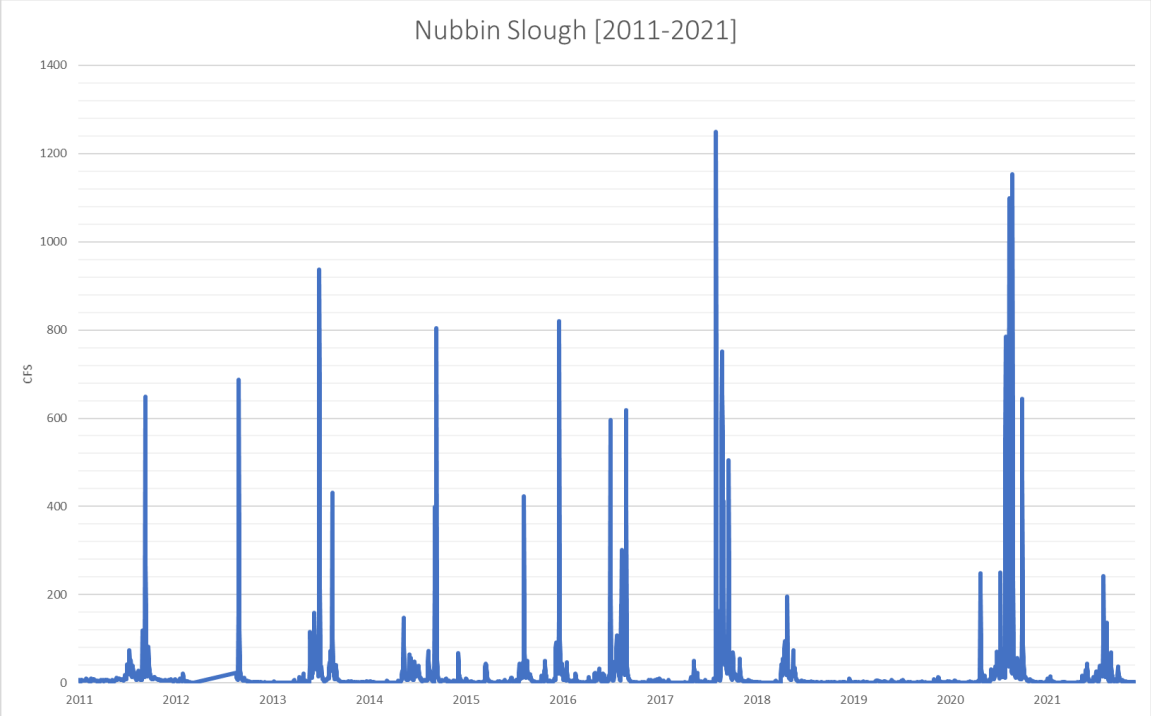

Figure 64. Flow hydrograph for Nubbin Slough [S385_W+S385_P].

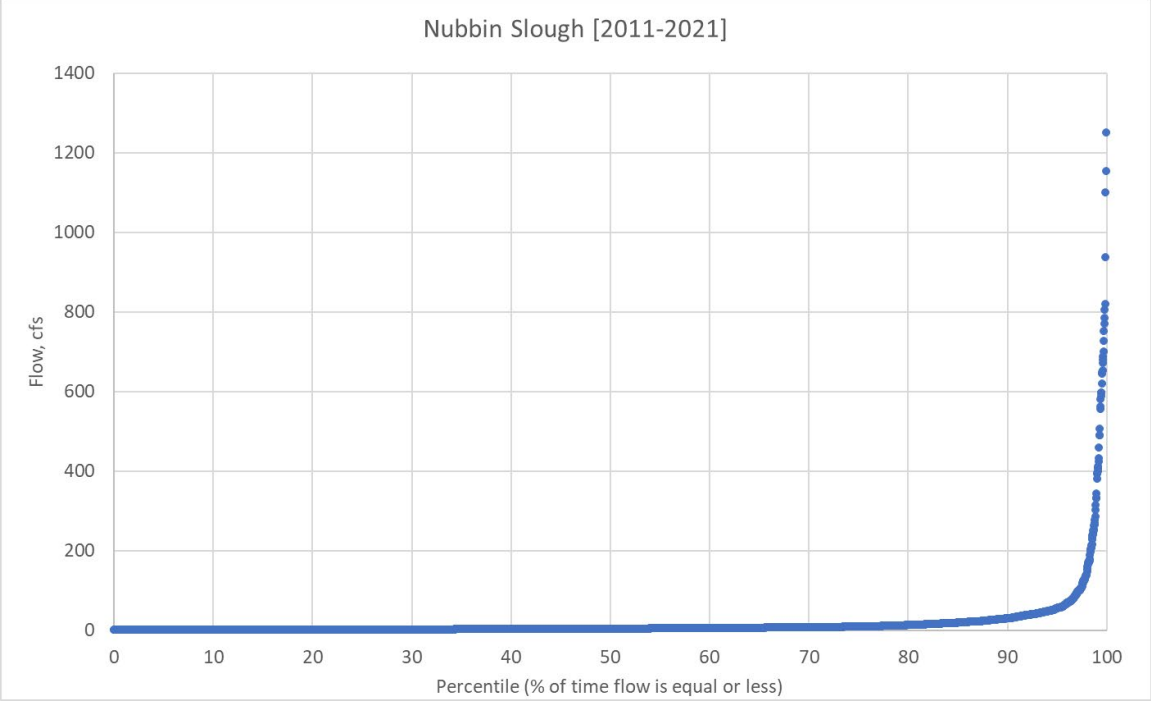

Figure 65. Flow exceedance for Nubbin Slough [S385_W+S385_P].

TAYLOR CREEK AT GRASSY ISLAND

Flow in Taylor Creek near Grassy Island (**Figure 66**) averaged 37,430 ac-ft/yr during the evaluation period (2004-2022). No flow was present only 2% of the time, and the maximum observed flow rate was 1,870 cfs. Available flow (90th percentile) was approximately 133 cfs (**Figure 67**). Approximately 41% of the total volume occurred at extreme flows, i.e. greater than the available flow (90th percentile). There appears to be enough water available to support a project in this location. Further analysis is being conducted as part of the proposed Grassy Island FEB project design.

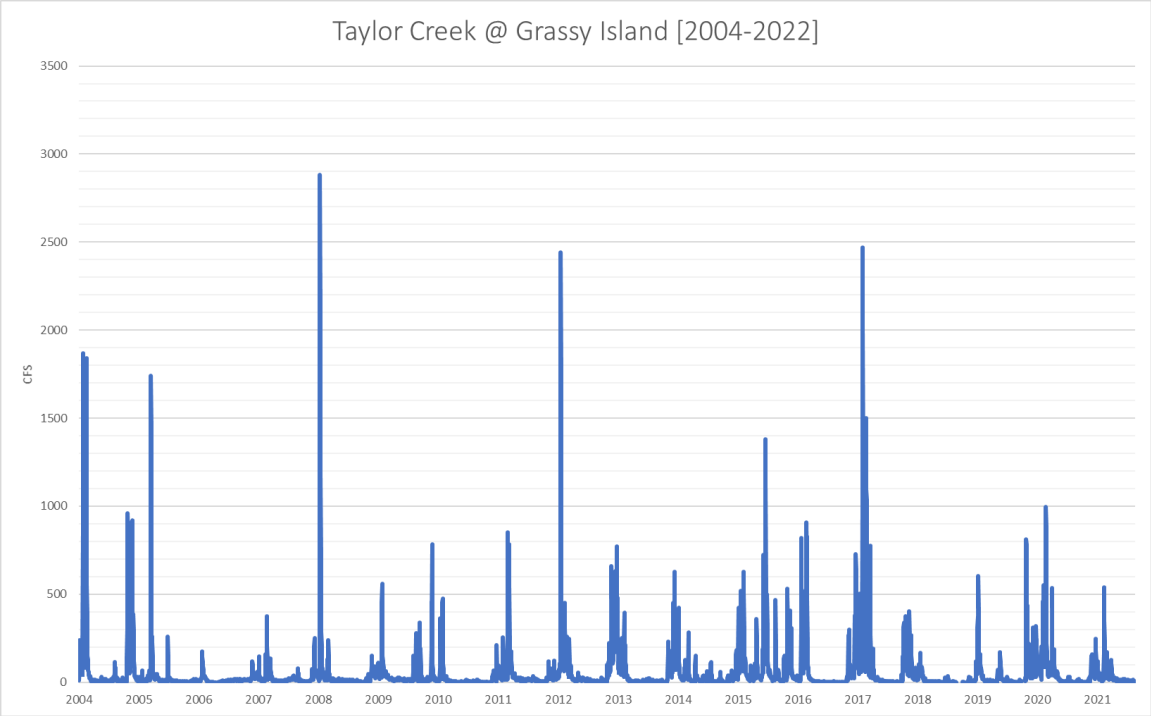

Figure 66. Flow hydrograph for Taylor Creek at Grassy Island [02274325].

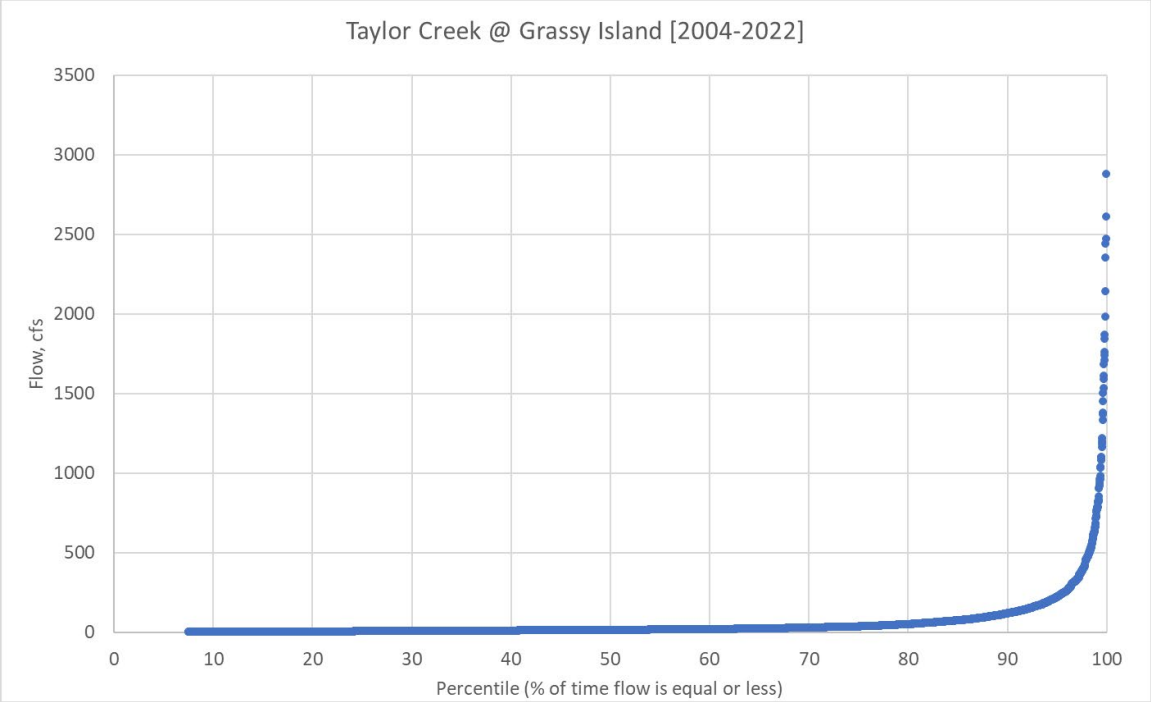

Figure 67. Flow exceedance for Taylor Creek at Grassy Island [02274325].

MOSQUITO CREEK

Flow at Mosquito Creek (**Figure 68**) averaged 9,009 ac-ft/yr during the evaluation period (2010-2022). No flow was present approximately 8% of the time, and the maximum observed flow rate was approximately 340 cfs. The available flow (90^{th} percentile) was approximately 33 cfs (**Figure 69**). Approximately 34% of the total volume occurred at extreme flows, i.e. greater than the available flow (90^{th} percentile). Based on this analysis, it appears that there is water to support a small storage or treatment project. See **Appendix A5** for further details.

