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memorandum

date August 21, 2014

to Joanne Vernon, P.E.

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Ralph Montgomery, Ph.D.
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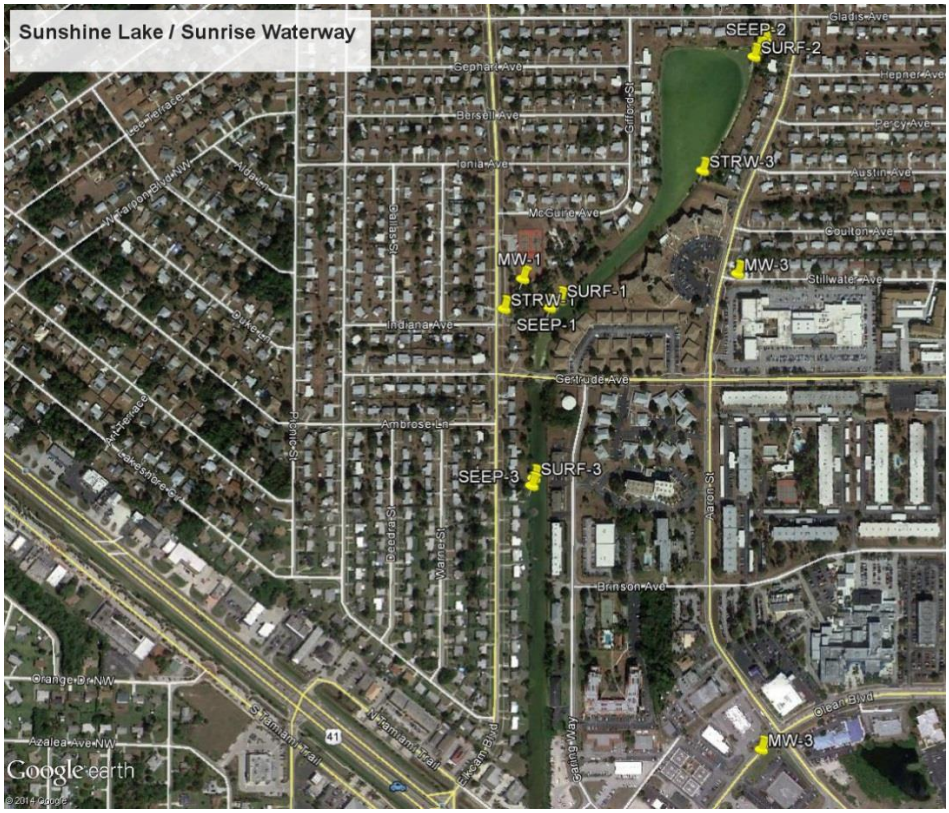
subject Revised Interim Report – Tasks 8 and 9 for Sunshine Lake / Sunrise Waterway

Introduction

Task 8 of the project involves the analysis of preliminary results from the combined monitoring of the following: 1) the open waters of the lake and waterway, 2) stormwater inflows into the lake, 3) groundwater seepage into the lake, and 4) the surficial aquifer. Sampling locations are indicated in Figure 1.

Figure 1 – Locations of sampling sites for surface water samples (SURF – 1, 2 and 3), stormwater runoff samples (STRW-1, 2 and 3), groundwater seepage (SEEP-1, 2 and 3) and surficial aquifer (MW-1, 2 and 3).



Preliminary results are to be analyzed to determine if there is evidence of elevated levels of nutrients and/or bacteria in samples collected from those same locations. This interim report will summarize findings to date (mid-August) related to the characterization of both nutrient concentrations and levels of fecal coliform bacteria. More specifically, this Technical Memorandum interprets results from ongoing monitoring efforts to determine if nutrient and/or bacteria levels are excessively high, and if so, what actions are recommended to determine their source(s).

Methods for Assessment of Data

Nutrients

Surface Water

For the surface waters of Sunshine Lake and the Sunrise Waterway, nutrient concentrations were compared to criteria established by the State of Florida, as contained in the Florida Department of Environmental Protection's (FDEP) Surface Water Quality Standards (FAC 62-302). Within 62-302, there are guidance criteria for the nutrients total nitrogen (TN) total phosphorus (TP) and also for the plant pigment chlorophyll-a, an indicator of the amount of algae within the water. Water quality data contained with the preliminary report conducted on Sunshine Lake and the Sunrise Waterway (Atkins 2011) indicate that the lake would be classified by FDEP as a low-color (platinum-cob alt units < 40) and high alkalinity (specific conductance > 100 µS / cm) waterbody. While there was an algal mat that filled approximately 50 percent of the lake's volume, most of the algae was not suspended within the water column, and therefore the amount of chlorophyll-a in the water column did not exceed the impairment threshold of 20 µg Chl-a / liter set for low color, alkaline lakes by FDEP in their Numeric Nutrient Concentration (NNC) criteria (FAC 62-302).

Based on the characteristics listed above, nutrient impairment of the open waters of Sunshine Lake and Sunrise Waterway would be indicated if the annual geometric mean TN concentration exceeds 1.91 mg / liter, and if the annual geometric mean TP concentration exceeds 0.09 mg / liter. Those TN and TP values are indicated for lakes where algal concentrations are deemed non-impaired, which is quantified as chlorophyll-a concentrations less than 20 µg Chl-a / liter. However, the algal bloom in Sunshine Lake and Sunrise Waterway appears to be associated with an algal mat growing up from the bottom, rather than phytoplankton floating in the water column. As an indicator of problematic algal blooms, it appears that the criteria of 20 µg Chl-a / liter fails to capture this local water quality problem. If, however, the local algal bloom is viewed as being functionally equivalent to a phytoplankton bloom, the TN and TP guidance criteria would be 1.05 and 0.03 mg / liter for TN and TP, respectively.

