Preliminary Evaluation of Water Quality near the Dunes Development, Sanibel FL.

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## Executive Summary

SCCF Marine Lab conducted a series of water quality monitoring events between June and September 2011 in coordination with the City of Sanibel Department of Natural Resources in an effort to better characterize the water quality immediately adjacent to the Dunes development and assess its potential impact on the nearby estuary water quality. Samples were collected during a wet and dry period along a transect from Dunes Lake #4 to the mouth of Tarpon Bay. Samples were also collected along a transect parallel and adjacent to Lake #4 during a spring low tide. Additional samples were collected from six stormwater catch basins during a rain event to evaluate nutrient inputs into the Dunes lakes at the direction of the Dunes Homeowner's Association. Data collected within the project area for a Ding Darling National Wildlife refuge project were also used in this evaluation. High concentrations of nitrogen and chlorophyll *a* were found in Dunes Lake samples and at sites adjacent to Dunes Lake #4. The nitrogen concentrations were much reduced on the downstream side of a mangrove community between The Dunes and Ladyfinger Lakes. This suggests that the mangrove buffer was providing ecosystem services by removing nutrients from this possible source (The Dunes Development). However during extended wet periods with high precipitation, removal of nitrogen by the mangrove community was reduced and concentrations of nitrogen above numeric water quality criteria were still present on the downstream side of the mangrove forest.

Monitoring also showed high concentrations of nitrogen and phosphorus were present in stormwater runoff from residential and golf course land use types which discharge into The Dunes lakes system. In addition, the mangrove habitat immediately adjacent to Dunes Lake #4 had uniformly high concentrations of nitrogen and chlorophyll *a* along a parallel transect to the lake. Irrigation water, fertilizer runoff or groundwater seepage along with periodic overtopping of the lake spillway are probable sources of this elevated nitrogen.

In summary, it appears that the Dunes development is a source for elevated nitrogen levels in waters immediately adjacent to it; and the nearby mangrove ecosystem removes much of this nitrogen before it discharges into Ladyfinger Lakes and Tarpon Bay. Stormwater runoff amounts can dictate the levels of nitrogen which are seen downstream of the mangrove community.

## Background and Description of Work:

On June 24 and August 26, 2011, SCCF Marine Lab staff collected surface water samples along a transect from 9 meters downstream of Dunes Lake number 4 through Ladyfinger Lakes to the mouth of Tarpon Bay (Figure 1). Dunes Lake number 4 was also sampled near the spillway during these events. The sampling locations had been previously chosen by James Evans of the City of Sanibel's Department of Natural Resources. In addition, on July 6, 2011, SCCF Marine Lab staff sampled stormwater runoff at 6 sites previously designated by Dunes Golf Course Manager Sean Balliet (Figure 1) in the vicinity of Dunes residential and Golf Course lands on Sanibel Island, Florida. The purpose of collecting these samples was to better understand the contribution the Dunes development makes to nutrient loading in Tarpon Bay and the contribution of runoff to the current high nutrient condition of the lakes in the Dunes development.

On Friday August 19, SCCF Marine Laboratory staff sampled 6 previously selected sites along the golf cart path adjacent to Dunes Lake #4. The samples were collected on the estuary side of the cart path (Figure 1). Dunes Golf Course manager (Mitch) informed SCCF that they had applied a full run

of irrigation water on the golf course the night before (approximately 350,000 gallons) this monitoring effort.

Also used in this monitoring effort were results of water quality sampling undertaken August 31- September 1 at 9 culverts beneath Dixie Beach Road (Figure 1). These culverts connect mangrove habitats immediately adjacent to the Dunes development with the estuarine habitats of Ladyfinger Lakes and Tarpon Bay. This sampling was conducted for Ding Darling National Wildlife Refuge and included additional sites at the mouth of Lady Finger Lakes (NWR16) and within Tarpon Bay (NWR 03).

These monitoring efforts were intended to provide a better understanding of the contribution the Dunes development makes to nutrient and other pollutant loading in Tarpon Bay.