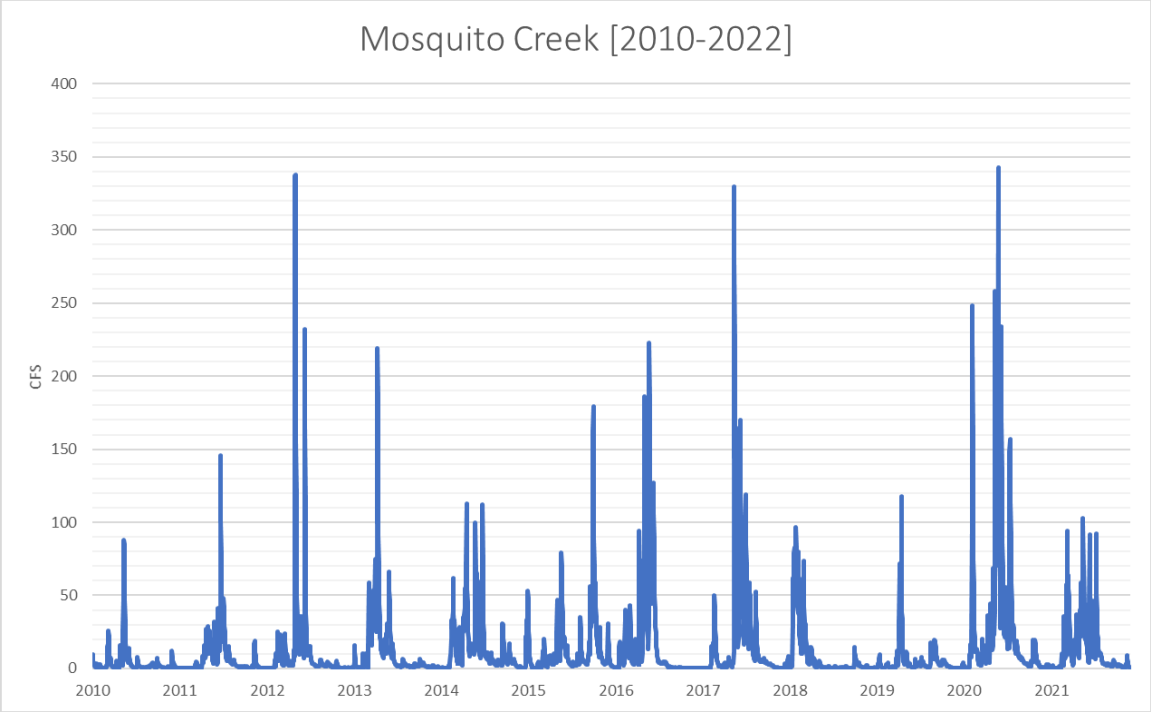

Figure 68. Flow hydrograph for Mosquito Creek [02275197].

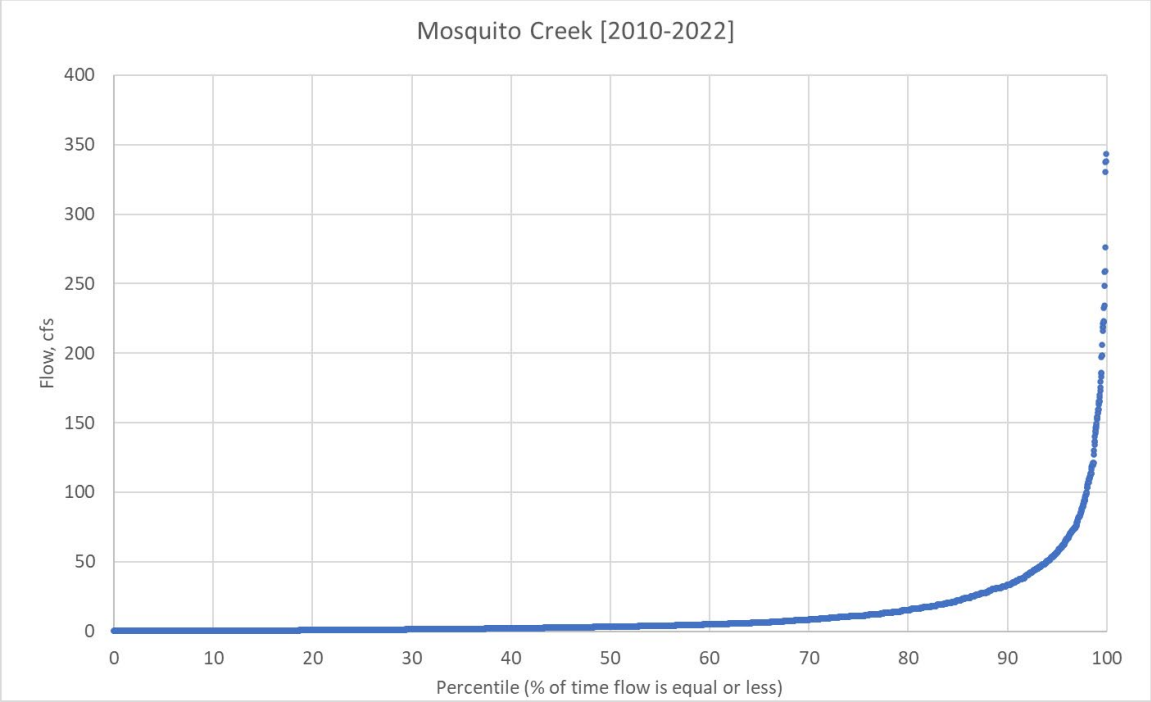

Figure 69. Flow exceedance for Mosquito Creek [02275197].

WOLFF CREEK

Flow at Wolff Creek (**Figure 70**) averaged 3,483 ac-ft/yr during the evaluation period (2003-2022). No flow was present approximately 8% of the time, and the maximum observed flow rate was approximately 300 cfs. Available flow (90th percentile) was approximately 11 cfs (**Figure 71**). Approximately 51% of the total volume occurred at extreme flows, i.e. greater than the available flow (90th percentile). Based on this analysis, water availability is low but opportunities for on-site passive detention should be pursued. See **Appendix A5** for further details.

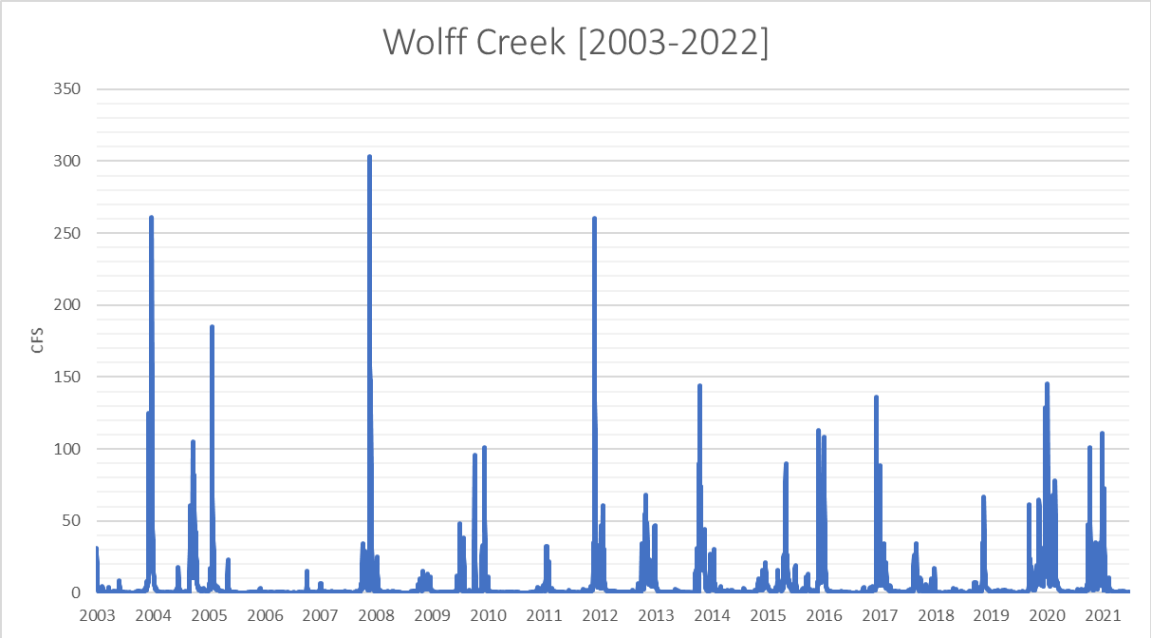

Figure 70. Flow hydrograph for Wolff Creek [02274505].

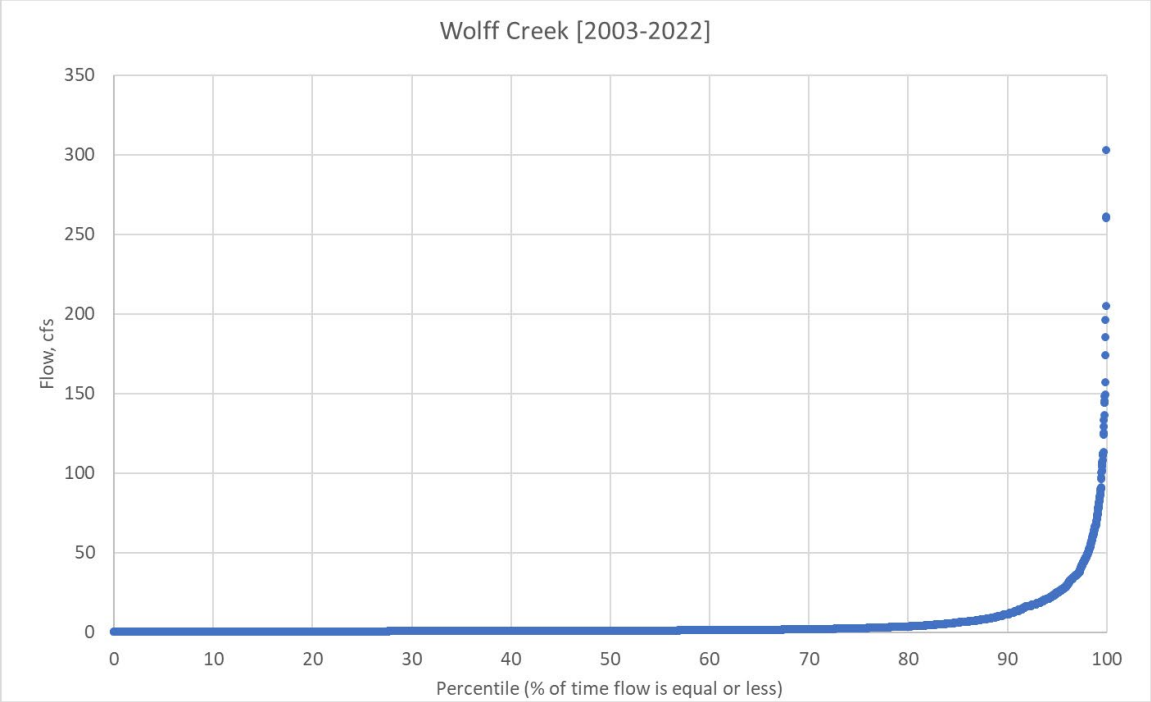

Figure 71. Flow exceedance for Wolff Creek [02274505].

AGRICULTURAL DITCH

Flow at Agricultural Ditch (**Figure 72**) averaged 18,541 ac-ft/yr during the evaluation period (2003-2022). No flow was present approximately 5% of the time, and the maximum observed flow rate was approximately 750 cfs. Available flow (90^{th} percentile) was approximately 68 cfs (**Figure 73**). Approximately 39% of the total volume occurred at extreme flows, i.e. greater than the available flow (90^{th} percentile). Based on this analysis, water should be available for the proposed TCNS 214 Dispersed Storage and Treatment Project with a 20 cfs pump.

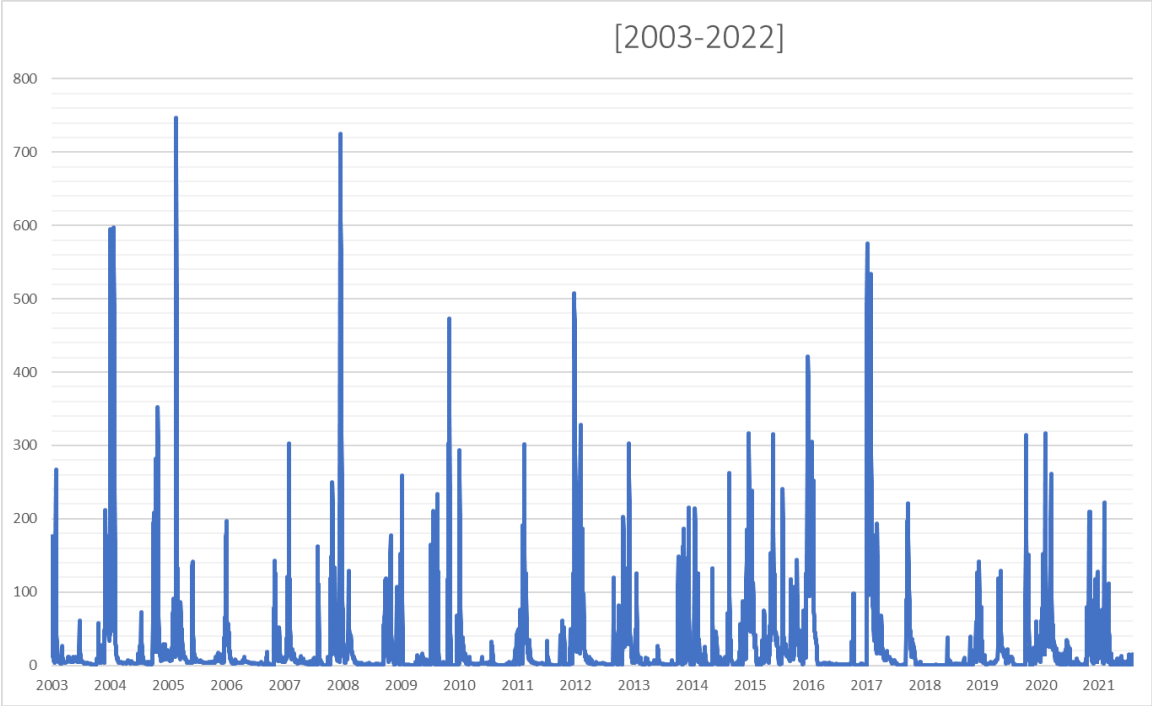

Figure 72. Flow hydrograph for Agricultural Ditch [02274490].