Surface Water	Not Problematic	Problematic
TN (mg / liter)	1.05 to 1.91	> 1.91
TP (mg / liter)	0.03 to 0.09	> 0.09

Stormwater Runoff

Harper and Baker (2007) summarize water quality data collected throughout the state of Florida over a period from the 1977 to 2007. Of particular reference to Sunshine Lake are results from undeveloped landscapes as well as data from single family residential land uses, the dominant land use in the watershed of Sunshine Lake and Sunrise Waterway.

In the category of undeveloped / rangeland / forested land cover, overall mean TN and TP values for stormwater runoff were 1.15 and 0.055 mg / liter for TN and TP, respectively (Baker and Harper 2007). The range of TN values for runoff in undeveloped / rangeland / forested land cover was between 0.70 and 1.52 mg TN / liter. For TP, the range of values recorded was 0.02 to 0.10 mg TP / liter. In the category of single family residential land cover , overall mean TN and TP values for stormwater runoff were 2.07 and 0.327 mg / liter for TN and TP, respectively (Baker and Harper 2007). The range of TN values for runoff in single family residential land cover was between 1.02 and 3.99 mg TN / liter (one study had a slightly higher TN concentration in runoff, but data from that site were flagged as having problematic values for TP). For TP, the range of values recorded was 0.102 to 0.510 mg TP / liter (one study had a much higher TP concentration in runoff, but results were flagged as being problematic). The category of "normal undeveloped" contains the range of values displayed in Harper and Baker (2007) for the categories of undeveloped / rangeland and forested landscapes.

The category of "lower range developed" contains the range of values between the lowest mean value and the overall mean value for studies summarized in Harper and Baker (2007) for the category of single-family residential landscapes. The category "elevated developed" contains the range of values between the overall mean value and the highest mean value for studies summarized in Harper and Baker (2007) for the category of single-family residential landscapes. The category "excessive developed" refers to concentrations higher than the highest mean value for studies summarized in Harper and Baker (2007) for the category of single-family residential landscapes.

Stormwater runoff	Normal undeveloped	Lower range developed	Elevated developed	Excessive developed
TN (mg / liter)	**0.070 to 1.52**	**1.02 to 2.07**	**2.07 to 3.99**	**> 3.99**
TP (mg / liter)	**0.002 to 0.100**	**0.102 to 0.327**	**0.327 to 0.510**	**> 0.510**

Groundwater Seepage

For groundwater seepage, results were compared to results shown in PBS&J (2009). Concentrations of TN and TP were collected from groundwater seepage meters placed into both shallow and deep areas of Lakes Conine, Haines, Rochelle and Shipp, located in Polk County.

In contrast to surface water samples and stormwater runoff, groundwater seepage has received much less attention, in terms of determining the range of values expected from undisturbed and urbanized landscapes. Also, groundwater seepage meters have been deployed in some locations without sufficient attention to the phenomenon of settling, which can give rise to inaccurate measurements (PBS&J 2009).

In a report conducted for FDEP, four lakes in Central Florida were studied to determine the quantity and quality of groundwater seepage coming into the lakes (PBS&J 2009). There were 3 to 6 samples taken over a 6 month period from each of four sites per lake; this represents a fairly robust data set.

The average TN concentration in groundwater seepage collected from the four lakes was 2.5 mg TN / liter, with a range of 0.4 to 14.3 mg TN / liter. The average TP concentration in groundwater seepage collected from the four lakes was 0.055 mg TP / liter, with a range from 0.002 to 0.373 mg TP / liter.

As opposed to stormwater runoff, there is a much more limited data set for nutrient concentrations in groundwater seepage from undeveloped landscapes. As such, the category of "normal undeveloped" displays the range of values below the lowest concentrations recorded from the developed watersheds that were sampled in the report by PBS&J (2009). The category of "lower range developed" contains the range of values from the lowest concentrations recorded up to the overall mean in the report by PBS&J (2009). The category "elevated developed" represents the range of values from the overall mean to the highest concentration recorded in the report by PBS&J (2009). The category "excessive developed" refers to the highest concentrations recorded for groundwater seepage in the report by PBS&J (2009).

Groundwater seepage	Normal undeveloped	Lower range developed	Elevated developed	Excessive developed
TN (mg / liter)	**< 0.40**	**0.40 to 2.50**	**2.50 to 14.3**	**> 14.3**
TP (mg / liter)	**< 0.002**	**0.002 to 0.055**	**0.055 to 0.373**	**> 0.373**

Surficial Aquifer

Similar to groundwater seepage, there is not as much data available to characterize the effects of undeveloped vs. urbanized landscapes on water quality in the surficial aquifer. Sonntag (1987) included some information that can be used to characterize TP concentrations in the Biscayne Aquifer, which is the surficial aquifer in Miami-Dade County. And data can be constructed to derive mean and maximum values for TN as well, by adding the individual nitrogen species that combined equate to TN. The results shown in Adamski and Knowles (2001) can be similarly combined to derive groundwater values for TN, but "phosphorus" data are only shown for dissolved phosphate (aka orthophosphate), not TP. In the Biscayne aquifer, there can be fairly significant differences between TP and orthophosphate concentrations (even when both expressed in units of mg / liter as P). Therefore, while TN guidance can be developed from both studies, only the results from Sonntage are used for screening for TP in the surficial aquifer.

The average TN concentration in the Biscayne aquifer is calculated at approximately 0.53 mg TN / liter. The maximum concentration of ammonia nitrogen (as N) was 1.9 mg / liter, and the maximum concentration of nitrate plus nitrate (as N) recorded in the Biscayne aquifer was 3.4 mg / liter. The mean TP concentration in the Biscayne aquifer was 0.02 mg TP / liter, with a range from 0.01 to 0.07 mg TP / liter. In the study by Adamski and Knowles (2001) the median concentrations of TN from the surficial aquifer were 0.34 and 0.35 mg TN / liter, respectively, from the Ocala National Forest and developed areas within Lake County, respectively. Although median TN values did not vary much between developed and undeveloped landscapes in this study, there was separation between maximum values; the highest TN concentration in the surficial aquifers were 2.48 and 5.20 mg TN / liter, respectively, for sites in the Ocala National Forest and locations in Lake County, respectively.

