PELICAN BAY SERVICES DIVISION
Municipal Service Taxing and Benefit Unit

NOTICE OF PUBLIC MEETING

JULY 12, 2018

THE CLAM BAY COMMITTEE OF THE PELICAN BAY SERVICES DIVISION WILL MEET AT 1:30 PM ON THURSDAY, JULY 12 AT THE PELICAN BAY SERVICES DIVISION, 3RD FLOOR OF THE SUNTRUST BUILDING, SUITE 302, LOCATED AT 801 LAUREL OAK DRIVE, NAPLES, FLORIDA 34108.

AGENDA

1. Roll call
2. Agenda approval
3. Approval of 05/03/18 meeting minutes
4. Audience comments
5. Clam Bay
   a. Update on hand-dug channel maintenance
   b. Update on exotic maintenance
   c. Canoe trail marker 12
6. Clam Pass
   a. H&M June tidal ratio report
   b. June aerial photos
   c. FDEP requiring idle speed signage
7. Water quality
   a. THA contract for WQ in 2018
   b. Tomasko report on Nov. 2017-April 2018 Clam Bay WQ results
   c. Copper results
   d. Copper sediment testing in Upper Clam Bay
   e. Documentation of rookery
   f. Using hydrogen peroxide algacide in swale on east side of berm
   g. Upland pond WQ report
8. Next meeting: September 6
9. Adjournment

ANY PERSON WISHING TO SPEAK ON AN AGENDA ITEM WILL RECEIVE UP TO THREE (3) MINUTES PER ITEM TO ADDRESS THE BOARD. THE BOARD WILL SOLICIT PUBLIC COMMENTS ON SUBJECTS NOT ON THIS AGENDA AND ANY PERSON WISHING TO SPEAK WILL RECEIVE UP TO THREE (3) MINUTES. THE BOARD ENCOURAGES YOU TO SUBMIT YOUR COMMENTS IN WRITING IN ADVANCE OF THE MEETING. ANY PERSON WHO DECIDES TO APPEAL A DECISION OF THIS BOARD WILL NEED A RECORD OF THE PROCEEDING PERTAINING THERETO, AND THEREFORE MAY NEED TO ENSURE THAT A VERBATIM RECORD IS MADE, WHICH INCLUDES THE TESTIMONY AND EVIDENCE UPON WHICH THE APPEAL IS TO BE BASED. IF YOU ARE A PERSON WITH A DISABILITY WHO NEEDS AN ACCOMMODATION IN ORDER TO PARTICIPATE IN THIS MEETING YOU ARE ENTITLED TO THE PROVISION OF CERTAIN ASSISTANCE. PLEASE CONTACT THE PELICAN BAY SERVICES DIVISION AT (239) 597-1749. VISIT US AT HTTP://PELICANBAYSERVICESDIVISION.NET.

07/05/2018  1:43 PM
PELICAN BAY SERVICES DIVISION
CLAM BAY COMMITTEE MEETING
MAY 3, 2018

The Clam Bay Committee of the Pelican Bay Services Division met on Thursday, May 3 at 1:30 p.m. at the SunTrust Bank Building, 801 Laurel Oak Drive, Suite 302, Naples, Florida 34108. In attendance were:

**Clam Bay Committee**
Susan O'Brien, Chairman
Bohdan Hirniak
Rick Swider

**Pelican Bay Services Division Staff**
Neil Dorrill, Administrator
Mary McCaughtry, Operations Analyst
Marion Bolick, Operations Manager
Lisa Jacob, Associate Project Manager
Barbara Shea, Recording Secretary

**Also Present**
Jennifer Bobka, Earth Tech
Mike Shepherd, PBSD Board
Maricelle Kitchener, Turrell, Hall & Associates
Jeremy Sterk, Earth Tech
Trent Waterhouse, PBF

APPROVED AGENDA (AS AMENDED)