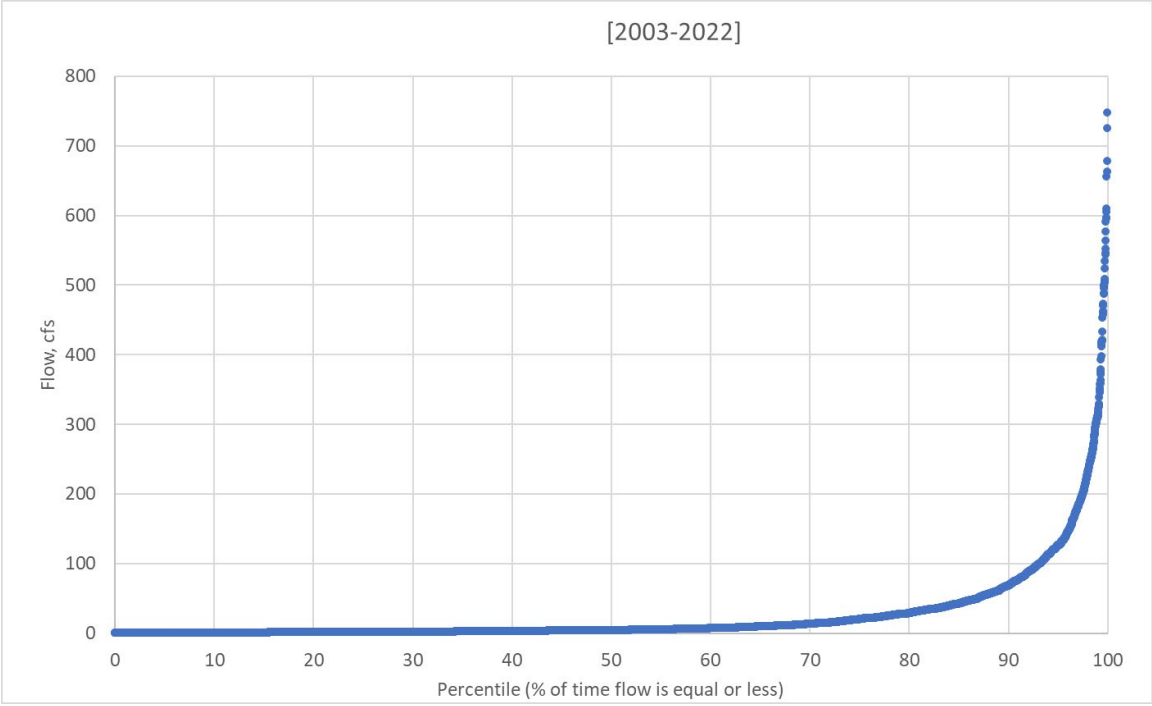

Figure 73. Flow exceedance for Agricultural Ditch [02274490].

RESEARCH AND TECHNOLOGY NEEDS

During the course of this assessment, research and technology needs were identified and are described below.

The ortho-P levels were high at most locations investigated but often particulates were also present. Further study is needed to understand the soil and water chemistry in these systems and in particular the extent of the solubility of the parameters.

Additionally, the impact from phosphorus stored in the soils or sediments is not fully known (sometimes referred to as legacy P). It can be very difficult to discern when P in soils is an issue and this is an area where further study is needed. P stored in soils becomes a problem when it becomes mobile. The University of Florida Institute of Food and Agricultural Sciences (IFAS) has developed a methodology to determine the soil storage capacity for sandy soils "soil P storage capacity" (SPSC) (Nair et al. 2010) but soil tests are needed to determine the SPSC value. According to Task 2 Evaluation of Existing Information for the Technical Assistance in Review and Analysis of Existing Data for Evaluation of Legacy Phosphorus in the Lake Okeechobee Watershed (Soil & Water Engineering Technology, Inc. [SWET], 2007), there are two pools of legacy P. One pool is mobile and can be transported downstream to Lake Okeechobee and the other has been irreversibly attached to the soil and has "little or no chance of moving to the lake." SWET assumed that irreversibly attached pool was negligible but stated that that this is not well known. While Reddy et al. 2011 reported that 35% of TP in soils was nonreactive and not biologically available. More research is needed to determine the impact of P stored in soils on water quality in the S-191 Basin.

Task 2 of the 2007 SWET report estimated 15,053 t P was stored in the A horizon and 3,857 t P stored in the E horizon in the S-191 Basin. The accuracy in the amount of legacy P from the Task 2 Report was $\pm$ 30% and for the mobility factors was $\pm$ 25% (SWET, 2008). It is suggested that a soil P storage and mobility study be conducted on SFWMD land within the LOW to obtain additional information on this topic. It is also recommended that the Coordinating Agencies continue to optimize BMPs to reduce nutrient imports to reduce the amount of P stored in the soils and to investigate ways to reduce soil P mobility. Currently, an experiment being conducted on Buck Island Ranch in the Indian Prairie Subwatershed funded by FDACS and SFWMD is using vegetation filter strips to remediate legacy P. If the results are favorable, this method may be considered for areas within the S-191 Basin with high phosphorus in the soils that is mobile and causing water quality issues.

There have been some studies conducted on P in the sediments in the LOW. A study conducted in the 1990's indicated that the secondary, tertiary and field ditches were contributors of particulate P but that the primary canals were net sinks (Mock, Roos & Associates et al., 1997). That study also concluded, based on a literature review, that erosion from sediments was a greater sink of P rather than a release of P back into the water column. From 2000 to 2004, the SFWMD conducted a demonstration project to determine the water quality benefits of using sediment removal technologies at Lettuce Creek (Environmental Research & Design, 2004a). The technology tested did not make an impact due to the majority of P in Lettuce Creek being soluble, the very fine size of the particulates in Lettuce Creek, and fish getting caught in the equipment. Also, in 2004, a half mile portion of the L-63N canal was dredged for maintenance and a study was conducted to determine the amount of phosphorus in the dredged materials (Environmental Research & Design, 2004b). Approximately, 4 t of phosphorus was removed during the 63-day project. Alum was used to reduce TP and TSS concentrations in the dredge slurry. Statistically significant increases in TP and turbidity were observed in the downstream portions of the canal during the project. The report also provided recommendations to improve the dredging and monitoring process. Additional work is needed to fully understand the impact of the sediments and their removal on the TP load and how to address it. Also, it is recommended that the 1997 Mock, Roos & Associates et. al, study be updated as canal sediments can change with time.

Further investigation is also needed into the groundwater and surface water interactions. The water table is fairly close to the surface in this basin and based on the high nutrient concentrations in the groundwater near the dairies, this may have an impact on downstream surface water concentrations at the upstream monitoring sites.

To provide a more robust evaluation of the operating projects reduction estimates or expectations need to be developed for every project for TP, TN and/or storage based on what is applicable for the project type. Then monitoring needs to be conducted to determine if those reduction estimates are met. For the S-191 Basin most of the projects have TP removal reduction estimates but no estimates are provided for TN or storage. It is recommended that where data are available, these be developed and reviewed each year. New projects should require this information and follow up monitoring. It should be noted that nutrient removal estimates for all three parameters may not be possible as there may be some projects that are only for storage or only for nutrient removal. If that is the case it should be clearly stated. SFWMD should also continue its investigations on ways to improve the STA performance.

The contributing areas for the upstream monitoring sites were recently delineated and during that project, there were areas of S-191 identified that are not currently represented by upstream monitoring (**Figure 74**). The contribution from these areas is not known at this time and it is recommended that monitoring be added to these areas as resources allow. The sample collection frequency at most of the upstream monitoring sites is bi-weekly when flowing (some sites are collected weekly). The parameters collected include TP, OPO4, TN, ammonium (NH_4), nitrite + nitrate (NOx), dissolved oxygen (DO), specific conductance, pH, and water temperature. This collection frequency and parameters in addition to TP began in February of 2020 after the SFWMD Governing Board approved an expanded monitoring network which also include 37 additional upstream monitoring sites in the LOW. The expanded parameters and increased frequency provide valuable information for the watershed assessments and should continue.

Water from each of the upstream monitoring sites eventually flows to the S-191 structure but the loading impact from those sites to the structure is not known. Further investigation is needed in this area. Five upstream monitoring sites also have measurements of flow through the USGS monitoring funded by FDACS (**Figure 74**). Zhang et al. (2021) determined the average annual flows, FWMC and loads from these sites (**Table 34**). It is recommended that the TP and TN loads be calculated annually for these sites and published in the SFER. Pass-through loads should be considered for sites that receive loads from an upstream site such as TCNS 213 which receives flow from TCNS 209. This would provide additional information on the impact of those upstream monitoring sites in terms of load. Currently the five sites represent load from the headwaters area of Taylor Creek, Agricultural Ditch, Wolff Creek and Mosquito Creek. Additional flow monitoring should be considered for mid-Taylor Creek, Nubbin Slough, Henry Creek, and Lettuce Creek. This would allow a determination of which tributaries in the basin contribute the most nutrient loads.

Table 34. Average Annual Flow, TP load, TP FWMC, TN load, and TN FWMC data at upstream sites in S-191 with measurements of flow from WY2006 to WY2019 (Source Zhang et al. 2021).

Water Quality Site Name	Flow Site Name	Average Flow (ac-ft)	Average TP Load (t)	Average TP FWMC (µg/L)	Average TN Load (t)	Average TN FWMC (mg/L)
TCNS 209	02274005	3,000	2	550	11	2.49
TCNS 213	02274010	28,000	20	577	80	2.28
TCNS 214	02274490	18,000	14	559	44	1.88
TCNS 217	02274505	3,000	1	320	8	1.81
02275197	02275197	8,000	6	515	24	2.14

In 2021, SFWMD began exploring a new remote sensing technology using satellites, with cost-share funding from FDEP. In May 2021, SFWMD executed a contract with Black and Veach and their sub-contractor Satelytics, for a pilot study of remote sensing for Total Phosphorus and Total Nitrogen on land

and in water. Preliminary results have shown that this technology could be a very powerful tool to identify the source of high nutrient concentrations in SFWMD waterbodies.

SFWMD also needs to continue to work with FDEP and FDACS to try to identify the causes of the increasing TP concentration trends at the five upstream monitoring sites and work to develop projects and adjust programs to address the causes. BMPs need to be optimized to address remove soluble P.

Storage targets should be developed for each LOW basin and subwatershed to ensure the placement of storage projects in the right locations to maximize benefits. A strategic planning exercise recommended by University of Florida (University of Florida, 2015) could be used to develop these targets. Additional data and analyses are needed to determine runoff timing and distribution should be considered when selecting and designing projects. Additional research is also needed to determine if there is a relationship between nutrient discharges and other system conditions (e.g. temperature, pass-through events, nutrient speciation, and algae blooms).

Rainfall trend analyses should also be completed. Rainfall trends should be evaluated for the time periods on which nutrient concentration and loading trends are evaluated to see if there are any patterns. Additionally, rainfall trends should be reviewed to determine possible impacts from climate change.

The Research and Technology needs are summarized in **Appendix A1.**

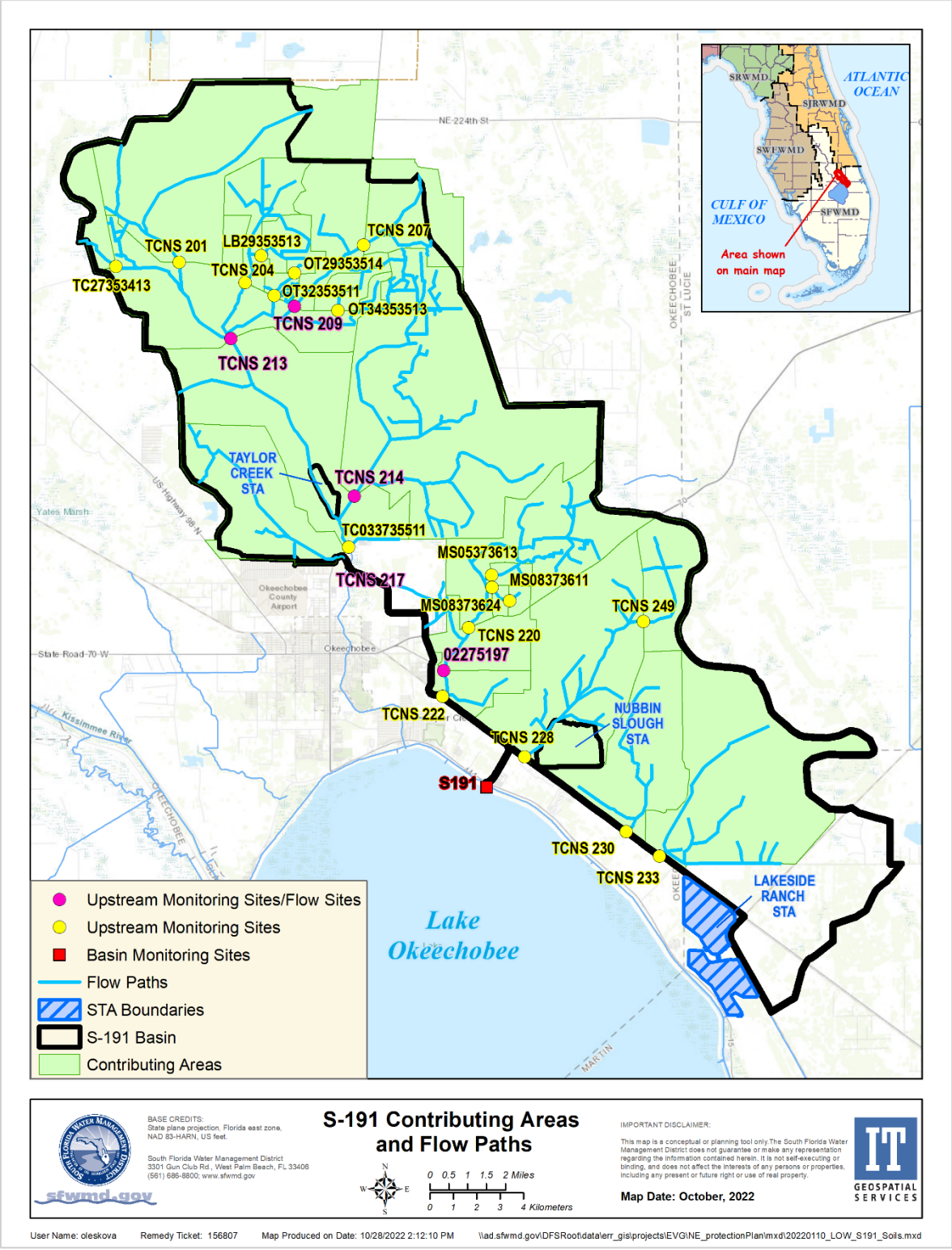

Figure 74. Contributing areas for the upstream monitoring sites in the S-191 Basin. White areas within the basin represent the monitoring gaps.