Somewhat similar to the situation with groundwater seepage, there is a much more limited data set for nutrient concentrations in the surficial aquifer from undeveloped landscapes. As such, the category of "normal undeveloped" displays the range of values below the lowest concentrations recorded from the developed watersheds in the reports by Sonntag (1987) and Adamski and Knowles (2001). The category of "lower range developed" contains the range of values from the lowest concentrations recorded up to the overall mean in the reports by Sonntag (1987) and Adamski and Knowles (2001). The category "elevated developed" represents the

range of values from the overall mean to the highest concentration recorded in the reports by Sonntag (1987) and Adamski and Knowles (2001). The category "excessive developed" refers to the highest concentrations recorded for groundwater seepage in the reports by Sonntag (1987) and Adamski and Knowles (2001).

For phosphorus, proposed criteria may be problematic. The data set from Adamski and Knowles (2001) only included data on "phosphate" (as P) not "total phosphorus". Data shown in Sonntag (1987) indicates that phosphate as P can underestimate the total amount of phosphorus in the surficial aquifer. However, the data from Sonntag (1987) is from the carbonate-rich Biscayne aquifer, which raises the potential problem that phosphorus would be absorbed onto the carbonate sediments of the aquifer matrix, rather than be distributed in the porewater itself.

Surficial aquifer	Normal undeveloped	Lower range developed	Elevated developed	Excessive developed
TN (mg / liter)	< 0.23	0.23 to 0.35	0.35 to 5.2	< 5.2
TP (mg / liter)	< 0.01	0.01 to 0.02	0.02 to 0.07	> 0.07

Fecal Coliform Bacteria

Surface Water

Sunshine Lake and the Sunrise Waterway are classified as Class III freshwater waterbodies. This classification is often referred to as "fishable / swimmable" waters. As such, the relevant guidance for fecal coliform bacteria are that the number of colony forming units (cfu) per 100 ml of water shall not exceed a monthly average of 200, based on 10 sampling efforts per month. As very few entities sample that frequently, FDEP typically bases impairment status based on the standard that no more than 10 percent of samples shall exceed 400 cfu / 100 ml. If a single sample is collected on a waterbody, and its bacterial abundance exceeds 400 cfu / 100 ml, then it is also true that "more than 10 percent" of samples have exceeded 400 cfu / 100 ml. Additionally, a single value in excess of 800 cfu / 100 ml is sufficient to characterize a waterbody as "impaired" for fecal coliform bacteria.

In a 2003 report, researchers from the University of Florida suggested that lakes with fecal coliform bacteria concentrations between 0 and 200 cfu / 100 ml could be classified as "good", while lakes with values between 200 and 800 could be considered "moderate". Lakes with fecal coliform bacteria in excess of 800 cfu / 100 ml were characterized as "poor" (University of Florida 2003).

Surface water	Normal undeveloped	Lower range developed	Elevated developed	Excessive developed
Fecal Coliform Bacteria (cfu / 100 ml)	0 to 200	200 to 400	400 to 800	> 800

Stormwater Runoff

Migliaccio and Castro (2009) summarize water quality data collected throughout Miami-Dade County during three storm events: June 24, 2003, June 22, 2005, and August 27, 2005. While these results are from only 3 rainfall events, they represent water quality data from a wide variety of highly urbanized landscapes.

The category of "normal undeveloped" contains the range of values displayed in Migliaccio and Castro (2009) between the lowest value recorded and the lowest median value for any station. The category of "lower range developed" contains the range of values between the lowest median value for any station and the arithmetic mean of the median values for all stations. The category "elevated developed" contains the range of values between the arithmetic mean of the median values for all stations and the maximum value recorded from any of the 13 sampling locations. The category "excessive developed" refers to concentrations higher than maximum value recorded, as shown in Table 2-2 of Migliaccio and Castro (2009).

Stormwater runoff	Normal undeveloped	Lower range developed	Elevated developed	Excessive developed
Fecal Coliform Bacteria (cfu / 100 ml)	5 to 40	40 to 264	264 to 8,900	> 8,900

Results

Nutrients

It is anticipated that nutrient concentrations from stormwater runoff and other sources would include values higher than those typically recorded from undeveloped landscapes in Florida, since the watershed is in fact completely developed. A more relevant question would be "Are nutrient concentrations in stormwater runoff substantially higher than values typically seen in urbanized watersheds?" Similarly, nutrient concentrations in both groundwater seepage and the surficial aquifer would be expected to be higher than samples from an undeveloped landscape, but are they higher than concentrations typically seen in areas with similar levels of development?

If nutrient concentrations in stormwater runoff, groundwater seepage and/or the surficial aquifer are substantially higher than values seen in other developed landscapes, then it could be that there are "unique" sources of nutrient loads in the watershed, above and beyond those typically encountered in an urbanized landscape. If nutrient concentrations in stormwater runoff, groundwater seepage and/or the surficial aquifer are mostly in-line with expectations from an urbanized watershed, then perhaps there is something unique about Sunshine Lake and the Sunrise Waterway that makes it more susceptible to nutrient loads than the typical lake in an urban setting.

Surface Water

As seen in Figures 1 and 2, TN and TP concentrations (respectively) are mostly in the range of values that would not cause concern. However, the algal bloom in Sunshine Lake and the Sunrise Waterway was not a phytoplankton bloom, it was an algal mat that was associated with the lake bottom and which was then removed from the lake by dredging. The surface water guidance developed here may not be useful for characterizing the nutrient status of the lake and waterway if the nutrients loaded to these waterbodies are taken up by a similar algal mat as what originally occurred. Subsequently, results from the water column itself could be low because of low rates of loading, or they could be low because of an alternative nutrient sink (e.g., a re-forming algal mat). Results should be interpreted with caution.

Figure 1. Surface water total nitrogen concentrations within Sunshine Lake/ Sunrise Waterway.