1. Roll call
2. Agenda approval
3. Approval of 03/08/18 meeting minutes
4. Audience comments
5. Clam Bay
   a. Update on March mangrove monitoring
   b. Rookery photos/videos
   c. Bee boxes
   d. Debris removal and hand-dug channel maintenance
   e. Update on exotic maintenance
   f. Canoe trail marker 12
   g. Update modems on tidal gauges *(add-on)*
6. Clam Pass
   a. Update on dredging
   b. H&M April tidal ratio results
   c. FDEP requiring idle speed signage
7. Water quality
   a. Proposal for copper sediment testing in Upper Clam Bay
   b. Copper results
   c. Upland pond WQ reports
   d. Data needed for Tomasko WQ report
   e. Contract for THA WQ work for 2018
   f. Other
8. Next meeting: July 12, 17, or 23
9. Adjournment
PBSD BOARD MEMBER, MR. RICK SWIDER, WAS WELCOMED AS A NEW MEMBER TO THE CLAM BAY COMMITTEE

ROLL CALL
All members were present and a quorum was established

AGENDA APPROVAL
Mr. Hirniak motioned, Ms. O’Brien seconded to approve the agenda as amended, with the addition of item #5g. The motion carried unanimously.

APPROVAL OF 03/08/18 MEETING MINUTES
Mr. Hirniak motioned, Ms. O’Brien seconded to approve the 03/08/18 meeting minutes as amended. The motion carried unanimously.

AUDIENCE COMMENTS
Mr. Trent Waterhouse, PBF board member, commented on (1) the recent motion filed by the PBF with the judge to get the lawsuit (against FWC to obtain a Manatee Protection Zone designation) remanded to the lower courts to obtain a decision, (2) plans by Mr. Gary McAlpin, Collier County Manager of Coastal Management Programs, to install four signs (idle or slow speed) in Outer Clam Bay, and (3) comments by Mr. McAlpin indicating that the County has no plans for manatee signage in Clam Bay until the PBF lawsuit is resolved.

CLAM BAY
UPDATE ON MARCH MANGROVE MONITORING
Mr. Sterk, consultant with Earth Tech, commented on the results of the March semi-annual mangrove monitoring, which showed that a majority of the plots were relatively stable. However, additional dead trees were observed, considered to be “after-effects” of Hurricane Irma. Mr. Ste:k noted two out of the 21 plots as areas of concern.

ROOKERY PHOTOS/VIDEOS
Mr. Sterk provided drone photos of the rookery in Upper Clam Bay near Station #8, and suggested the high density of nests could be the source of high phosphorus levels in water quality data in this area. Ms. Marielle Kitchener, consultant with Turrell Hall & Assoc., offered to contact Dr. Tomasko (CH2Mhill) to determine a “suggested method of documentation” of the nests.

BEE BOXES
Ms. O’Brien commented that the PBF is not interested in installing bee boxes.

DEBRIS REMOVAL AND HAND-DUG CHANNEL MAINTENANCE
Mr. Sterk commented that his firm, Earth Tech, will begin the annual hand-dug channel maintenance and IRMA debris removal work. The project is estimated at 40 days utilizing 6-8 workers.

UPDATE ON EXOTIC MAINTENANCE
None
CANOE TRAIL MARKER 12
Mr. Sterk commented that canoe trail marker 12 remains on the County’s list of markers to be replaced.

UPGRADE MODEMS ON TIDAL GAUGES (ADD-ON)
Ms. Jacob commented that she will work with Mr. Sterk and/or Mr. Kevin Locher (Locher Environmental) to upgrade the modems on the tidal gauges, at a maximum estimated cost of $2,000. The deadline to upgrade is December 2019.

CLAM PASS
UPDATE ON DREDGING
Mr. Dorrill provided an update on the current dredging project, which may be substantially complete by Tuesday, May 8. He commented very positively on the quality and speed of the work of the contractor, Cavache, Inc.