DISCUSSION AND RECOMMENDATIONS

Projects and programs have made an impact in the S-191 Basin, but an additional 56 t/yr reductions are needed to get from the WY2017-WY2021 TP load of 68 t/yr to the TP planning target of 12.3 t/yr based on a 5-year rolling average. The recently completed and upcoming projects with known TP load reduction estimates are expected provide an additional 24.8 t/yr TP reduction. Thus, the Coordinating Agencies need to consider additional source controls and additional projects to achieve an additional 31.2 t/yr TP reduction. Based on the high TP concentrations and the contribution of flow to the TCNS subwatershed, it appears that both nutrient and storage projects are needed to achieve the nutrient reduction goals. Assuming most of the benefits from the source control programs have likely been realized in the S-191 Basin since they have been in place for many years (**Table 9**), the amount of TP load reduction needed may require additional projects and the existing and planned projects should be enhanced and optimized to achieve more. Based on the high Ortho-P values and low TSS concentrations at the S-191 structure, additional efforts should focus on addressing soluble P, but sediment controls should also be considered at the upstream monitoring sites.

Several upcoming or recently completed projects will assist with nutrient reductions and/or additional storage. These include the completion of the S-191A pump station, and the Brady Ranch and Grassy Island ASR and FEBs. ASR wells are planned for the S-191 Basin as part of the CERP and will provide additional storage and reduce dry-out conditions for downstream STAs. The CERP ASRs may also provide ancillary water quality benefits. Lakeside Ranch STA Phases I and Phase II are now operational. Additionally, repairs were recently finished to the Nubbin Slough STA. There is an upcoming innovative technology project that will be located immediately upstream of the S-191 structure. Also, SFWMD recently received a grant to implement a project along Agricultural Ditch on the TIITF lands. Efforts should continue to optimize the HWTT projects and projects to enhance the performance of the existing STAs.

A re-evaluation of the BMPs used in the contributing areas for the sites with TP concentration increasing trends should also be considered. BMPs should be optimized to maximize the reduction of ortho-P, maximize the reduction of nutrient inputs to the soil and reduce mobility of P transport. While a majority of the agricultural landowners are enrolled in the BMP program in the S-191 basin, there are areas that are unenrolled that need to be addressed, particularly upstream of the five upstream monitoring sites with increasing trends. FDACS need to be determine if these areas are “unenrollable” or if the owners need to be notified of the requirement to implement BMPs or conduct monitoring under Chapter 40E-61, F.A.C. A large reduction in TP load from the enrollment of the remaining acreage is not expected since the FDACS BMP program began in the S-191 Basin in 2003.

SFWMD needs to continue to monitor and work with FDACS and FDEP to investigate the potential causes and means to address the water quality issues on all five sites with increasing trends. Four of the five sites are downstream of operating or former dairy barns which had compliance monitoring wells with nutrient concentrations above the background monitoring wells. A couple of the operating barns also had relatively high spray-field effluent nutrient concentrations. As a result, FDEP is following up with the dairy permitting program and reviewing groundwater/surface water interactions with SFWMD. The FDEP dairy program should be reviewed to determine if additional cost share or BMP requirements are needed to prevent high nutrient concentrations in groundwater and spray-field effluent. Perhaps the requirements for dairy wastewater treatment pond closure should also be reviewed.

During discussions with FDACS and FDEP, it was mentioned that the source control program boundaries for dairies are not clearly delineated. The implementation verification program efficiency would be improved if these boundaries were clearly defined as FDACS could focus on the portions that fall under their program and likewise FDEP’s inspections could focus on the portion of the property that they regulate. Therefore, it is recommended that dairy source control program boundaries be clearly delineated so that FDACS and FDEP understand who is responsible for what portions of a dairy property for implementation verification inspections.

Septic tank clusters are located within the contributing areas of TCNS 214 and TCNS 220 and adjacent to LB29353513 which are exhibiting increasing trends. SFWMD will notify FDEP who will review the septic tank clusters which may be addressed under future plan requirements under the Clean Waterways Act.

The ERP program is currently undergoing rulemaking to revise the rules to update the stormwater design and operation regulations, using the most recent scientific information available. The Clean Waterways Act (Chapter 2020-150) requires a consideration of BMPs and design criteria as part of that process. The updated rules will only be applicable to permit applications made after the rules are amended. It is important to note that not every property in the LOW has an ERP. It is dependent upon the activity as defined by Ch. 62-330.202, F.A.C. Also, older projects in existence prior to the ERP rules may not have been required to have a SWM and may not have the same level of treatment.

Since the reduction from additional source controls cannot be quantified at this time , the Coordinating Agencies need to consider additional projects to achieve the estimated 26 – 31.2 t/yr long-term average annual TP reduction for this basin. This team considered the following potential projects:

- Additional Storage at Nubbin Slough STA to prevent dryout
- Project at Mosquito Creek
- Project along Wolff Creek on SFWMD owned property

A conceptual project feasibility and risk assessment was completed for each of these proposed projects (**Appendix A5**) and a brief summary of those results are presented here. While additional storage in the Nubbin Slough tributary would be beneficial, projects depending on additional pumps are not likely to be the most cost effective according to the water availability analysis. Instead, passive detention and wetland restoration projects may be better suited for this area. These could assist in reducing intense peak flows and potentially increase baseflow available to the STA.

An additional project located at Mosquito Creek would also be heavily dependent upon land availability and would need to consider the upstream HWTT facility. The water availability analysis indicates relatively consistent, low velocity flows in Mosquito Creek may be sufficient to support a small project. See **Appendix A5** for further details.

SFWMD and FDACS projects in place or planned currently provide regional treatment for most of the major tributaries in the watershed but there is nothing along Wolff Creek. SFWMD's Grassy Island Property which encompasses a portion of Wolff Creek was considered as a potential project location. However, the potential project location would be at a minimum approximately 3 miles upstream of the existing monitoring station (where Wolff Creek enters into L-63N at TCNS 217) due to the location of the SFWMD property and Federal Aviation Authority restrictions. Thus, potential nutrient contributions downstream of the project would not be captured. Based on that and limited water availability, an on-site detention project might be best. Additionally, water from Wolff Creek (TCNS 217) has relatively good water quality compared to other areas of the watershed and is estimated to only contribute 1 t/yr of TP annually to L-63N. Water availability analysis also indicates potential project benefits are expected to be small (**Appendix A5**).

The team also considered recommending a new large-scale regional project to achieve the necessary load reduction. Ideally, it should be located as close to the S-191 structure as possible to treat water immediately before it discharges into the lake. However, it was decided not to make this recommendation at this time because currently the pump capacity exceeding the 90th percentile of available flow at the S-191 structure. Instead, it is recommended that operations for existing and planned projects in the S-191 Basin be evaluated basin-wide for comprehensive management to ensure that they are coordinated, synchronized, and operated for maximum nutrient reduction and storage. Once that is completed and if it is determined that the S-191A pump can pull water from the lake into the S-191 Basin, that potential project

could be revisited, if needed, dependent upon land availability. See **Appendix A5** for further details on the risk assessment.

The team also considered a previously proposed project which proposed to place a pump station at the confluence of the L-63N borrow canal and the C-59 Canal to deliver additional water to the Nubbin Slough STA via a force main. Based on the water availability analysis, it is not recommended to revisit this project at this time for two reasons. First, the Nubbin Slough STA has recent completed significant repairs and is expected to begin to provide treatment for a higher proportion of Nubbin Slough flow volume. Second, it was decided not to make this recommendation at this time because currently the pump capacity exceeding the 90th percentile of available flow at the S-191 structure. Additionally, staff learned that the railroad tracks between the proposed pump and the STA may have been a major hinderance as to why this project did not move forward previously.

Additional recommendations based on the water availability analysis included automating all project inflow pumps to limit response lag and flow bypass due to the short duration, high flow events. And, the planned FEB and ASR projects should be operated to moderate the observed flashy flows by increasing baseflow to retain storage capacity for peak flow events. Also, additional passive stormwater detention and wetland restoration projects should be considered throughout the watershed to assist with decreasing peak flows and increasing base flows.

The Coordinating Agencies also need to continue to enhance existing projects and make any necessary repairs to ensure full project utilization and maximum nutrient reductions. Specific recommendations include automating all STA structures at both the Taylor Creek and Nubbin Slough STAs to allow for a quicker response to operational changes to enhance performance and resizing the Nubbin Slough STA inflow pump to ensure steady operation. Also, as much as possible, nutrient reductions and storage of projects currently undergoing design should be maximized. It is anticipated that the 24.8 t/yr TP reduction from the recently completed and planned projects may be achieved in 2030, assuming the projects are completed on time and can achieve their long-term estimated TP reductions within five years of operation. The additional 26 to 31.2 t/yr reduction needed for this basin may prove more challenging to attain due to the flashiness of the basin which has high flows in a short amount of time.

This assessment also outlined several areas where additional research is needed such as solubility of parameters, soil water chemistry, remediation of legacy P, and groundwater surface interactions. It is recommended that soil P storage and mobility studies be conducted on SFWMD lands within the LOW to gather additional data. And SFWMD should update the LOW canal sediment study that was completed in 1997 (Mock, Roos & Associates et al., 1997) as sediments can change over time.

Target goals for nutrients and storage are needed to better evaluate projects and storage targets are needed for the S-191 Basin. The University of Florida recommended a strategic planning exercise for the LOW (University of Florida, 2015) and one should be conducted specifically to develop storage goals and targets for each basin to ensure the placement of storage projects in the right locations to maximize benefits.

SFWMD should continue the increased frequency and additional parameters collected as part of the expanded monitoring network. Additional upstream monitoring for areas of the basin not currently monitored and additional flow monitoring for key tributaries should also be considered. SFWMD should also calculate loads for the upstream monitoring sites with flow and publish the results annually in the SFER.

Additional data and research are needed to determine impacts of the timing of runoff and relationships between nutrient discharges and other system conditions (e.g. temperature, pass-through events, nutrient speciation, and algae blooms. Trends in rainfall should also be reviewed for periods evaluated for nutrient loading and concentration trends and to determine possible impacts from climate change.

The Coordinating Agencies also need to continue to develop a rapid assessment process to notify and share information when unusual events happen in an effort to be more proactive in managing specific water quality issues such as the event that occurred in the spring of 2021 in Otter and Taylor Creeks.

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APPENDIX A1 RESEARCH AND TECHNOLOGY NEEDS

1. Continue investigations into the five upstream monitoring sites with increasing TP concentration trends (TCNS 214, TCNS 220, TCNS 209, OT34353513, and LB29353513) to determine the potential causes and develop actions to reverse the trends.
    a. This may include review of additional data, additional field visits and the use of remote sensing.
    b. Continue to investigate the groundwater/surface water interactions.
2. Sediments/Soils/Legacy P
    a. Investigate soil-water chemistry to determine solubility of parameters and how soils and sediments may release P.
    b. Consider conducting a Legacy P study on SFWMD land.
    c. Consider updating the LOW canal sediment study as sediments can change with time (Mock, Roos & Associates et al., 1997; Environmental Research & Design, 2004b) and conduct studies to determine the impact of canal dredging on long-term P loads.
    d. Continue research targeting remediation of phosphorus stored in soils (legacy P) via BMPs or other measures.
    e. Conduct soil P storage and mobility studies on SFWMD lands within the LOW.
3. Targets and Estimates
    a. Use a strategic planning exercise to develop storage targets for each subwatershed and basin in the LOW as recommended by the University of Florida (University of Florida, 2015).
    b. Where data are available, develop TP and TN reduction and/or storage estimates to provide a more robust evaluation of existing projects. Additional monitoring should be considered for projects without the necessary data. Nutrient and/or storage estimates based on project type should be required for every new project, along with monitoring to determine if project goals are met.
4. Monitoring
    a. Continue to monitor at the increased frequency and collect the additional parameters approved as part of the expanded monitoring network.
    b. Consider additional flow monitoring stations and upstream monitoring locations in areas not currently monitored.
    c. Calculate loads for the upstream monitoring sites with flow and publish the results annually in the South Florida Environmental Report (SFER).
5. Distribution/Relationships
    a. Additional data and analyses are needed to determine runoff timing and distribution and should be considered when selecting and designing projects.
    b. Additional research is also needed to determine if there is a relationship between nutrient discharges and other system conditions (e.g. temperature, pass-through events, nutrient speciation, dry-out conditions, and algae blooms).