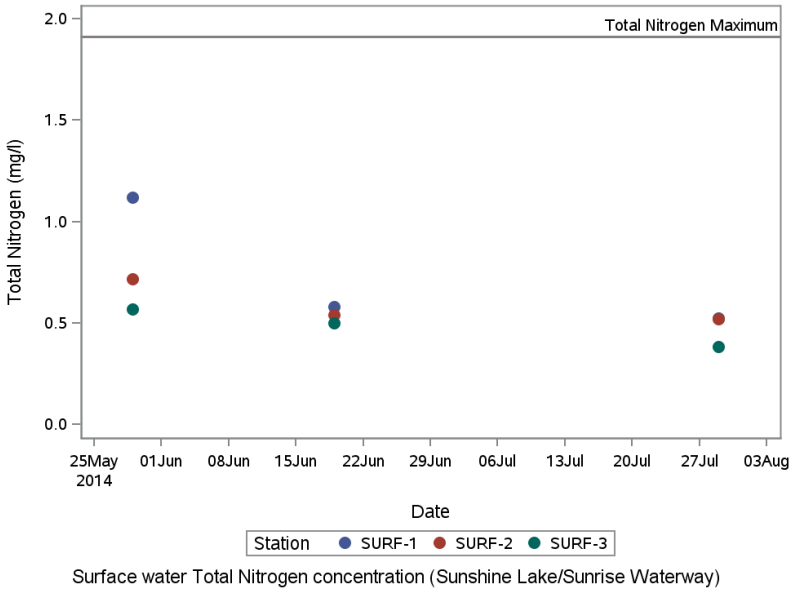
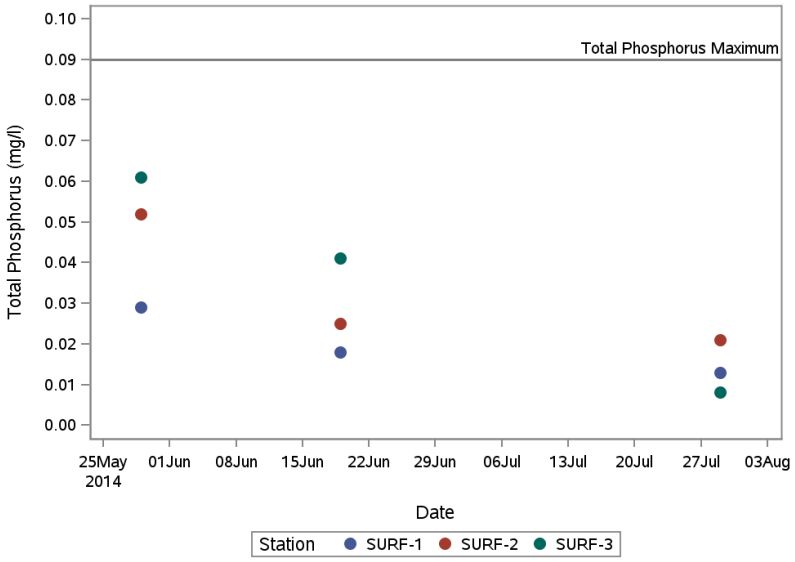


Figure 2. Surface water total phosphorus concentrations within Sunshine Lake/ Sunrise Waterway.



Stormwater Runoff

Figure 3 shows that the levels of TN in stormwater runoff are only moderately enriched, compared to concentrations expected from an urbanized watershed. Approximately 38% of TN values are in the range of "normal undeveloped" indicating little evidence of the influence of the urbanized watershed. More than half (ca. 55%) of the remaining values fall in the categories of "lower range developed" to "elevated developed" **with the final 17% of values within the range of "excessive developed".** In contrast, most values for TP (ca. 79%) were in the range of "excessive developed" (Figure 4). These findings suggest that TP values, much more so than TN,

are far in excess of those that would be expected to occur in stormwater runoff from the typical urbanized watershed.

Figure 3. Stormwater runoff total nitrogen concentrations within Sunshine Lake/ Sunrise Waterway.