## Methods:

Samples for the transect through Ladyfinger Lakes were collected June 24, 2011 using a kayak as necessary to access the sites. The samples were collected after an extended dry period, during an ebb tide with noticeable outgoing current at all sample sites. Samples collected on August 26, 2011, were taken on a late spring ebb tide with precipitation of at least 1.0 inches over the past 24 hours during a relatively wet period.

The runoff monitoring conducted on July 6, 2011, included samples collected from catch basins covered with steel gratings during a 0.6 inch rainfall event. All catch basins drained into lakes located on the Dunes Golf Course. Stormwater flow was observed at all sample locations at the time of sampling. Three of the designated sites (Dunes 1-3) were catch basins upstream of the golf course and contained only residential runoff. Three sites (Dunes 4-6) were located on the golf course and contained runoff from the golf course and upstream residential land use.

Samples for the transect adjacent to Dunes Lake number 4 were collected August 19, 2011, using a telescopic sampling stick with bottles dedicated for each analyte. Samples were collected at a low tide between 11 am and 12 noon, three days prior to any precipitation. Tides during this period were near quarter moon and thus characteristic of neap tides. *In situ* sampling at each site included temperature, pH, salinity, dissolved oxygen and turbidity. Discrete samples for chlorophyll *a* and colored dissolved organic matter (CDOM) were analyzed at the SCCF Marine Lab while samples for nitrogen and phosphorus analyses were delivered the same day to Lee County Environmental Laboratory, following established protocols.

The additional data provided through an effort funded by the Ding Darling refuge (culvert sampling) was derived from samples collected August 31 -September 1, 2011, on a late spring ebb tide after 2.3 inches of precipitation in the previous 24 hours.

## Results with Discussion:

A summary of the results from all analyses is provided in Table 1. Runoff monitoring conducted July 6, 2011, indicated residential samples (stations Dunes 1-3) had higher variability in nutrient values (nitrogen and phosphorus) than golf course site (Dunes 4-6) samples. The highest and lowest values for nitrogen (TN) and phosphorus (TP) occurred at residential sites. All samples had nitrogen and phosphorus concentrations greater than the 90$^{th}$ percentile value for all Florida lakes (Hand 2008; *see* Figure 2). This is not unusual for a golf course with surrounding development. All of the runoff sites drained into the Dunes stormwater lake system.

The three golf course sites had significantly greater concentrations of chlorophyll *a*. This would be expected because water from the lakes was backed up into these catch basins. The lakes contain higher levels of chlorophyll *a* (an indicator of micro-algae) because they serve as an incubator for algae growth due to high nutrient concentrations, slow moving water and warm temperatures.

A relatively high fraction of the nitrogen in all samples was inorganic nitrogen (ammonia + NOx). This is typically an indicator of fertilizer or animal waste in the sample. Inorganic nitrogen is converted to organic nitrogen fairly quickly in an aquatic environment due to uptake by algae and plants.

The concentrations of indicator bacteria (*Enterococci*) in all samples were very high. In other studies we have found this is typical of stormwater runoff in this area. The indicator bacteria originate from various sources including birds and mammals and thrive in lawns and other habitats. During a storm event, the bacteria are washed into the surrounding waterbodies in high concentrations.

Sampling (August 19) in the estuary along a transect parallel to Dunes Lake 4 shoreline found chlorophyll *a* and nitrogen concentrations were high at all sites (Dunes 7-12) adjacent to the lake. This was comparable to previous results which showed high chlorophyll *a* and nitrogen concentrations at site NWR 15 located adjacent to Dunes Lake 4 just downstream of the spillway. There seems to be a fairly strong indirect relationship between TN concentrations and distance from lake suggesting that Lake 4 is a source of nitrogen to the adjacent estuary, and that significant pathways of delivery may include groundwater flow, overtopping of the lake, or irrigation overspray in addition to discharges from the spillway.

The nitrogen at all six sites adjacent to Lake 4 was primarily in organic form which is typical of estuarine samples due to rapid uptake of inorganic nitrogen by algae and plants. Previous sampling efforts had shown higher inorganic nitrogen fractions were present in stormwater runoff discharging to Lake 4. It is assumed that most of the inorganic nitrogen is converted to organic nitrogen quickly during its residence time in the lake ecosystem.