H&M APRIL TIDAL RATIO RESULTS
Ms. O’Brien commented that the April tidal ratios look good. Mr. Dorrill commented that Dr. Dabees reported to him that this morning’s tidal ratios were .76 or .78 which were the highest he has ever seen.

FDEP REQUIRING IDLE SPEED SIGNAGE
Ms. O’Brien commented on an e-mail from Mr. Dave Cook to Mr. Dorrill, which suggested that a condition of the FDEP Clam Bay permit requires that there be idle speed and no wake. Mr. Dorrill commented that he will discuss this issue with Dr. Dabees.

WATER QUALITY
PROPOSAL FOR COPPER SEDIMENT TESTING IN UPPER CLAM BAY
Ms. O’Brien commented on the Turrell, Hall & Assoc. sediment testing proposal of $2,962 to help determine the source of high copper at Station #9 (as provided in the agenda packet).

Mr. Hirniak motioned, Ms. O’Brien seconded to approve the Turrell, Hall & Assoc. sediment testing proposal of $2,962. The motion carried unanimously.

COPPER RESULTS

UPLAND POND WQ REPORTS
Ms. O’Brien commented that on 4/16/18 the Water Management Committee suggested that the Clam Bay Committee take another look at the possibility of reducing the proposed expenditure of $25,000 for four CH2MHiil quarterly water quality reports on WQ data from 28 of the upland ponds we manage.

Mr. Shepherd questioned what is actionable as a consequence of gathering this data.
Ms. O’Brien commented that we are currently impaired for copper and not meeting the criteria for total phosphorus in Clam Bay. She suggested that the FDEP may ask, “What are your inputs from the upland ponds into Clam Bay?” Ms. O’Brien commented that the water quality data is collected for documentation purposes and to provide to the FDEP as a defense and/or response to an inquiry. Mr. Hirniak commented that this documentation would show that we are
“proactive” and continue to monitor the data closely. Ms. Kitchener commented that the action of “trying” keeps the FDEP at bay.

Ms. O’Brien suggested that Mr. Hall and Dr. Tomasko weigh in on whether we should continue the quarterly reports “as is,” or could we change the scope and/or frequency.

Mr. Trent Waterhouse commented that the PBSD is the managing entity of Clam Bay, and the PBF has jurisdictional oversight, as acknowledged by the FDEP.

Mr. Dorrill commented that a violation by FDEP could result in the FDEP setting TDML (total daily maximum load) parameters or they may set mitigation requirements.

DATA NEEDED FOR TOMASKO WQ REPORT
Ms. O’Brien suggested that THA be given only the monthly water quality data for the six berm sites, without including any extraneous data.

CONTRACT FOR THA WQ WORK FOR 2018
Ms. Kitchener commented that the THA water quality contract expired on April 11. Mr. Dorrill will work with Ms. Jacob to get a new contract in place.

NEXT MEETING:
By consensus, the committee agreed that the next meeting of the committee would be held on July 12 at 1:30 p.m.

ADJOURNMENT
The meeting was adjourned at 2:50 p.m.

__________________________
Susan O’Brien, Chairman

Minutes approved [____] as presented OR [____] as amended ON [_____________________] date
Clam Pass Tide Monitoring - Click here for Maintenance Dredging Project details

Mean Low Tide Time Lag - 2018

Gage/Gulf Mean Tide Ratios - 2018

Gage/Gulf Mean Tide Ratios - 2017

https://www.humistonandmoore.com/clampass-tide

7/2/2018
Definitions:

**Mean Tide Ratio**: ratio of tide amplitude of gages over the tide amplitude from the Gulf of Mexico, averaged over a month. This ratio is representative of the pass's effectiveness in flushing water from the bay. The lower the ratio, the less efficient is flushing, indicating material accumulating in the pass.

**Mean Low Tide Lag**: time difference between low tide in the Gulf of Mexico and at the gage’s locations, averaged over a month in minutes. The time lag is also representative of the pass’s effectiveness in flushing water from the bay. The higher the lag the less efficient is flushing, indicating material accumulating in the pass.