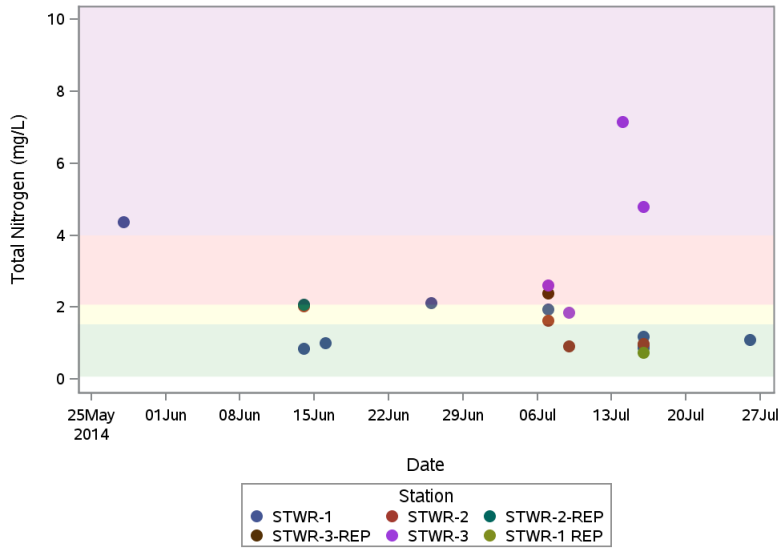
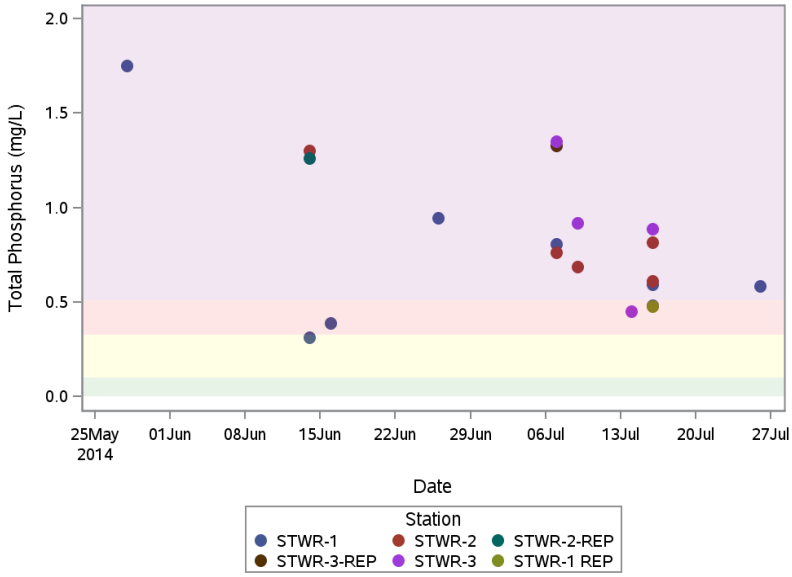
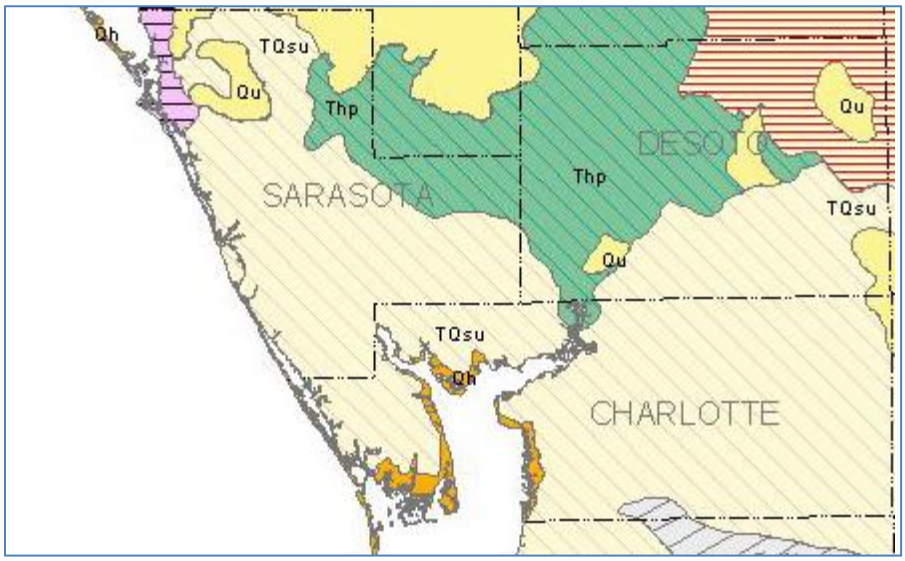


Figure 4. Stormwater runoff total phosphorus concentrations within Sunshine Lake/ Sunrise Waterway.



Two factors, considered together, suggest that the elevated levels of TP are not necessarily due to human-related pollution. First, the levels of TN are not similarly as elevated as TP. If elevated levels of TP were due to influences such as fertilizer application and/or sewage or pet wastes, similarly consistent elevated levels of TN would also be expected. Second, Charlotte County has surface geology that includes the phosphorus-rich soils of the Peace River Formation (Figure 5).

Figure 5. Surface geology in vicinity of Sunshine Lake / Sunrise Waterway (TQsu = Shelly sediments of Plio-Pleistocene, Thp = Peace River Formation). Figure derived from Scott et al. (2001)



Soils of the Peace River Formation are enriched enough to warrant mining interest in locations where land uses and the cost of land allow for such. Although the Peace River Formation is shown as ending just east of Port Charlotte, Scott et al. (2001) note that the boundaries shown in their maps are approximate, and that soils grade into each other at their boundaries. The report "Soil Survey of Charlotte County" by Henderson (1984) shows the soils directly adjacent to Sunshine Lake and the Sunrise Waterway as being in the Matlacha Urban Land Complex. In Charlotte County, that soil complex was described as having a "VERY HIGH potential for P movement from the site and for an adverse impact on surface waters" (Table 13 in Hurt et al. 2013).

It is thus possible that elevated levels of TP in stormwater runoff represent a condition related to "natural" sources of phosphorus based on local geology, rather than being related to human pollutant sources.

Groundwater Seepage

Levels of TN and TP are mostly within the range of "lower range developed" to "elevated developed" (Figures 6 and 7, respectively). No values for TN fall within the range of "elevated developed" or "excessive developed" values. For TP, one value fell within the range of "elevated developed" and none were within the range of "excessive developed".

Figure 6. Seepage total nitrogen concentrations within Sunshine Lake/ Sunrise Waterway.