A water quality data logger deployed at the Lake 4 spillway demonstrated that during tides greater than +2.7 feet MLLW, estuarine water breaches the spillway and mixes with nitrogen rich waters of Lake 4. This phenomenon was witnessed in person by SCCF Marine Lab staff several times during spring tides in August (Rick Bartleson and Mark Thompson, personal observation).

The results from transect sampling confirmed a high concentration of chlorophyll *a* and nitrogen at the site (NWR15) immediately downstream of Lake 4 spillway. The nitrogen was primarily all in organic form which is typical of estuarine samples due to rapid uptake by algae and plants. The spillway was not discharging during the June 24$^{th}$ event but on the August 26$^{th}$ event, the spring flood tide had breached the spillway and water from Lake #4 had discharged into the mangrove habitat downstream (NWR15). Nitrogen and chlorophyll *a* levels in Lake # 4 were relatively higher than the concentrations at the site just downstream (NWR15) as would be expected if the lake were a source (Figure 3-4).

During the June 24 and August 26 transect sampling efforts; nitrogen concentrations were much lower at the Dixie Beach Road culvert (next site downstream – NWR14) compared to the lake and site just downstream (NWR15). The two samples taken in Ladyfinger Lakes were comparable to the Dixie Beach Rd. culvert site in nitrogen, while chlorophyll was greater at the Ladyfinger Lakes sites than the Dixie Beach sample (Figure 3-4). Nitrogen and chlorophyll *a* concentrations were lowest at the mouth of Tarpon Bay (NWR11) as would be expected due to dilution. These results suggest a nutrient gradient exists between Dunes Lake 4 and Tarpon Bay and that the highest concentrations are centered at the Lake. By the time the water flows through culverts at Dixie Beach Rd. it has traveled through a dense mangrove habitat which appears to have removed a significant amount of the nitrogen. After flowing through the mangroves, nitrogen was at levels at or below the 50$^{th}$ percentile of all Florida estuaries (Hand 2008).

When comparing transect results from the two dates, we see that nitrogen at the culvert and all sites through Ladyfinger Lakes into Tarpon Bay was significantly greater during the August monitoring than during June. This may be attributable to the onset of wet season (after our June monitoring) and a rain event with discharge from Lake 4 preceding the August sampling event.

Additional information derived from our sampling effort at all nine Dixie Beach Rd. culverts on August 31 support the idea that nitrogen levels at these sites can be influenced by runoff volume. In the 24 hour period preceding the August 31 sampling event at the culverts, we had approximately 2.3 inches of precipitation, as recorded at the National Wildlife Refuge station on Sanibel Captiva Rd. On an extreme low tide, nitrogen levels ranged from 0.7 to 2.7 mg/l at the culverts. Total nitrogen at the NWR14 site was nearly twice the concentration that it was during the August 26th rain event monitoring and was over three times greater than the dry period monitoring in June. Mangrove habitats seem to act as a nitrogen-removing buffer during dry periods and lower flow rates. However, large rain events during the wet season can produce large flows, decreases residence time and limits the effectiveness of nitrogen removal by mangroves.

The findings discussed above were those that SCCF determined to be noteworthy. Other information is contained in the raw data provided in this summary. Please contact Mark Thompson, M.S., Sanibel Captiva Conservation Foundation Marine Lab, with any further inquiries.

**Figure 1: Sites sampled by SCCF Marine Lab during this study.**

Table 1. Summary of water quality data collected at monitoring sites for Dunes characterization study.