6. Rainfall

    a. Review trends in rainfall when evaluating nutrient trends and for possible impacts from climate change.

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APPENDIX A2 ITEMS CONSIDERED IN ASSESSMENTS

Table A2-1. Items to consider for detailed assessments in selected focus areas.

Topic	Task
Detailed Data Analyses	• Determine statistically significant trends in basin flow, concentration, and loads. Found in Basin Level and Upstream Level Analysis sections. • Determine dominant mechanisms and factors impacting pollutant levels in the watershed as a whole and in each basin (e.g., nutrients, nutrient speciation, runoff volume). Found in Basin Level Analysis, Upstream Level Analysis, and Water Availability Sections. • Is there interconnectivity between watersheds/basin that needs to be considered? Found in Basin Feature Section (Hydrology Subsection). • Evaluate storage volume estimates and determine needs for updating, modeling, and ground-truthing. See Introduction (Nutrient and Storage Targets for the S-191 Basin Subsection), Water Availability, and Research and Technology Needed Sections. • Determine how runoff timing and distribution should be considered when selecting and designing projects for a maximum benefit at the receiving body. See Research and Technology Needed Section. • Determine if there is a relationship between nutrient discharges and other system conditions (e.g., temperature, pass-through events, nutrient speciation, algae blooms). See Research and Technology Needed Section.
Projects & Programs Evaluation	• Determine whether projects are being operated according to design, including original design parameters (inflow, outflow, and operational constraints). Found in Project and Programs Evaluation Section (Projects Subsection). • Review project monitoring data to assess project performance. Found in Project and Programs Evaluation Section (Projects Subsection). • Identify existing project issues that need to be addressed (e.g., retrofits, enhancements, demonstration projects). Found in Project and Programs Evaluation (Projects Subsection), Water Availability, and Research and Technology Needs Sections. • Determine how the project treatment and storage capacities relate to the area, flow volume, and nutrient loading of the basin where it is located. Found in Project and Programs Evaluation Section (Projects Subsection), Water Availability, and Research and Technology Needs Sections. • Determine the percentage of the excess flow volume or nutrient load expected to be prevented/removed from the receiving water body. Found in Additional Nutrient Reductions Needed, Timeline to Achieve Recently Completed and Planned Projects Reductions, and Research and Technology Needs Sections. • Identify potential improvements of public and private stormwater management systems. Found in Project and Programs Evaluation Section (ERP/SW Permits and FDEP Permits Subsections). • For potential future projects, determine the plan for implementation or if it should be reconsidered. Found in Project and Programs Evaluation (Projects Subsection) and Discussion and Recommendations Sections. • Establish expectations and criteria for future projects based on lessons learned and current measured/documented results. See Executive Summary (Project Recommendations Subsection), Water Availability, Research and Technology Needs, and Discussion and Recommendations Sections. • Investigate locations for future projects considering runoff area to be captured and the project site characteristics, such as the historic uses of the land, ownership, size, cultural resources, protected species, and water supply considerations. See Water Availability and Discussion and Recommendations Sections.

Topic	Task
Make Determinations and Develop Solutions	• Determine the primary (e.g., agricultural vs. non-agricultural) and secondary land uses (e.g., septic tanks, dairies, rural residential ranchettes). Found in Basin Features (Land Uses Subsection), Project and Programs Evaluation (Septic Tanks Subsection), and the Upstream Level Analysis Sections. • Determine concentration hot spots based on upstream data. Found in Upstream Level Analysis Section. • Identify additional information and steps needed to assess BMPs, in coordination with the appropriate agency. Found in Executive Summary (Actions Needed by the Coordinating Agencies Subsection), Project and Programs Evaluation (BMP Enrollment as of November 2021 Subsection), Upstream Level Analysis, and Research and Technology Needs Sections. • Identify potential solutions to resolve the water quality problems, (e.g. performance enhancements for existing projects and programs, new projects, cost share programs, and/or advanced source controls). See Executive Summary (Project Recommendations Subsection), Project and Programs Evaluation, Water Availability, and Discussion and Recommendations Sections. • Determine how the impact from future source controls, projects, and programs will be measured. See Discussion and Recommendations Section.
Research & Technology	• Identify gaps in research specific to a watershed, basin, and/or receiving water body. Found in Basin Level Analysis, Upstream Level Analysis, and Research and Technology Needs Sections. • Identify gaps in research specific to a project or technology. Found in Project and Programs Evaluation (Projects Subsection) and Research and Technology Needs Sections. • Identify the most promising technologies and their pros and cons for the specific land uses. Found in Project and Programs Evaluation (Projects Subsection) and Discussion and Recommendations Sections. • Identify legacy P impacts and effective treatment technologies. See Research and Technology Needs Section.
Monitoring Optimization	• Identify if monitoring network optimization efforts are needed (e.g., move, remove, or add sites), due to access or maintenance issues, changes in land uses, and/or unfavorable monitoring conditions. See Research and Technology Needs Section. • Identify improvements to methods for measuring flow or collecting water quality data as needed. See Research and Technology Needs Section. • Develop and apply adjustment factors as needed when data collection methods have changed. Not applicable for this S-191 Assessment. • Identify monitoring gaps and how they can be accounted for (e.g., estimating flows from upstream monitoring locations). See Research and Technology Needs Section.

APPENDIX A3 – 2020 NRCS SSURGO SOIL SERIES IN THE S-191 BASIN

2020 NRCS SSURGO Soil Series in S-191	Acres	Percent Area
Immokalee fine sand, 0 to 2 percent slopes	34287.6	28.72%
Myakka fine sand, 0 to 2 percent slopes	32424.0	27.16%
Basinger fine sand, 0 to 2 percent slopes	6883.9	5.77%
Waveland and Immokalee fine sands	5967.2	5%
Basinger and Placid soils, depressional	4827.7	4.04%
Floridana, Riviera, and Placid soils, depressional	3937.6	3.3%
Floridana, Placid, and Okeelanta soils, frequently flooded	3705.3	3.1%
Manatee loamy fine sand, frequently ponded, 0 to 1 percent slopes	2523.9	2.11%
Bradenton fine sand, 0 to 2 percent slopes	2287.6	1.92%
Okeelanta muck, frequently ponded, 0 to 1 percent slopes	1988.4	1.67%
Pinellas fine sand, 0 to 2 percent slopes	1863.7	1.56%
Malabar fine sand, high, 0 to 2 percent slopes	1509.3	1.26%
Wabasso fine sand, 0 to 2 percent slopes	1433.2	1.2%
Oldsmar fine sand, 0 to 2 percent slopes	1418.2	1.19%
Pomello fine sand, 0 to 5 percent slopes	1202.6	1.01%
Placid and Basinger fine sands, depressional	1188.3	1%
Valkaria fine sand, 0 to 2 percent slopes	1086.2	0.91%
Parkwood fine sand	1036.2	0.87%
Riviera fine sand, 0 to 2 percent slopes	855.5	0.72%
Samsula muck, frequently ponded, 0 to 1 percent slopes	735.2	0.62%
Pineda-Riviera fine sands association, 0 to 2 percent slopes	731.9	0.61%
Wabasso sand, 0 to 2 percent slopes	610.0	0.51%
Lawnwood and Myakka sands	583.8	0.49%
Gator and Tequesta mucks	578.6	0.48%
Holopaw fine sand, 0 to 2 percent slopes	578.3	0.48%
Water	547.1	0.46%
Riviera fine sand, frequently ponded, 0 to 1 percent slopes	478.5	0.4%
Lawnwood and Myakka fine sands	446.5	0.37%
Pineda-Pineda, wet, fine sand, 0 to 2 percent slopes	423.1	0.35%
Basinger sand, 0 to 2 percent slopes	389.9	0.33%
Floridana fine sand, frequently ponded, 0 to 1 percent slopes	317.7	0.27%
Salerno and Punta sands	300.3	0.25%
Pendarvis and Pomello sands, 0 to 5 percent slopes	269.2	0.23%
St. Johns fine sand	259.1	0.22%
Satellite sand, 0 to 2 percent slopes	236.6	0.2%
Pomello sand, 0 to 5 percent slopes	209.6	0.18%
Waveland-Lawnwood complex, depressional	165.0	0.14%
Udorthents, 2 to 35 percent slopes	153.3	0.13%
Ft. Drum fine sand	137.6	0.12%
Wabasso and Oldsmar fine sands, depressional	127.4	0.11%
Hobe sand, 0 to 5 percent slopes	89.2	0.07%
Chobee muck, frequently ponded, 0 to 1 percent slopes	84.8	0.07%
Salerno sand	73.2	0.06%
Hontoon muck, frequently ponded, 0 to 1 percent slopes	68.0	0.06%
Waveland and Lawnwood fine sands, depressional	62.1	0.05%
Paola and St. Lucie sands, 0 to 8 percent slopes	61.1	0.05%
Ankona-Urban land complex	52.4	0.04%
St. Lucie sand, 0 to 8 percent slopes	51.9	0.04%
Sanibel muck	37.2	0.03%
Jupiter sand	28.9	0.02%
Boca fine sand	17.5	0.01%
Jonathan sand, 0 to 5 percent slopes	16.3	0.01%
Winder sand, frequently ponded, 0 to 1 percent slopes	12.4	0.01%
Anclote sand, frequently ponded, 0 to 1 percent slopes	8.7	0.01%
Hallandale sand, 0 to 2 percent slopes	8.0	0.01%
Orsino fine sand	7.3	0.01%
Hallandale sand	5.5	0%
Pompano sand, 0 to 2 percent slopes	4.6	0%
Hobe fine sand, 0 to 5 percent slopes	3.4	0%
Adamsville fine sand, organic substratum	2.0	0%
Arents, 45 to 65 percent slopes	0.8	0%
Udorthents, 0 to 35 percent slopes	0.2	0%

APPENDIX A4 – SFWMD UNPUBLISHED SKT S-191 UPSTREAM SITES RESULTS

Table A3-1 below provides the results from the unpublished SKT Analysis conducted as part of the 2020 Lake Okeechobee Watershed Protection Plan update. Three periods were reviewed; pre-protection plan from WY1991-WY2004; post protection plan from WY2005-WY2018; and the period of record WY1991-WY2018. Cells highlighted in red indicate that more than 50% of the monthly data were missing. Cells highlighted in yellow indicated a significant trend. For this assessment report, only sites with 50% or greater available data for the period of WY2005-WY2018 with stastically increasing significant trends were considered (LB29353513, OT34353513, and TCNS 214).