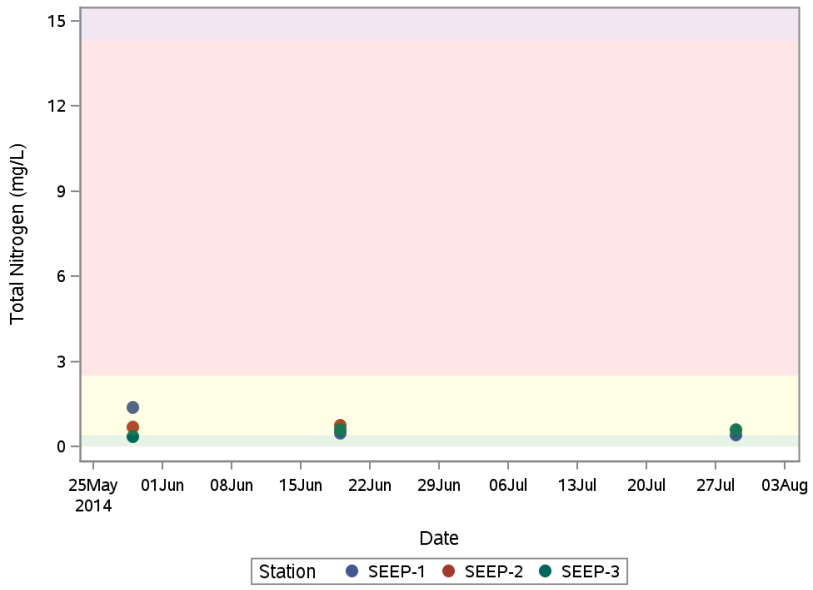
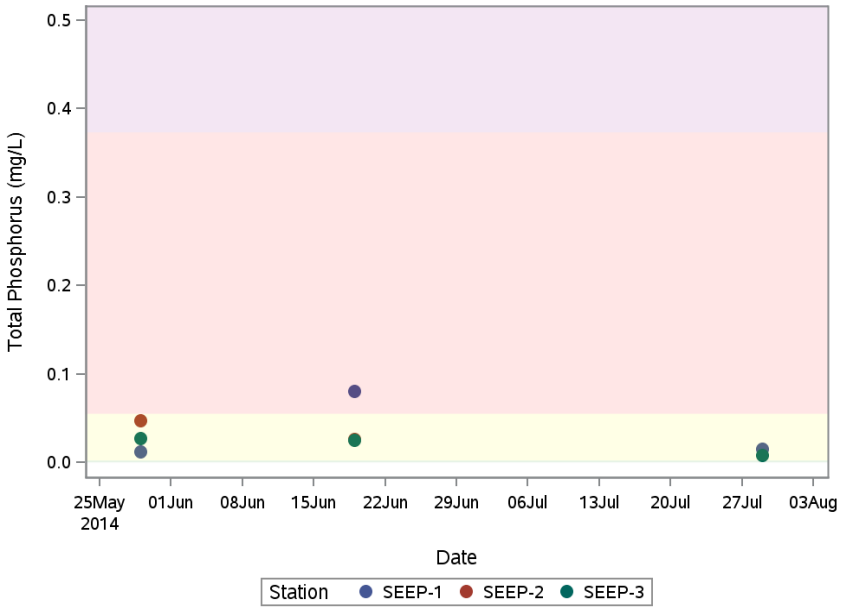


Figure 7. Seepage total phosphorus concentrations within Sunshine Lake/ Sunrise Waterway.



Surficial Aquifer

Levels of TN are mostly within the range of "elevated developed" (Figures 8). No values for TN within the range of "excessive developed" values. In contrast, TP values were almost exclusively within the range of "excessive developed" (Figure 9).

Figure 8. Surficial Aquifer total nitrogen concentrations within Sunshine Lake/ Sunrise Waterway.

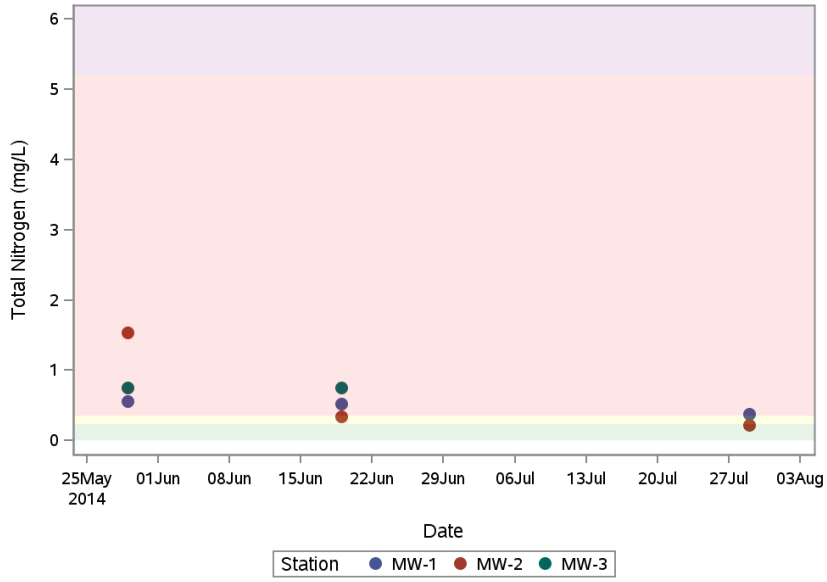


Figure 9. Surficial Aquifer total phosphorus concentrations within Sunshine Lake/ Sunrise Waterway.

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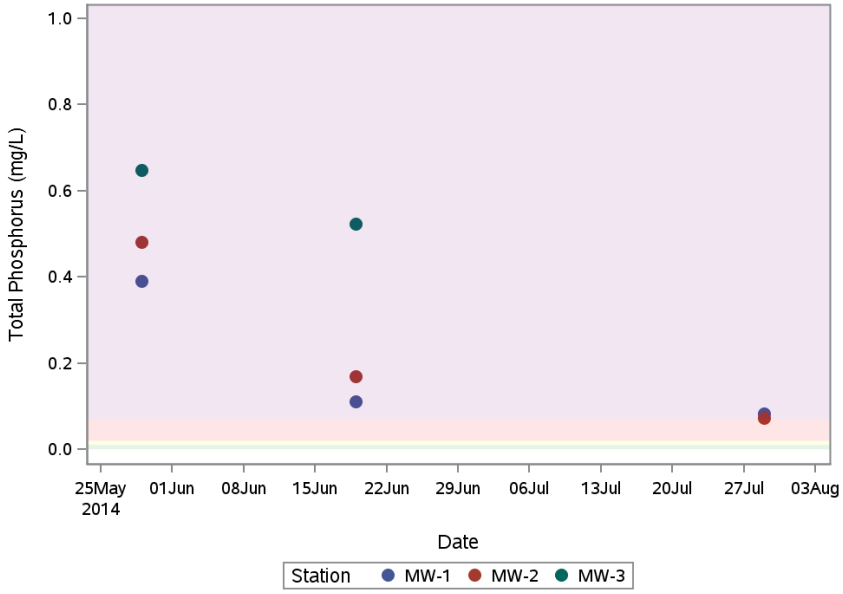
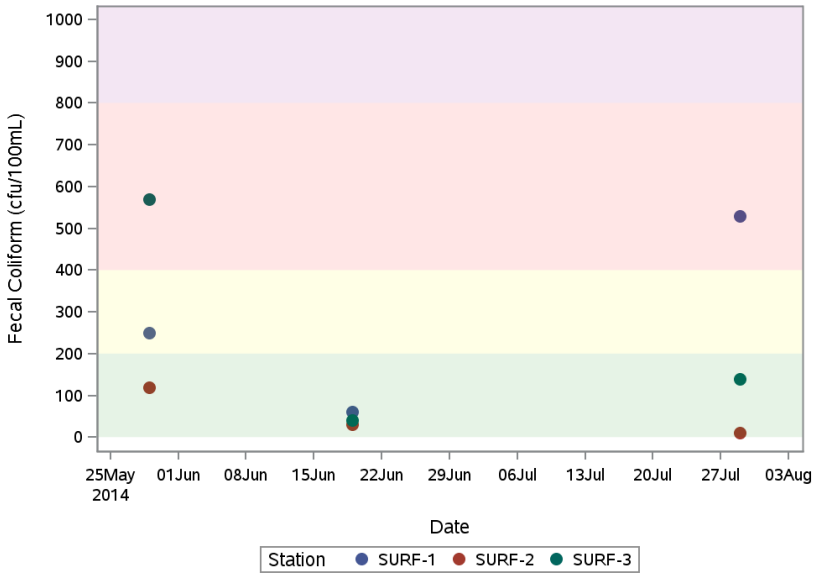