| Station | Latitude | Longitude | Sample Date | Sample Time | 24hr Precip (in) | CDOM (QSE) | Chlorophylla (ug/l) | DO (mg/l) | Enterococci (col/100ml) | pH | Salinity (PSU) | NH4 (mg/l-N) | Nox (mg/l) | TKN (mg/l) | TN (mg/l) | TP (mg/l) | Turbidity NTU | Water Temp C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lake 4 | 26.455130 | -82.052680 | 6/24/2011 | 12:15 | 0 | 152.6 | 177.4 | 2.69 | 74 | 8.4 | 6.88 | 0.014 | | NS | NS | NS | 57.3 | 33.7 |
| NWR11 | 26.455190 | -82.052820 | 6/24/2011 | 13:45 | 0 | 11.98 | 5.92 | 4.74 | 1 | 8 | 36.9 | 0.014 | 0.01 | 0.14 | 0.14 | NS | 4.6 | 32.3 |
| NWR12 | 26.456850 | -82.056290 | 6/24/2011 | 13:30 | 0 | 24.5 | 9.32 | 3.92 | 1 | 7.8 | 37.9 | 0.014 | 0.01 | 0.59 | 0.59 | NS | 8 | 33.3 |
| NWR13 | 26.457280 | -82.059050 | 6/24/2011 | 12:50 | 0 | 37.6 | 7.32 | 3.13 | 31 | 7.6 | 38.7 | 0.014 | 0.01 | 0.52 | 0.52 | NS | 80.3 | 33.1 |
| NWR14 | 26.458990 | -82.064990 | 6/24/2011 | 12:35 | 0 | 47.2 | 2.34 | 1.58 | 63 | 7.5 | 38.9 | 0.031 | 0.01 | 0.4 | 0.4 | NS | 0 | 30.9 |
| NWR15 | 26.463417 | -82.066490 | 6/24/2011 | 12:10 | 0 | 239.2 | 563.5 | 1.77 | 10 | 7 | 45.2 | 0.121 | 0.01 | 3.6 | 3.6 | NS | 127 | 28.5 |
| Dunes1 | 26.447160 | -82.049510 | 7/6/2011 | 14:40 | 0.58 | 202.3 | 5.06 | 3.29 | >2400 | 7.4 | 0.87 | 0.411 | 0.268 | 2.7 | 2.9 | 0.28 | 18.8 | 28.8 |
| Dunes2 | 26.449110 | -82.049450 | 7/6/2011 | 14:50 | 0.58 | 78.5 | 0.77 | 5.6 | >2400 | 7.5 | 0.08 | 0.035 | 0.245 | 0.81 | 1.1 | 0.23 | 10.7 | 30.3 |
| Dunes3 | 26.454830 | -82.051080 | 7/6/2011 | 15:05 | 0.58 | 247.5 | 6.18 | 3.5 | >2400 | 6.8 | 0.31 | 1.05 | 0.297 | 6.6 | 6.9 | 1.5 | 24.8 | 29.4 |
| Dunes4 | 26.448600 | -82.047650 | 7/6/2011 | 15:20 | 0.58 | 218.3 | 51.5 | 4.1 | >2400 | 7.9 | 1.99 | 0.319 | 0.168 | 4.6 | 4.8 | 0.47 | 18.6 | 29.5 |
| Dunes5 | 26.451340 | -82.044080 | 7/6/2011 | 15:30 | 0.58 | 187.4 | 29 | 3.6 | >2400 | 7.4 | 1.2 | 0.405 | 0.175 | 4.1 | 4.2 | 0.73 | 25 | 29.3 |
| Dunes6 | 26.451340 | -82.041330 | 7/6/2011 | 13:38 | 0.58 | 139.9 | 24.1 | 4.3 | >2400 | 7.7 | 0.8 | 0.184 | 0.159 | 3.7 | 3.9 | 0.37 | 20.1 | 29.7 |
| Dunes7 | 26.456580 | -82.052190 | 8/19/2011 | 11:00 | 0 | 246.8 | 254.2 | 0.1 | NS | 6.2 | 37.5 | 0.041 | 0.01 | 3 | 3 | NS | 76.7 | 29.8 |
| Dunes8 | 26.456180 | -82.052220 | 8/19/2011 | 11:15 | 0 | 241.3 | 107.3 | 0.1 | NS | 6.4 | 43 | 0.028 | 0.01 | 2.7 | 2.7 | NS | 28.6 | 32.04 |
| Dunes9 | 26.455460 | -82.052890 | 8/19/2011 | 11:25 | 0 | 220.2 | 241.98 | 0.2 | NS | 6.4 | 37.2 | 0.034 | 0.01 | 2.1 | 2.1 | NS | 12.1 | 29.3 |
| Dunes10 | 26.454770 | -82.052660 | 8/19/2011 | 11:35 | 0 | 201 | 138.8 | 0.7 | NS | 6.4 | 37.2 | 0.036 | 0.01 | 2.6 | 2.6 | NS | 5 | 30.4 |
| Dunes11 | 26.454420 | -82.052460 | 8/19/2011 | 11:45 | 0 | 202.1 | 152.5 | 0.2 | NS | 6.3 | 38.1 | 0.04 | 0.01 | 2.6 | 2.6 | NS | 13.6 | 31.4 |