Background

Clam Pass is a small wave dominated inlet on the southwest coast of Florida that provides a tidal connection to 500 acres of the wetland preserve at Clam Bay Natural Resource Protection Area (NRPA). This preserve includes several interconnected bays surrounded by extensive areas of mangrove wetlands. The preserve is a pristine environmental resource that is collectively known as Clam Bay. Clam Pass has gone through periods of inlet migration as well as closure, because the relatively small tidally prism for Clam Bay provides critical balance between tidal energy and littoral process at the inlet channel.

Humiston & Moore Engineers provides professional engineering services to Pelican Bay Services Division of Collier County, Florida for Clam Pass and Clam Bay. Humiston & Moore Engineers provided engineering services to assist Turrell Hall & Associates in the development of the Clam Bay NRPA management plan of 1998 and the updated plan of 2014. The engineering services included the development of design criteria for the inlet stability and conditions for maintenance dredging to maintain hydraulic efficiency and avoid potential inlet closure including. The implementation of the NRPA management plan includes various monitoring to maintain the health of the eco system. In addition to the ecological and biological monitoring of the bay system and its function as a protected environmental resource, the monitoring program includes hydraulic and physical monitoring of the inlet and bay system to monitor the stability of the pass and assess maintenance requirements. Monitoring of the hydraulic and physical conditions of the Clam Bay system continues according to the updated NRPA management plan. The hydraulic monitoring includes continuous water level and tidal data collection at 4 locations within the bay system.
From: David Cook 

Subject: Fwd: FW: Clam Pass - Construction Drawings and Specifications for PBSO review

Date: March 26, 2018 at 3:25 PM

To: Neil Dorrill, Scott William Streckenbein, Jim Hoppensteadt, Susan O'Brien, and others

Dear Neil,

In reading through this document I was struck by the language covering manatees - section 10.8 and especially 10.8.2. It says that Florida DEP requires that there be an idle speed and no wake restriction in the Clam Bay ecosystem as a condition of the permit. I know this would be your personal opinion and not a legal one, but does this mean that we already have standing under Florida law to post idle speed in Clam Bay?

The permit is a multi-year permit, under which this dredging is taking place. Is that correct?

What do you think?

Is there other language in the original permit that supports these same comments?

Thanks

Dave

-------- Forwarded message --------
From: JacobLisa <JacobLisa@cohen.com>
Date: Mon, Mar 26, 2018 at 2:19 PM
Subject: FW: Clam Pass - Construction Drawings and Specifications for PBSO review
To: David Cook <David.Cook@cohen.com>

Dave, here’s the Clam Pass draft construction plans and the technical specs. Let me know if you need anything else. Thanks, Lisa

From: Matthew Fleming

Sent: Thursday, March 22, 2018 3:42 PM
To: JacobLisa <JacobLisa@cohen.com>; Mohamed Dabees <Mohamed.Dabees@cohen.com>
Cc: Celia Follows <Celia.Follows@cohen.com>
Subject: Clam Pass - Construction Drawings and Specifications for PBSO review

Lisa.

As we discussed this morning - attached are the latest and greatest of the Clam Pass drawings and specs for PBSO to review prior to Monday’s meeting.

Matthew

Matthew Fleming, M. Sc.
Humiston & Moore Engineers
office: 239-566-0649 x105
cell: 239-572-4903
www.humistonmoore.com
should also be contacted in Jacksonville (1-904-232-2580) for north Florida or in Vero Beach (1-407-562-3909) for south Florida*.

10.8.1.4. Siltation Barriers, if used, shall be made of material in which manatees cannot become entangled, are properly secured, and are regularly monitored to avoid manatee entrapment. Barriers must not block manatee entry to or exit from essential habitat.