Fecal Coliform Bacteria

Surface Water

Results shown in Figure10 show that most values for fecal coliform bacteria fall within the range considered "moderate" by University of Florida Researchers, with a few values in excess of 400 cfu / 100 ml.

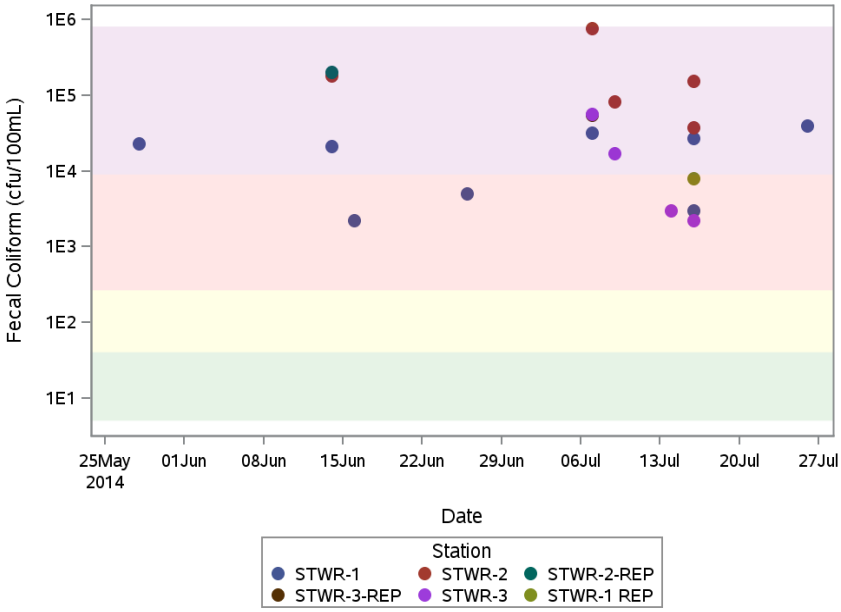
Figure 10. Surface water fecal coliform bacteria concentrations (cfu/100 ml) within Sunshine Lake/ Sunrise Waterway.



Stormwater Runoff

As opposed to surface water, values of fecal coliform bacteria in stormwater runoff include numerous examples of values well above the threshold for "excessive developed" levels (Figure 11). Some of the values recorded were nearly 100 times higher than the threshold value for "excessive developed" of 8,000 cfu / 100 ml.

Figure 11. Stormwater runoff fecal coliform bacteria concentrations (cfu / 100 ml) within Sunshine Lake/ Sunrise Waterway (data plotted on log-scale, where "1E2" = 100, "1E3" = 1,000, "1E4" = 10,000, "1E5" = 100,000, and "1E6" = 1,000,000)



In an effort to determine the source of the very high levels of fecal coliform bacteria found in some of the storm samples, additional analyses were conducted. While fecal coliform bacteria have been used for decades as an indicator of risks to public health, many types of bacteria that are not pathogenic (i.e., disease-causing) also test positive as "fecal" coliform bacteria. In some locations, alternative tests for bacteria such as *E. coli* or *Enterococci* have been conducted. While these organisms are an improvement over the use of fecal coliform bacteria, these organisms are termed "facultative anaerobes" which means that they can grow and reproduce in soils and sediments, and thus are limited as an indicator of recent contamination. Consequently, tests were run with the use of the indicator bacteria within the genus *Bacteroidetes*, which are considered a better indicator of humans as a source than alternative indicator organisms such as *E. coli* and *Enterococci*. As bacteria in the genus *Bacteroidetes* are strict anaerobes, their presence is an indicator of recent contamination from fecal material. These bacteria are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

Water samples were collected and sent to a private laboratory in Miami which used a molecular biological technique, Polymerase Chain Reaction (PCR) to determine the presence of these indicator organisms by detecting the presence of DNA sequences from these organisms. In this way, an entire water sample can be tested for the indicator of human contamination. Based on preliminary results, the very high levels of fecal coliform bacteria found in stormwater do NOT, as of yet, appear to be due to humans as a primary source. The first round of results found no evidence of humans in any of the three stormwater samples. A second round did find evidence of human-derived bacteria, but the total quantity of bacteria that could be traced to humans as a source was well under 1 percent of the total amount of "fecal coliform" bacteria quantified. A similar test for dogs found evidence of bacteria from dogs in stormwater runoff, but also at levels of less than 1 percent of total "fecal coliform" bacteria.