| Dunes12 | 26.454130 | -82.052280 | 8/19/2011 | 11:55 | 0 | 207.2 | 215.7 | 0.3 | NS | 6.6 | 32.3 | 0.136 | 0.01 | 3.8 | 3.8 | NS | 18.9 | 29.8 |
| Lake 4 | 26.455130 | -82.052680 | 8/26/2011 | 18:18 | 1 | 194 | 141.2 | 6.03 | 624 | 8.3 | 6.41 | 0.087 | 0.01 | 3.9 | 3.9 | | 60.3 | 32.6 |
| NWR11 | 26.463417 | -82.066490 | 8/26/2011 | 19:45 | 1 | 43.4 | 14.4 | 5.19 | 1 | 8.1 | 27.5 | 0.014 | 0.01 | 0.46 | 0.46 | | 11.8 | 31.6 |
| NWR12 | 26.458990 | -82.064990 | 8/26/2011 | 19:25 | 1 | 54.9 | 10.96 | 3.69 | 1 | 7.8 | 27.5 | 0.014 | 0.01 | 0.75 | 0.75 | | 0 | 31.1 |
| NWR13 | 26.457280 | -82.059050 | 8/26/2011 | 19:10 | 1 | 55.7 | 11.06 | 3.6 | 1 | 7.8 | 28.11 | 0.014 | 0.01 | 0.73 | 0.73 | | 7.8 | 31.5 |
| NWR14 | 26.456850 | -82.056290 | 8/26/2011 | 18:40 | 1 | 88.9 | 5.31 | 1.12 | 192 | 7.1 | 27.3 | 0.023 | 0.01 | 0.78 | 0.78 | | 0 | 29.8 |
| NWR15 | 26.455190 | -82.052820 | 8/26/2011 | 18:20 | 1 | 129.7 | 145.2 | 0.7 | 435 | 6.8 | 25.8 | 0.08 | 0.01 | 2.7 | 2.7 | | 27.6 | 30.8 |
| DBCulv1 | 26.446599 | -82.056121 | 8/31/2011 | 10:20 | 2.3 | 306.9 | 32.7 | 0.6 | | 7.1 | 26.3 | 0.078 | 0.01 | 2.4 | 2.4 | 0.21 | 4.5 | 26.5 |
| DBCulv2 | 26.453064 | -82.056253 | 8/31/2011 | 10:28 | 2.3 | 211.4 | 3.83 | 1.09 | | 7.3 | 15.95 | 0.014 | 0.01 | 1.6 | 1.6 | 0.037 | 8 | 25.8 |
| DBCulv3 | 26.000000 | -82.000000 | 8/31/2011 | 10:45 | 2.3 | 161.9 | 39.1 | 0.42 | | 7.2 | 17.51 | | | | | | 13.8 | 26.3 |
| DBCulv4 | 26.455622 | -82.056306 | 8/31/2011 | 10:55 | 2.3 | 158 | 36.7 | 0.21 | | 7 | 17.6 | 0.014 | 0.01 | 1.7 | 1.7 | 0.071 | 14.6 | 26.3 |
| DBCulv6 | 26.457804 | -82.056358 | 8/31/2011 | 11:15 | 2.3 | 117.1 | 2.99 | 0.27 | | 7 | 23.8 | 0.014 | 0.01 | 0.8 | 0.8 | 0.052 | 5.4 | 26.6 |
| DBCulv7 | 26.459925 | -82.056122 | 8/31/2011 | 11:21 | 2.3 | 118.5 | 3.51 | 0.41 | | 7.1 | 23.2 | 0.014 | 0.01 | 0.63 | 0.63 | 0.044 | 4.5 | 26.6 |
| DBCulv8 | 26.460906 | -82.056373 | 8/31/2011 | 11:35 | 2.3 | 128.3 | 6.64 | 0.41 | | 6.8 | 23.2 | 0.026 | 0.01 | 0.92 | 0.93 | 0.059 | 4.6 | 26.6 |
| DBCulv9 | 26.464771 | -82.056444 | 8/31/2011 | 11:47 | 2.3 | 150.1 | 17.1 | | | | 21.1 | 0.027 | 0.01 | 1 | 1 | 0.051 | 4.7 | |
| NWR14 | 26.456850 | -82.056290 | 8/31/2011 | 11:10 | 2.3 | 137 | 28 | 0.3 | | 7.1 | 21.4 | 0.014 | 0.01 | 1.4 | 1.4 | 0.043 | 9.55 | 26.5 |
| Lake 4 | 26.455130 | -82.052680 | 9/1/2011 | 10:35 | 1.3 | | | 4.2 | | 7.6 | 6.7 | | | | | | | 28.1 |
| NWR03 | 26.445525 | -82.088411 | 9/1/2011 | 11:30 | 1.3 | 50 | 46.8 | 4.46 | | 8.2 | 28.4 | 0.014 | 0.01 | 2.1 | 2.1 | 0.1 | 32.5 | 27.9 |
| NWR16 | 26.438749 | -82.088030 | 9/1/2011 | 10:50 | 1.3 | 56.2 | 18.45 | 3.78 | | 7.7 | 27.8 | 0.014 | 0.17 | 0.65 | 0.82 | 0.031 | 5.9 | 27.4 |