Table A4-1 Unpublished SKT results for S-191 Basin

	WY1991-WY2004					WY2005-WY2018					POR				
Station	% Missing Months	tau	Seasonal Sen Slope	Pvalue	Intercept	% Missing Months	tau	Seasonal Sen Slope	Pvalue	Intercept	% Missing Months	tau	Seasonal Sen Slope	Pvalue	Intercept
02275197	67.36%	-0.200	-0.106	***0.335***	4.437	55.36%	0.243	0.021	0.017	0.219	60.90%	-0.45257	-0.13071	***0.00276***	2.27828
LB29353513	25.64%	0.144	0.010	***0.244***	0.289	26.79%	0.266	0.028	***0.014***	0.274	26.23%	0.25578	0.01048	***0.0019***	0.27848
MS05373613	13.69%	0.020	0.005	***0.902***	1.293	52.38%	0.121	0.014	0.214	0.554	33.04%	-0.24505	-0.033	***0.04118***	1.482
MS08373611	7.74%	-0.548	-0.104	***0.001***	2.043	33.93%	0.046	0.009	0.565	0.631	20.83%	-0.3858	-0.04639	***0.00061***	1.71743
MS08373614	23.72%	-0.331	-0.066	***0.004***	1.686	56.55%	0.340	0.046	***0.027***	0.260	40.74%	-0.38355	-0.04857	***0.00108***	1.69671
OT29353514	55.36%	-0.112	-0.005	***0.444***	0.147	54.17%	0.354	0.032	***0.057***	0.006	54.76%	0.19982	0.005	***0.07871***	0.0955
OT32353511	35.12%	-0.077	-0.017	***0.445***	1.019	50.60%	-0.054	-0.012	***0.762***	1.457	42.86%	0.12522	0.01742	***0.18453***	0.81558
OT34353513	13.69%	-0.328	-0.012	***0.008***	0.213	34.52%	0.263	0.018	0.001	0.022	24.11%	-0.00894	-0.00021	***0.91345***	0.13492
TC03373511						60.12%	0.099	0.004	0.387	0.318	60.00%	0.039	0.002	0.736	0.354
TC27353413	56.55%	-0.108	-0.019	0.309	0.809	70.83%	-0.092	-0.004	***0.574***	0.346	63.69%	-0.35369	-0.02224	1.7E-06	0.79141
TCNS 201	25.00%	-0.021	-0.001	0.782	0.408	61.31%	-0.234	-0.013	0.038	0.525	43.15%	-0.09654	-0.00227	***0.1819***	0.44982
TCNS 204	19.05%	-0.073	-0.007	***0.525***	0.725	38.69%	0.053	0.004	0.526	0.723	28.87%	0.00927	0.00045	***0.90499***	0.71575
TCNS 207	2.38%	0.333	0.048	***0.021***	0.311	39.29%	-0.118	-0.008	***0.377***	0.688	20.83%	0.08608	0.00563	***0.38727***	0.55925
TCNS 209	3.57%	-0.107	-0.011	***0.322***	0.532	50.00%	0.215	0.014	***0.092***	0.243	26.79%	-0.15154	-0.00735	***0.07293***	0.51091
TCNS 213	2.98%	-0.148	-0.011	***0.200***	0.504	19.64%	-0.044	-0.002	***0.661***	0.427	11.31%	-0.14015	-0.00444	***0.06538***	0.47718
TCNS 214	1.79%	0.071	0.002	***0.349***	0.216	30.95%	0.489	0.024	0.000	0.185	16.37%	0.37516	0.0085	***1.9E-05***	0.156
TCNS 217	2.38%	-0.109	-0.006	***0.289***	0.392	9.52%	0.025	0.001	***0.799***	0.227	5.95%	-0.17591	-0.00531	***0.01537***	0.33381
TCNS 220	15.48%	-0.114	-0.008	0.081	0.597	43.45%	-0.073	-0.006	0.407	0.498	29.46%	-0.23353	-0.01013	***0.00305***	0.66387
TCNS 222	14.29%	-0.182	-0.010	***0.113***	0.615	25.00%	-0.157	-0.008	0.027	0.456	19.64%	-0.39873	-0.01139	***2.7E-05***	0.65249
TCNS 228	28.57%	-0.068	-0.006	***0.587***	0.586	63.69%	0.083	0.005	0.502	0.499	46.13%	-0.13338	-0.0065	***0.1059***	0.634
TCNS 230	30.95%	0.213	0.013	***0.091***	0.339	75.60%	0.204	0.012	***0.106***	0.513	53.27%	0.15184	0.00675	***0.11749***	0.3755
TCNS 233	4.76%	0.230	0.016	***0.039***	0.255	54.17%	0.111	0.010	0.277	0.548	29.46%	0.23017	0.00968	***0.00322***	0.28943
TCNS 249	23.21%	-0.153	-0.013	***0.120***	0.415	61.90%	0.088	0.003	0.467	0.137	42.56%	-0.30164	-0.00974	***0.0007***	0.36435

APPENDIX A5 CONCEPTUAL PROJECT FEASIBILITY AND RISK ASSESSMENT

NUBBIN SLOUGH STORAGE PROJECT

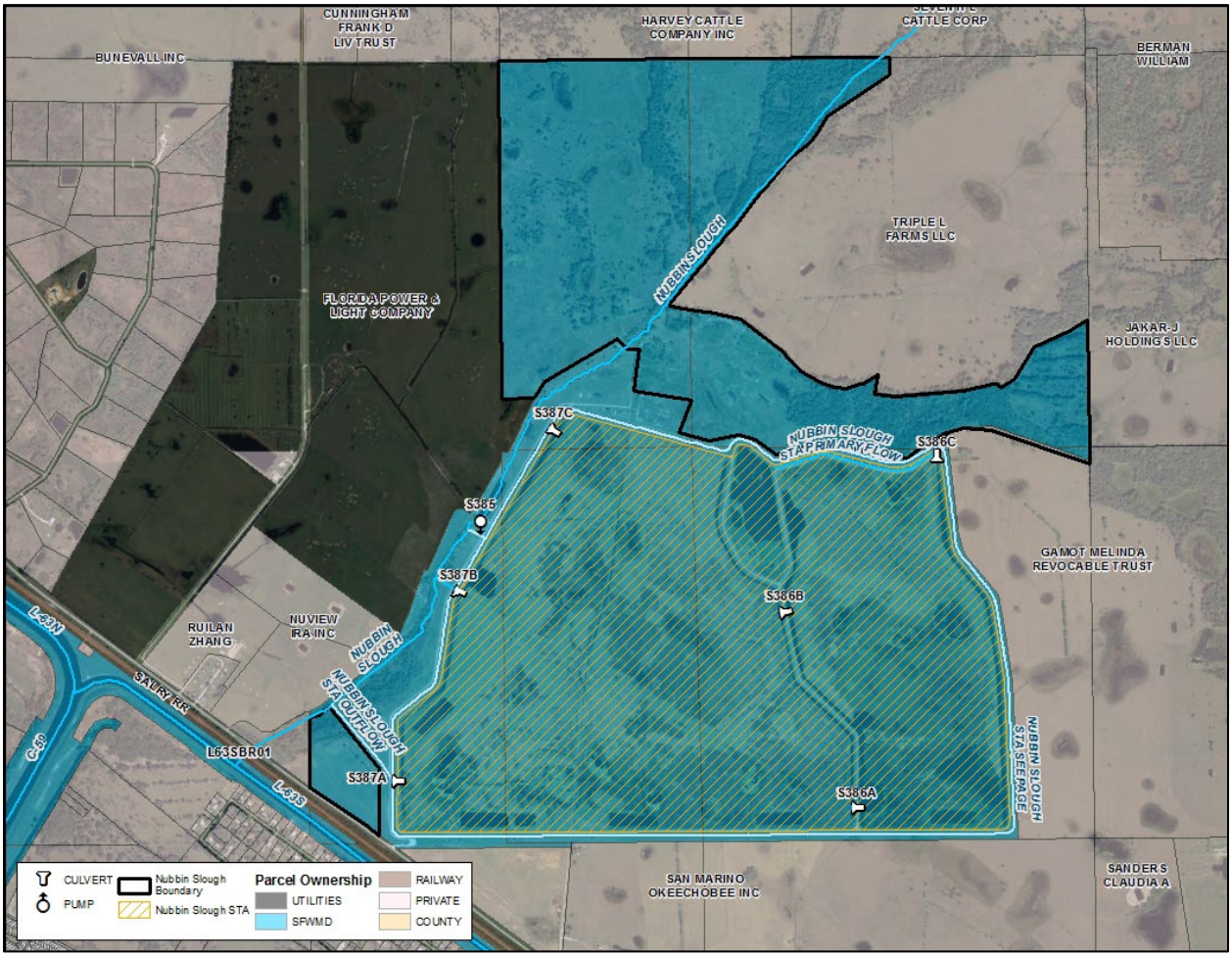

Figure A4-1. Proposed project location and land ownership.

S191 Basin Assessment Project Proposal

SFWMD should continue to investigate the possibility of additional storage upstream of the Nubbin Slough STA to assist with preventing dry-out at that facility.

Land Availability

SFWMD owns a total of 660 +/- acres immediately upstream and east of the Nubbin Slough STA (**Figure A4-1**). Surrounding parcels further upstream consist of privately-owned pasture and dairy operations.

Water Availability

Total flow in Nubbin Slough was analyzed for an 11-year period (2011-2021). Generally, flow in Nubbin Slough is exceptionally 'flashy' and characterized by short duration, high velocity flow events (**Figure A4-2**). On average, >30% of the total annual flow volume occurred during just 7 days/year and over a wide range of flows (>1000 cfs range). This hydrologic condition is not well-suited for additional pumps, which have a limited capacity to capture flow volumes during the short operational window, i.e. the ratio of total annual pump volume (ac-ft) to pump capacity (cfs)is low.

Instead, beneficial upstream storage projects could be designed to reduce peak flow events and increase baseflow through passive stormwater detention (e.g., wetland restoration, increased culvert/weir crest elevations, expanded stormwater ponds). These could be accomplished on existing SFWMD lands and through public-private partnerships.

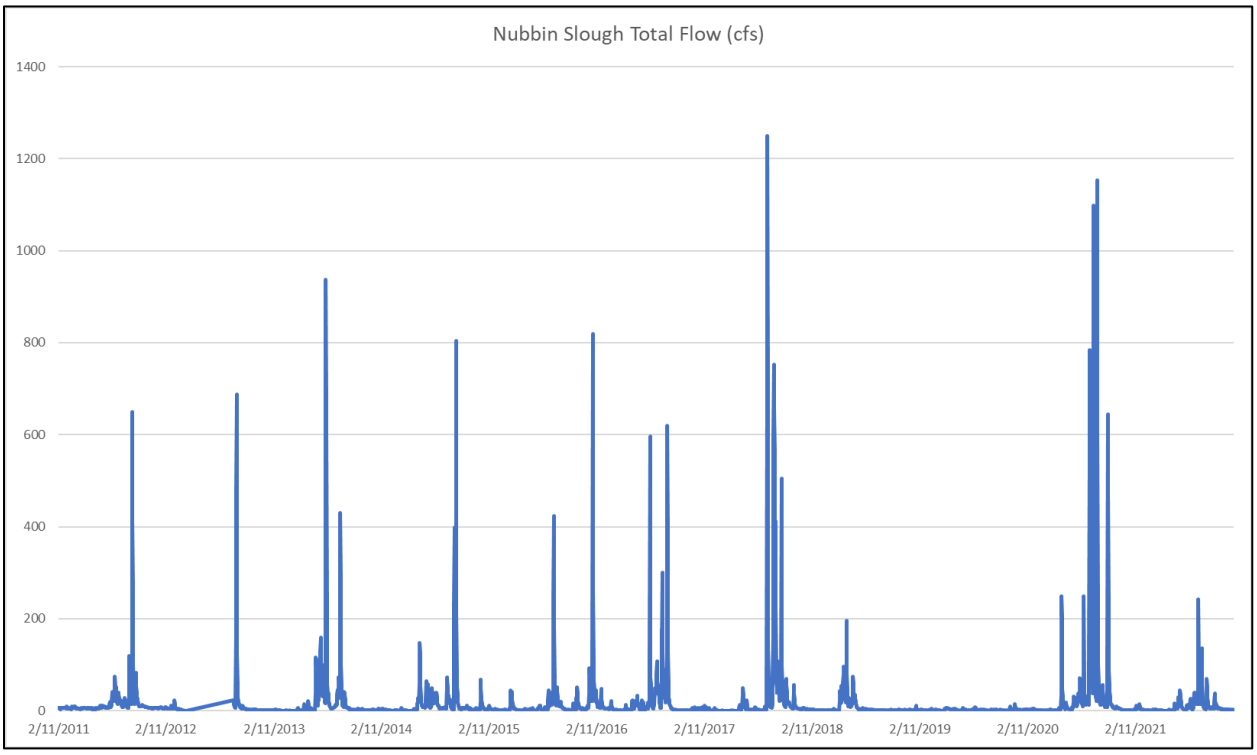

Figure A4-2. Nubbin Slough [S385_P + S385_W] hydrograph for the 2011-2021 period.

Other Considerations

SFWMD-owned property includes nine compensatory wetland mitigation areas (Lakeside Ranch) which require perpetual preservation.

SFWMD-owned property north of Nubbin Slough STA was previously operated as a dairy farm, and legacy phosphorus may be a concern in the area surrounding the previous dairy barn (**Figure A4-3**).

Land Management has significant ecological investment in the SFMWD-owned properties and has conducted maintenance, tree plantings, and other restorations activities in this area since 2014.

Substantial repairs to the Nubbin Slough STA levee and seepage ditch were completed in August 2021 restoring storage and treatment capacity within the project.

Summary

Benefits

- SFWMD-owned land may be available
- Proximity to Nubbin Slough STA
- High-quality monitoring data available and demonstrate need for additional improvements

Risks

- High velocity, short duration flows
- Onsite wetland mitigation
- Legacy phosphorus
- Existing ecological investments

Additional storage projects in the area upstream of Nubbin Slough STA (both SFWMD-owned and other) are desirable. However, projects relying on pumped inflow are not expected to be the most cost-effective and beneficial. Instead, passive detention and wetland restoration projects could be designed to restore more natural hydrologic conditions.

Projects could be accomplished on SFWMD-owned properties or through public-private partnerships further upstream but should be mindful of current and historical land uses.