Interpretation of Preliminary Results

Currently, results indicate the following:

- Nutrient concentrations within Sunshine Lake and the Sunrise Waterway are lower than nutrient concentrations in stormwater runoff and groundwater seepage, indicating that nutrient loads into the lake and waterway are taken up by "nutrient sinks" that are apparently not in the water column
- The low nutrient concentrations in the open waters of Sunshine Lake and the Sunrise Waterway possibly reflect a situation whereby algae growth on the bottom of the lake is the destination of nutrient loads, which is consistent with the previously noted condition of the lake
- If an algal mat is the nutrient destination of inflows to the lake, it is possible that the bloom could reform over time
- Nutrient concentrations in groundwater inflows and the surficial aquifer are higher than those expected from an undeveloped watershed, they mostly in-line with expected values from urbanized watersheds
- Concentrations of nitrogen in stormwater runoff are higher than those expected from an undeveloped watershed, but they are not substantially higher than expected values from urbanized watersheds
- In contrast to nitrogen, concentrations of phosphorus in stormwater runoff are substantially higher than expected values from urbanized watersheds
- The highest concentrations of phosphorus, by far, are those in stormwater runoff, suggesting stormwater runoff might be the most important loading source to the lake and waterway

- Concentrations of fecal coliform bacteria have been recorded at very high concentrations in stormwater runoff
- Additional tests do not indicate that humans are the primary source of the very high levels of fecal coliform bacteria in stormwater runoff

The results summarized above indicate that the nutrient loads required to account for the massive algal bloom in Sunshine Lake and Sunrise Waterway may be linked to excessive loads of phosphorus, rather than nitrogen. The algal mat that was recently removed by dredging was comprised of various species of cyanobacteria, many of which have been shown to be able to "fix" nitrogen from the atmosphere. In other Florida lakes, cyanobacteria abundance was shown not to be limited by nitrogen, but by phosphorus, as atmospheric di-nitrogen gas is an unlimited source of nitrogen.

The high concentrations of phosphorus in stormwater runoff could be the key to stimulating the growth of the algae bloom in Sunshine Lake and the Sunrise Waterway. However, the lack of similarly and consistently elevated levels of nitrogen in stormwater runoff (compared to phosphorus) suggests that sewage and/or fertilizer are not likely the source(s) of high levels of phosphorus. Instead, it is likely that the high levels of phosphorus in stormwater runoff are associated with the geologic formation referred to as the Peace River Formation of the Hawthorn Group. This geological formation, which extends into Charlotte County just east of Port Charlotte (Figure 2) is characterized by its elevated phosphorus content. Of particular note, the report titled "UF/IFAS Nutrient Management Series: Computational Tools for Field Implementation of the Florida Phosphorus Index - Charlotte County Florida" stated that the phosphorus-rich soils immediately adjacent to Sunshine Lake and the Sunrise Waterway have a "VERY HIGH potential…for an adverse impact on surface waters."

The high levels of fecal coliform bacteria found in stormwater runoff could be due to a number of sources, such as: 1) human sewage, 2) wildlife, 3) pet wastes, 4) soils, and 5) rotting vegetation. While it is tempting to conclude that high levels of fecal coliform bacteria are indicative of humans as a source, prior studies in the City of Miami, Collier County and in Hawaii have shown that soils and waterbodies in humid subtropical environments contain naturally-occurring bacteria that test positive as "fecal coliform" bacteria. While a more detailed assessment of sources (described above) did not find evidence of sewage as a primary source of the bacteria, the caveat that "an absence of evidence does not constitute evidence of absence" should be kept in mind. The fact that the samples analyzed did not produce evidence of humans as a significant proportion of the bacteria recorded does not mean that contamination by sewage is <u>never</u> a major problem.

Based on results received as of mid-August, it appears that the algal bloom in Sunshine Lake and the Sunrise Waterway may have been caused in part by excessive loads of phosphorus from stormwater runoff. Very high levels of phosphorus do not appear to be due to human impacts from either sewage or fertilizer, as levels of nitrogen are not similarly elevated (for the most part) and there is no evidence that high bacteria levels are related to sewage. Instead, high levels of phosphorus appear likely – at this time – to be due to runoff from soils with high natural phosphorus contents. The high nitrogen content of the previously dredged algal mat could be brought about through in-situ nitrogen fixation by cyanobacteria, a process that has been previously documented in other hypereutrophic lakes.

Recommendations for Additional Efforts

The nutrient source assessment results discussed here should be re-visited after the completion of the data collection phase of this project. It is possible that the interpretation of results could change, should ongoing and future results vary from those analyzed here.

Additionally, it is recommended that Charlotte County perform an additional assessment to determine not only what source(s) are NOT responsible for the high levels of bacteria found, but what source(s) ARE responsible. If the more specific tests used here did not find humans as the source of the bacteria in stormwater runoff, the question arises, "What is the source?" To address that question, keeping in mind the widespread public perception that fecal coliform bacteria must come from humans (or at least from mammals) the following additional effort is strongly recommended:

1. Using techniques outlined by FDEP, conduct a "Walk the WBID" exercise to identify and quantify (to the degree possible) potential sources of bacteria
    a. ESA and Atkins staff will document the presence or absence of wildlife, pet wastes, rotting vegetation, etc. associated with the stormwater conveyance system, including surveys of material within the first and last sections of the storm sewer systems
    b. ESA and Atkins staff will photograph and attempt to quantify the abundance of these potential bacteria sources in the watershed, including assessments of pet wastes in publically-accessed areas next to the storm sewer system
2. ESA and Atkins staff will conduct a replicated (n = 3) experiment whereby samples of soils, pet wastes and rotting vegetation are immersed in water-filled buckets (along with appropriate controls) to quantify the abundance of fecal coliform bacteria over time
3. Collection and analysis of stormwater samples for fecal coliform bacteria concentration before and after entering the concrete stormwater discharge pipe.
4. Interpretation of results from these efforts to include in the management plan recommendations
    a. Recommendations could include placement of dog waste stations, public education on discharge of grass clippings to the storm sewer system and/or changes in management of right of way by Count staff
    b. Recommendations will be coordinated with ongoing survey of sanitary sewer system via video surveys and interpretation of results from smoke tests, etc.

A cost estimate to conduct this additional effort is included as Appendix A.