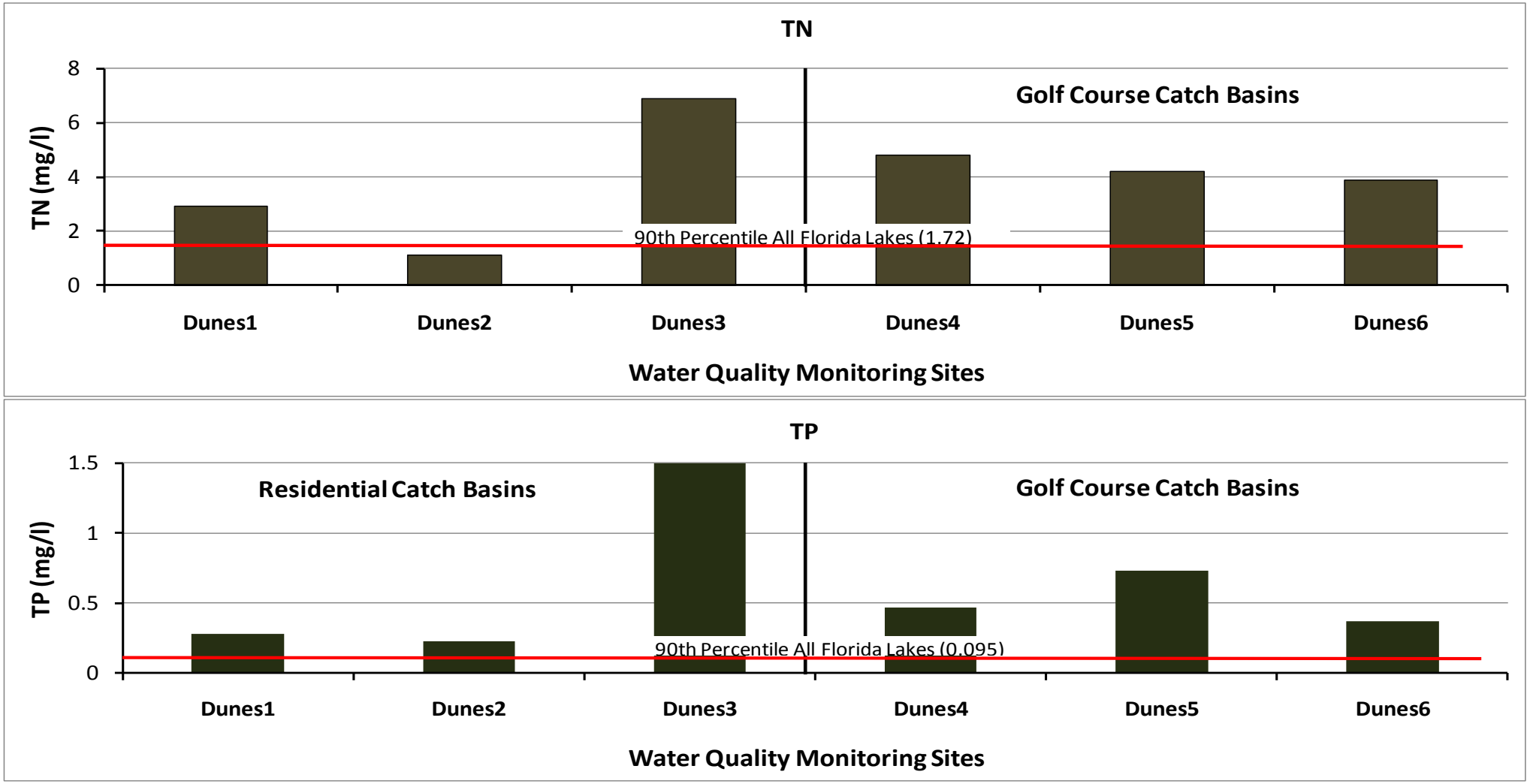


Figure 2: Total nitrogen and total phosphorus concentrations in runoff samples showing the 90$^{th}$ percentile of values for all Florida Lakes for reference.