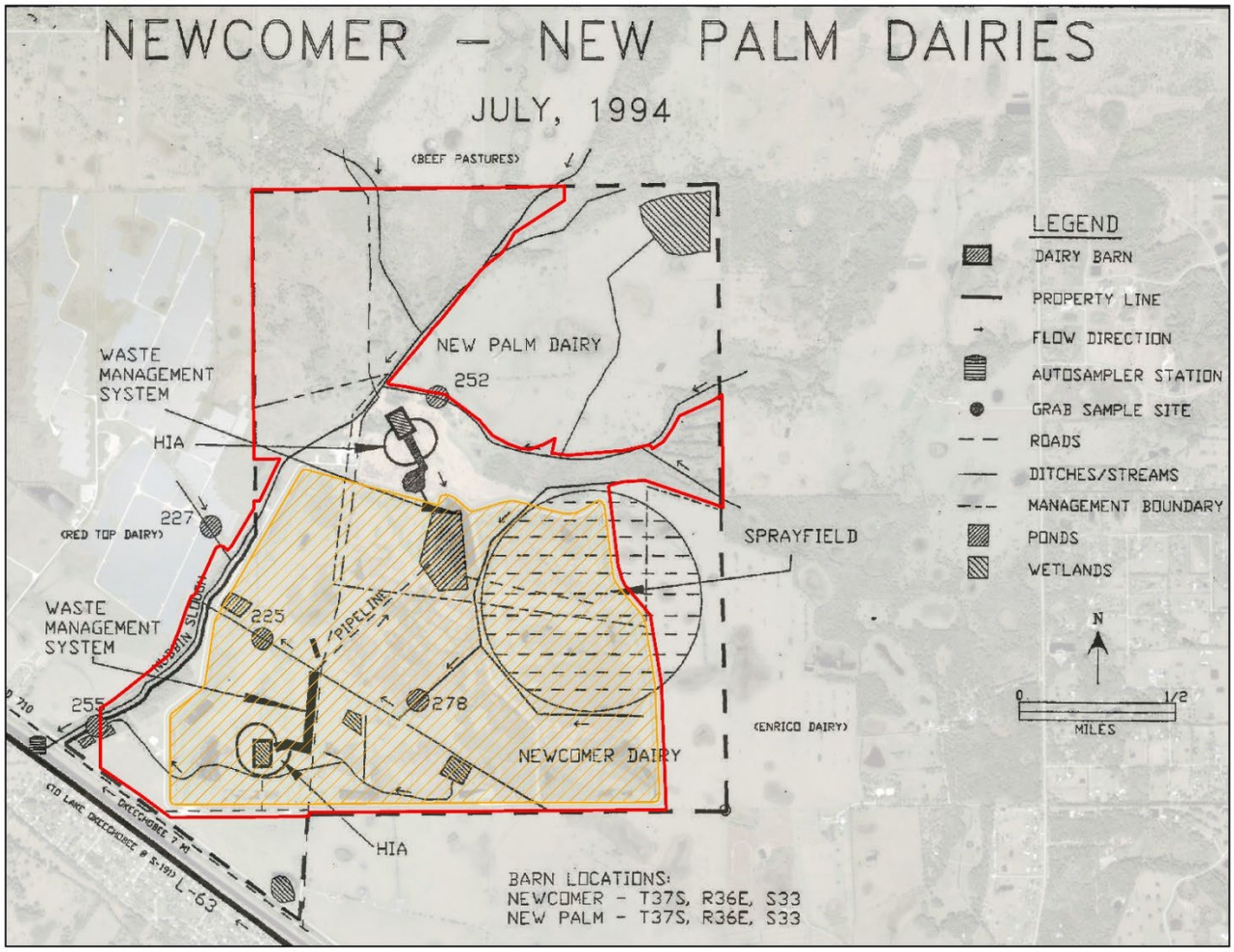

Figure A4-3. Historical features of New Palm Dairy and current Nubbin Slough STA.

S191 REGIONAL PROJECT

Figure A4-4. Area surrounding S-191, including SFWMD-owned parcels (blue).

S191 Basin Assessment Project Proposal

Also, a new large-scale regional project may need to be planned to obtain the estimated 13 - 18 t/yr long-term average annual TP reduction for this basin and ideally it should be located as close to the S-191 structure as possible to treat water immediately before it discharges into the lake.

Land Availability

Outside of existing canals, SFWMD does not have significant land ownership in the areas immediately adjacent to the S-191 structure (**Figure A4-4**). Approximately 500 acres of open pasture are located to the northwest of the structure but are in private ownership and bordered by several small residential areas.

Water Availability

Flow measurements were analyzed for a 10-year period (2012-2021). Flow averaged approximately 83,000 ac-ft/yr during the period. Maximum observed flow was approximately 5,000 cfs. Notably, no flow was observed almost 70% of the time.

Currently planned (e.g. Brady Ranch FEB and ASR, Grassy Island FEB and ASR, LOWRP ASR Well Clusters, TCNS 214 Dispersed Storage and Treatment Project) and newly completed projects (e.g. Lakeside Ranch STA) in the S-191 basin include approximately 500 cfs of pump capacity and should be considered when evaluating future water availability. Generally, flows through the S-191 structure are characterized by short duration, high velocity flow events (**Figure A4-5**). These extreme events are not efficiently captured through pumping (i.e. ratio of total ac-ft/yr captured to cfs pump capacity is low) since the operational window and expected pump hours are low.

FEB and ASR projects are expected to have a slight moderating effect on these hydrologic conditions. However, further modeling should be completed before significant additional pump capacity (beyond currently planned projects) is added to the S-191 basin.

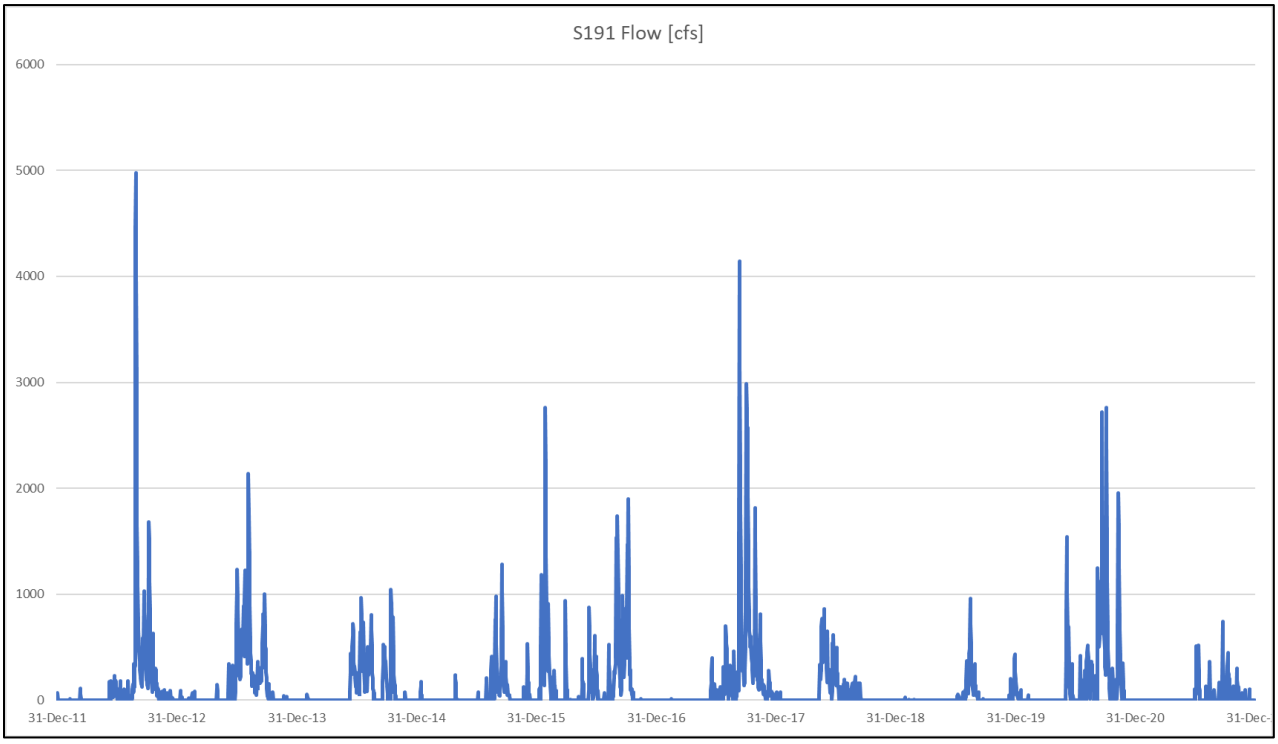

Figure A4-5. S-191 hydrograph for the 2012-2021 period.

Other Considerations

Operations plans for the Lakeside Ranch STA and S191A pump station are being revised and may impact observed conditions.

Summary

Benefits

- Significant flow volume (approx. 83,000 ac-ft/yr) observed through S-191
- Additional nutrient reduction necessary

Risks

- Short duration, high velocity flows provide limited opportunity for pump operation
- Land availability is limited

Several projects are planned for the S-191 basin and are expected to increase total pump capacity in the basin by greater than 500 cfs. This increased capacity is expected to be sufficient to capture S-191 discharge more than 90% of the year, and the remaining extreme event flows may not be efficiently captured through pumping.

Instead, moderated hydrologic conditions could be restored through projects designed to decrease peak flow events and increase baseflow. Project examples may include passive stormwater detention and wetland restoration projects throughout the basin. Similarly, operations for existing and planned projects should be evaluated to ensure holistic basin management. Operational examples include using ASR projects to ensure FEBs retain storage capacity throughout the wet season and coordinating Ovation pump algorithms to manage high flow events.

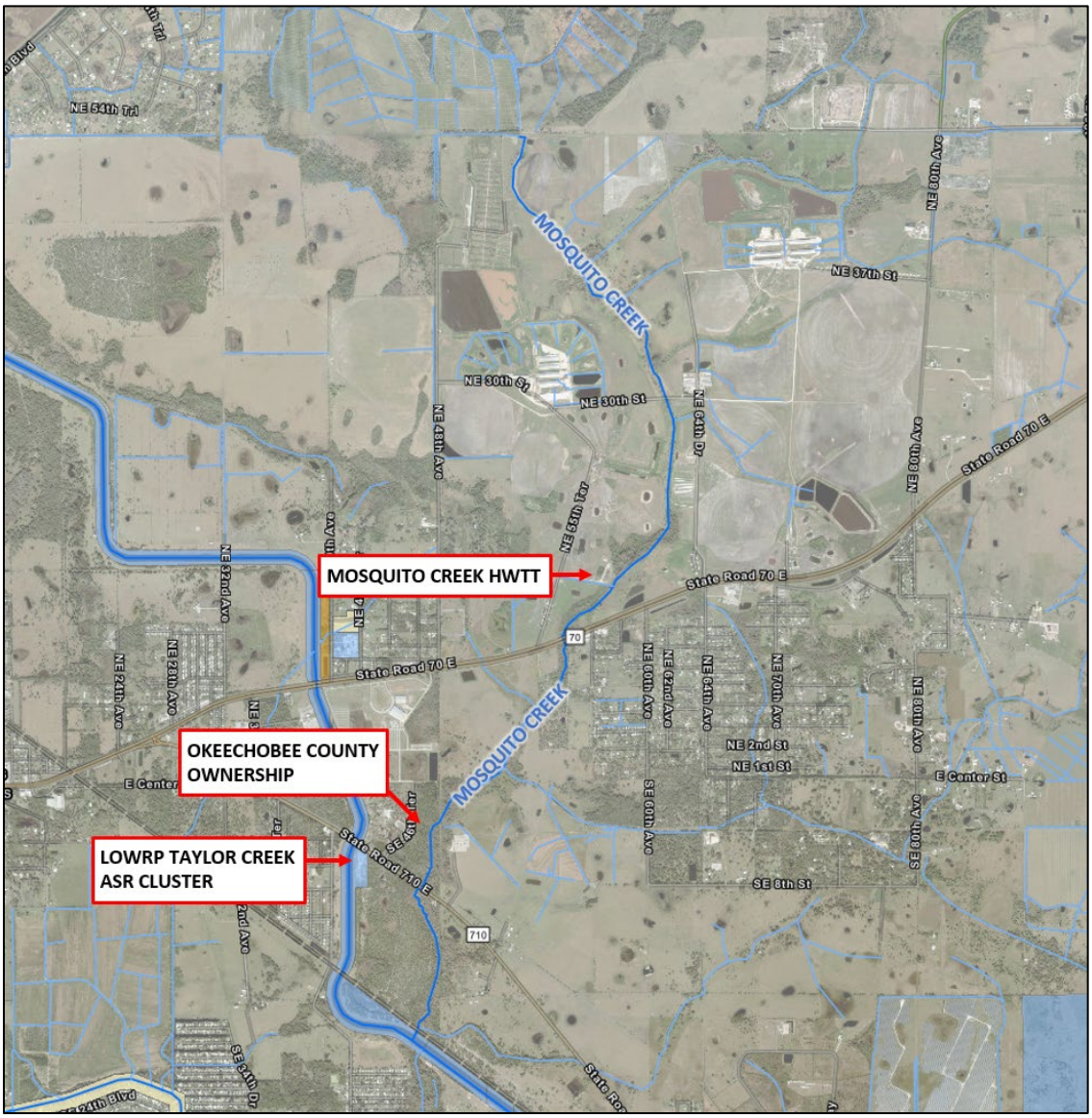

Figure A4-6. Location of Mosquito Creek and small SFWMD-owned parcels (blue).

S191 Basin Assessment Project Proposal

SFWMD should also investigate if an additional regional project can be planned along Mosquito Creek.

Land Availability

There is no significant SFWMD ownership in the Mosquito Creek watershed (**Figure A4-6**). Okeechobee County owns several small parcels (total = approx. 50 acres) of wooded area along Mosquito Creek just north of State Road 710.