10.8.1.5. If manatees are seen within 100 yards of the active daily construction/dredging operation, CONTRACTOR shall ensure that all appropriate precautions shall be implemented to ensure protection of the manatee. These precautions shall include the operation of all moving equipment no closer than 50 feet of a manatee. CONTRACTOR is advised that operation of any equipment closer than 50 feet to a manatee shall necessitate immediate shutdown of that equipment.

10.8.1.6. CONTRACTOR shall report any collision with and/or injury to a manatee immediately to the Florida Marine Patrol (1-800-DIAL-FMP, or 1-800-342-5367) and to the Florida Fish and Wildlife Commission Bureau of Protected Species Management at (850) 922-4330.

10.8.2. The Clam Bay ecosystem contains waterways that are difficult to navigate due to shallow water depths and meandering channels lined with protruding mangrove branches and roots to protect the significant natural resources and water quality of the Clam Bay ecosystem, and to provide protection to the public safety, a condition of the DEP permit requires that there be an idle speed and no wake restriction on motorized vessels used in the system. The CONTRACTOR shall adhere to an idle speed and “no wake” requirement in the project area.

10.9. Marine Turtle and Shorebird Nesting Protection

10.9.1. The project construction will occur during the shorebird nesting season and potentially a small portion of the sea turtle nesting season. Daily clearance is necessary for work activities continuing during the day. Nighttime activities are regulated in the state and federal permits. All requirements of the state and federal permits relating to endangered sea turtle and shorebird protection and work within the season must comply with those conditions. Daily clearance from the sea turtle and shorebird monitors, as deemed necessary, shall be required prior to the start or continuation of construction activity and movement of equipment across the beach. When moving heavy equipment from Construction Access to the area of WORK, a spotter shall walk ahead of the equipment to ensure safety to endangered species and pedestrians.

10.9.1.1. A pre-work conference shall be held between representatives of the CONTRACTOR, the ENGINEER, the Marine Turtle Permit holder, shorebird monitor, and a representative of the State Department of Environmental Protection, the U.S. Army Corps of Engineers, and Florida Fish and Wildlife Conservation Commission (FWC) prior to commencement of WORK.

10.9.1.2. In the event that an unmarked marine turtle nest or a dead, injured, or sick marine turtle is discovered during construction activities, the marine turtle permit holder and the Bureau of Protected Species Management shall
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Background information on CH2MHiI reports on Water Quality in PB’s upland ponds

- Clam Bay is a Class 2 water body so it is subject to regulation by Florida Department of Environmental Protection (FDEP).
- Between 2005 and 2012 FDEP collected and analyzed 25 water samples in Clam Bay and found that 12 of the samples (48%) exceeded allowable limits for copper.
- In November 2011 PBSD began collecting and analyzing water samples on a quarterly basis from selected ponds in PB because stormwater from these ponds flows into Clam Bay, and CH2MHiI began doing quarterly reports on the results, costing about $25,000 annually.
- In 2012 FDEP identified Clam Bay as impaired for copper and said detailed documentation of efforts to remedy the issue, e.g. monitoring water quality in upland ponds, was needed.
- In 2012 the Environmental Protection Agency adopted nutrient concentration criteria for Clam Bay (Florida Administrative Code (FAC) 62-302.531). This FAC established criteria for total phosphorus and total nitrogen in Clam Bay.
- In September 2013 the PBSD Board approved the immediate cessation of copper sulfate to treat algae in ponds PBSD manages and asked all PB associations to also cease using copper sulfate.
- The 2017 Clam Bay WQ report found 16 of 98 samples exceeded allowable limits, making Clam Bay impaired for copper. (Reducing the number of samples from 48% in 2005-2012 to 16% in 2017 is significant progress, but Clam Bay is still impaired for copper.)
- The 2017 Clam Bay WQ report found that 33 of 98 water samples (34%) in Clam Bay exceeded allowable upper limits for Total Phosphorus, significantly more than the allowable 15%.
- In 2017 the contract for CH2MHiI’s reports expired. Water samples from 29 selected ponds are still being collected and analyzed quarterly, but no reports are being done.
- Thus Clam Bay is currently impaired for copper and total phosphorus and a major part of the documentation that PBSD was doing to demonstrate its efforts to address the issue is no longer being done.
- The Clam Bay Committee will address this issue at its meeting on July 12, 2018.