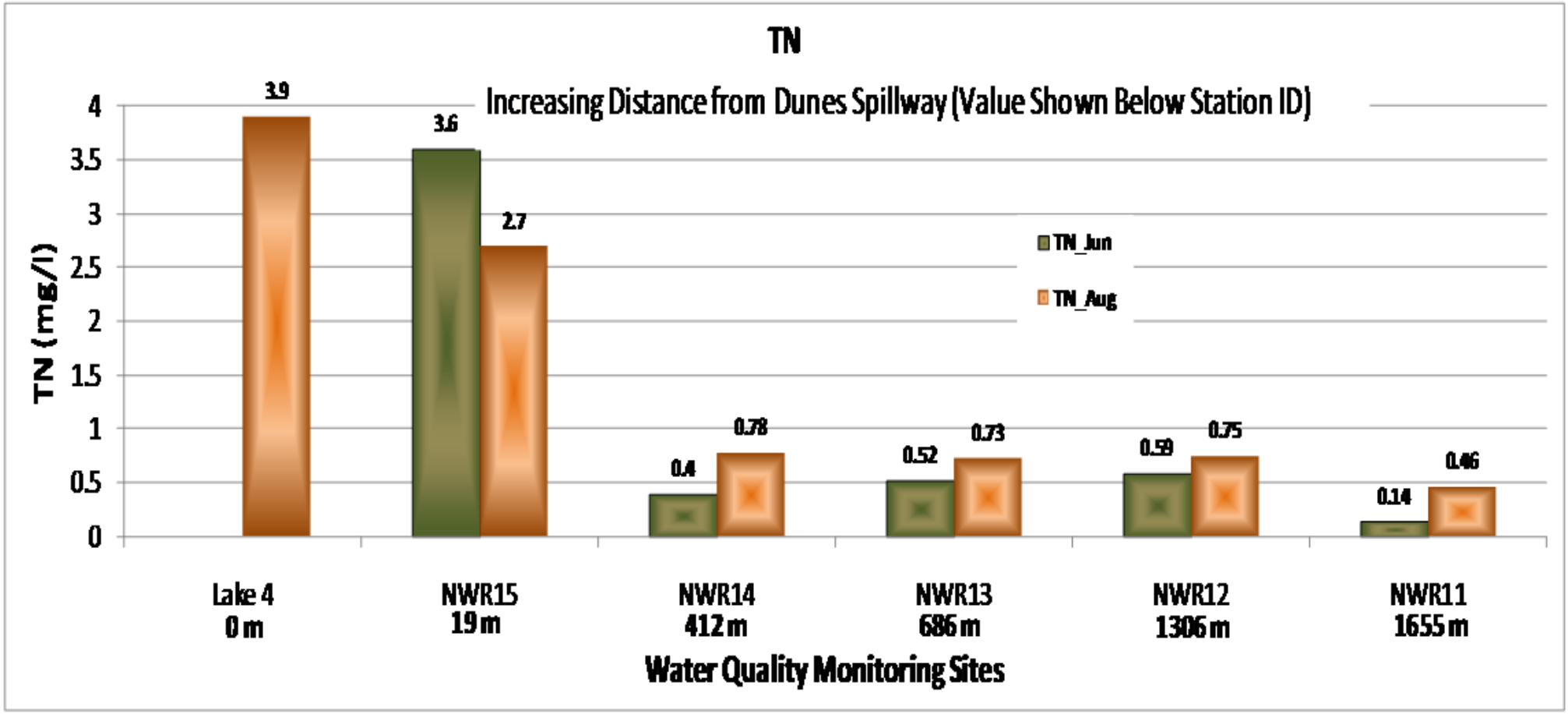


Figure 3: Concentrations of total nitrogen along a transect from Dunes Lake #4 spillway to the mouth of Tarpon Bay.