Water Availability

Flow measurements were analyzed for a 13-year period (2010-2022; **Figure A4-7**). Flows were relatively low (maximum = 343 cfs) and frequent (flow > 0 cfs approximately 70% of the time). Total volume for the period averaged approximately 9,000 ac-ft/yr.

Initial analysis suggests a small regional project could provide significant benefits downstream. A retention area or ASR project supported by a 15-30 cfs pump could potentially operate several months per year and capture up to 50% of the total discharge from Mosquito Creek. Significantly larger pump capacities have rapidly diminishing returns (ratio of total ac-ft/yr captured to cfs pump capacity).

A small pump intake basin (similar to Nubbin Slough STA) may benefit proposed project operation since a significant proportion of flows occur at < 5 cfs.

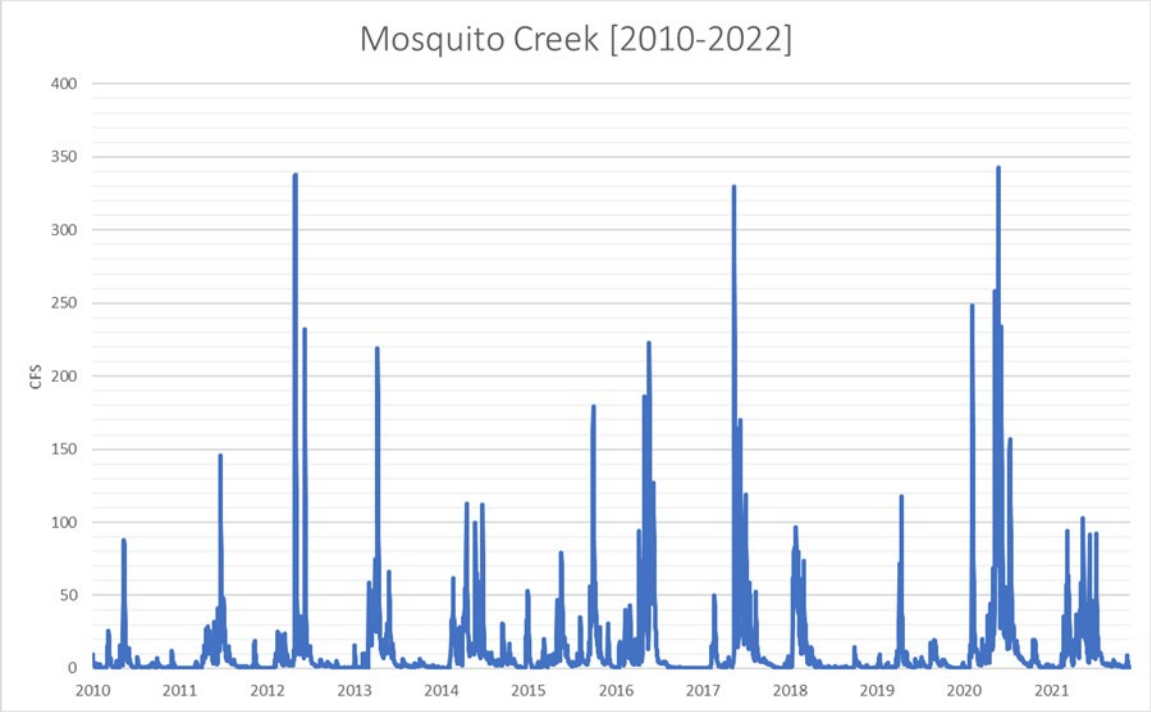

Figure A4-7. Mosquito Creek [Station 02275197] hydrograph for the 2010-2022 period.

Other Considerations

Significant land uses within the watershed include Okeechobee County Fairgrounds, Four Seasons residential neighborhood, and McArthur Dairy.

The Mosquito Creek Hybrid Wetland Treatment Technology (HWTT) is located just upstream of State Road 70 and operated by FDACS.

The LOWRP Taylor Creek ASR Cluster is planned along L-63N just south of SR710.

Summary

Benefits

- Relatively consistent, low flow velocities could potentially support a small project
- Nutrient concentrations elevated at TCNS 220 (Mosquito Creek at SR70)

Risks

- Land availability is limited

Observed conditions potentially support a small project designed to capture and/or treat relatively consistent, low velocity flows. Land availability is limited, but a partnership project could provide a small area for an innovative technology or ASR project. Note, any ASR project should be coordinated with nearby LOWRP Taylor Creek ASR Cluster to avoid potential conflict. High nutrient concentrations observed upstream (TCNS 220) indicate the project could potentially remove 2-5 metric tons of phosphorus pending final project design and further analysis.

WOLFF CREEK PROJECT

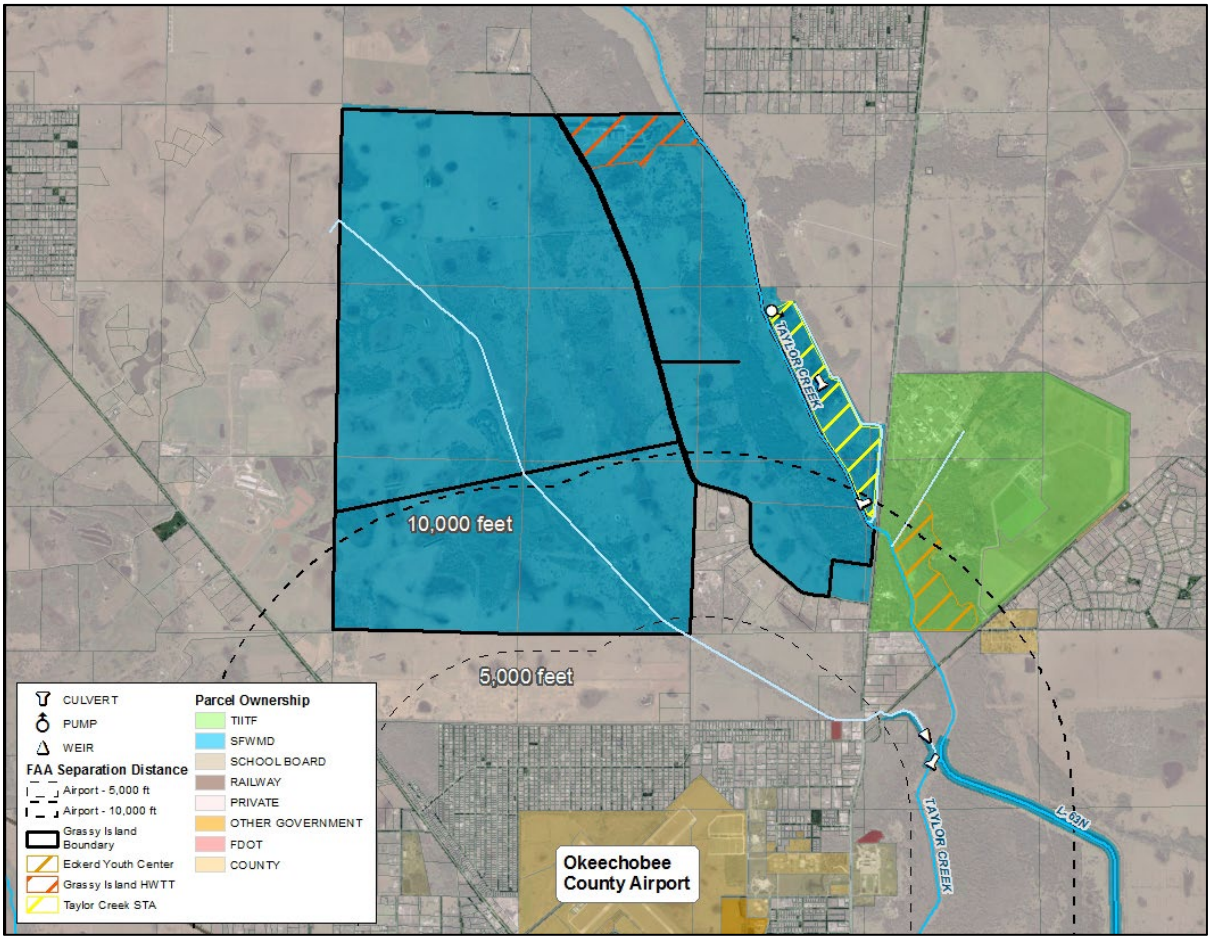

Figure A4-8. Proposed project location illustrating publicly owned lands and the restricted buffer area surrounding the Okeechobee County Airport.

S191 Basin Assessment Project Proposal

Pursue a treatment project along Wolff Creek on SFWMD owned lands.

Land Availability

SFWMD owns a total of 4,000 +/- acres (Grassy Island property) in this area, including upstream portions of Wolff Creek (**Figure A4-8**).

The southeastern portion of Wolff Creek and the Grassy Island property may be impacted by Federal Aviation Authority (FAA) hazardous wildlife restrictions. These FAA restrictions may prevent development of wetland areas likely to attract bird populations near the Okeechobee County Airport.

The Grassy Island FEB and ASR projects are currently in preliminary design and slated for construction on the Grassy Island property. However, the FEB and ASR project have not yet been sited and may conflict with a proposed Wolff Creek project.

Water Availability

Flow measurements were analyzed for a 20-year period (2003-2022). USGS monitors flow near Hwy 441 and the confluence of Wolff and Taylor Creeks. This point of measurement is significantly downstream of a potential project area and therefore may over-estimate water availability.

Average flow for the period was approx. 3,500 ac-ft/yr. Significantly, daily average flow was < 10 cfs almost 90% of the time and <5 cfs almost 85% of the time. Maximum flow was approx. 300 cfs (**Figure A4-9**).

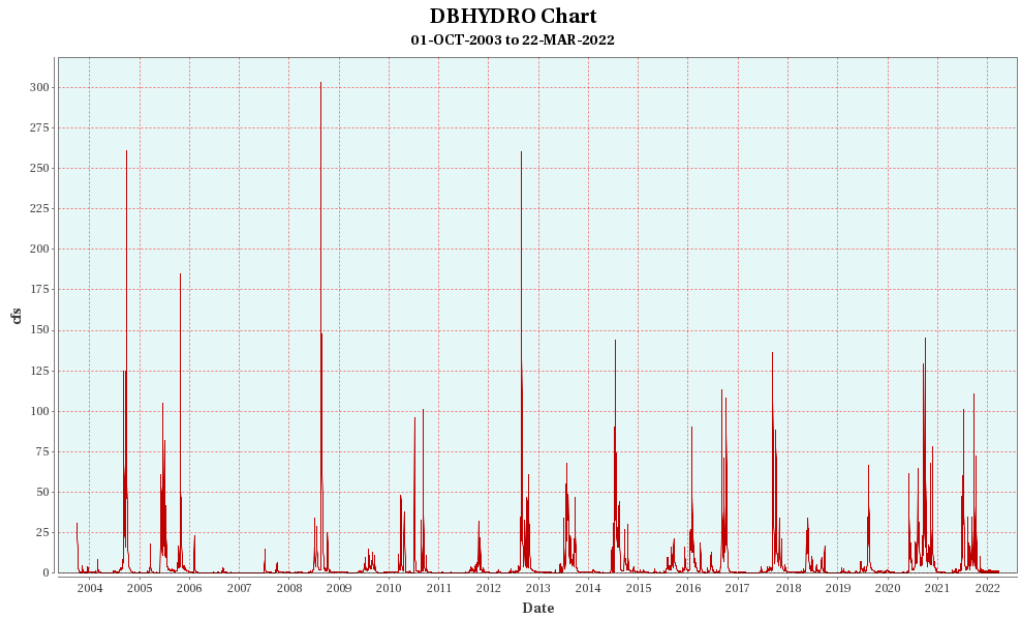

Figure A4-9. Wolff Creek [Station 02274505] hydrograph for the 2004-2022 period.

Other Considerations

Upstream portions of Wolff Creek drain open natural areas and low-intensity cattle leases that are not expected to contribute significant flow or nutrient loads.

Some minor detention projects have already been completed by SFWMD Land Management on the Grassy Island property.

Some overflow discharges from adjacent Rucks Dairy may be directed to the downstream portion of Wolff Creek. The Milking R project was completed in partnership with Rucks Dairy in approximately 2007 and increased retention of stormwater runoff from this property. Project is still in operation and providing storage benefits.

Summary

Benefits

- Significant SFWMD-owned land available
- Wolff Creek tributary does not have an existing project

Risks

- FAA development restrictions
- Footprint for co-located FEB & ASR projects not finalized
- Limited monitoring data available but indicates low water availability
- Proposed project location would be approximately 3 miles upstream of monitoring site

Areas outside the FAA restricted buffer zone are considerably upstream in the watershed. While no flow measurements are available in this immediate area, runoff and creek flow are expected to be very low based on downstream monitoring station and site conditions (**Figure A4-10**). Ditch blocks and small wetland detention areas could be used to slow flow velocities, retain volume, and provide treatment. However, some projects of this type have already been completed, and additional benefits are expected to be low. Still, passive detention projects are recommended where land is available and projects could be accomplished cost-effectively.

Areas within the FAA restricted buffer zone could support ASR and/or innovative technology projects. However, land availability is limited in this area, and projects of this type might be strategically located in other areas of the S191 basin for optimal results.

Figure A4-10. Wolff Creek on the Grassy Island property looking southeast in March 2022.