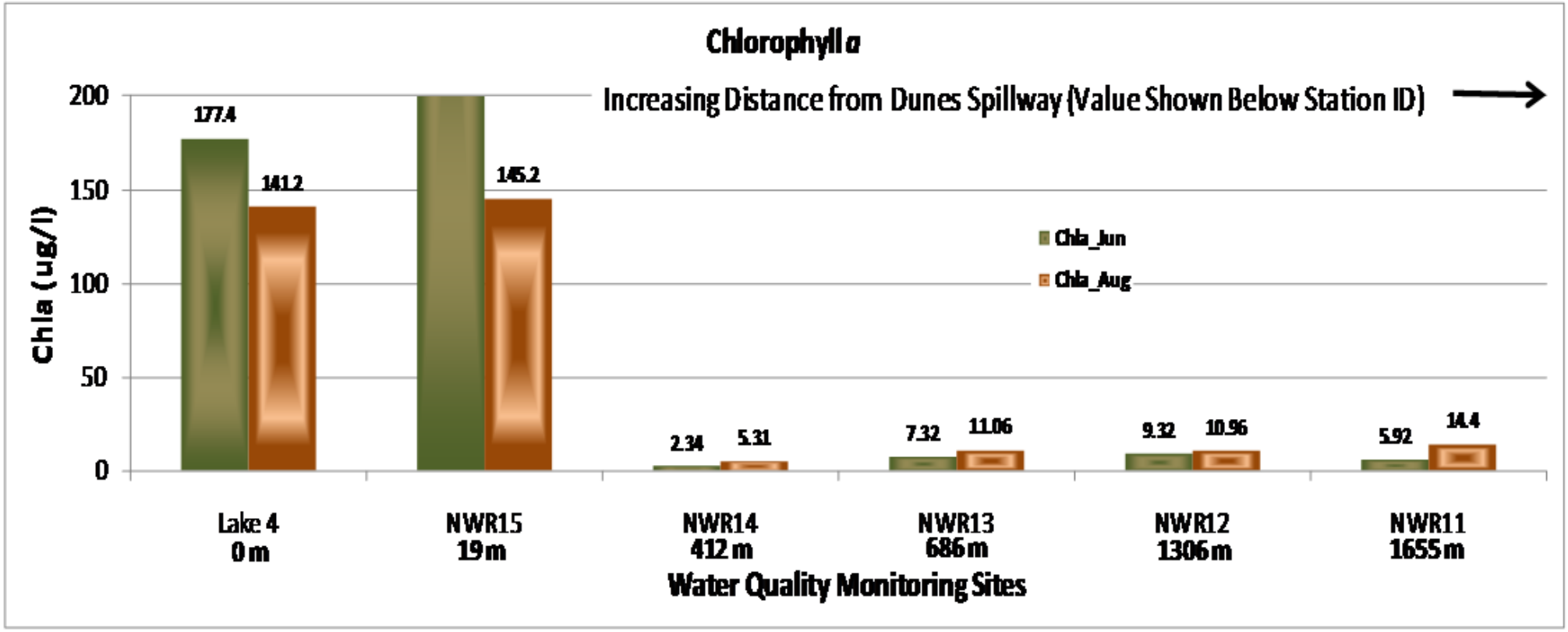


Figure 4: Concentrations of chlorophyll *a* along a transect from Dunes Lake #4 spillway to the mouth of Tarpon Bay.