Prepared by Susan O’Brien
July 2, 2018
memorandum

date March 7, 2018

to Tim Hall, Turrell, Hall and Associates, Inc.

from David Tomasko, Ph.D.
Emily Keenan, M.S.

subject Annual Report on Clam Bay Numeric Nutrient Concentration (NNC) Criteria

Executive Summary

Water quality data collected from Clam Bay between November 2016 and October 2017 were analyzed to determine the degree to which the waters of Upper, Inner and Outer Clam Bay are in compliance with relevant criteria. For nutrients, it was found that levels of phosphorus were out of compliance with existing site-specific criteria for Clam Bay. Levels of nitrogen were not out of compliance. Based on data from throughout the Clam Bay system, there is a positive correlation between phosphorus concentrations and the amount of algae in the water column, and an inverse correlation between phosphorus and levels of dissolved oxygen (DO). These results suggest that phosphorus concentrations are at potentially problematic levels in Clam Bay, and they should be carefully monitored, to ensure that conditions do not deteriorate. Should phosphorus continue to exceed established criteria; the County would benefit from the development of a detailed and data-rich phosphorus loading model, to develop appropriate management responses. Although this is supposition at this time, the temporal pattern of phosphorus exceedances suggests that nesting behavior of wading bird might better explain the temporal pattern of phosphorus enrichment than stormwater runoff. This potential link needs to be investigated in greater detail.

Levels of DO are problematic when compared to newly adopted criteria developed by the Florida Department of Environmental Protection (FDEP). For DO, 13 of the 98 samples had levels lower than existing guidance criteria from FDEP, a value in excess of the 10 percentile exceedance rate allowed by FDEP. For copper, 16 of 98 samples collected in Upper, Inner and Outer Clam Bay exceeded FDEP criteria for Class II marine waters. Based on this exceedance rate, the waters of Clam Bay would be determined to be “impaired” for copper. The majority of the copper impairments occurred within Upper and Inner Clam Bay, at stations 1, 2 and 3, and special attention should be placed on determining the potential cause(s) of elevated copper at those locations. The determination of copper exceedances in freshwater sampling sites in the watershed requires the simultaneous collection of data on “hardness”. Unfortunately, not all of the copper values from freshwater locations were accompanied by hardness values, so the degree of impairment cannot be fully investigated.

Future sampling should include measurements of water clarity for all Clam Bay sites, and measurements of hardness for all freshwater sampling sites.
Background

Over the past several decades, it has become well-established that an over-abundance of the plant nutrients nitrogen and/or phosphorus can have adverse impacts on the water quality and ecology of lakes, rivers and estuaries. Excessive nutrient supply can stimulate the growth of nuisance plants, creating nuisance algal blooms. In a system like Clam Bay, algal blooms can reduce water clarity, which is essential for the continued persistence of seagrass meadows, which provide food and shelter for the majority of recreationally and commercially important species of fish and invertebrates (such as crabs and shrimp). Once algal blooms die-off, their decomposition can reduce levels of DO, which is essential to most forms of aquatic life. Successful management of coastal waterbodies thus requires the collection, analysis and interpretation of results from water quality monitoring programs, particularly data related to nutrient amounts and sources.

Determination of Impairment Status

In 2012, the United States Environmental Protection Agency formally adopted nutrient concentration criteria for Clam Bay, as produced for Collier County, which had also been reviewed and approved by FDEP. The Numeric Nutrient Concentration (NNC) criteria produced for Clam Bay are termed Site Specific Alternative Criteria (SSAC) and they are listed in Florida Administrative Code (FAC) 62-302.531. The SSAC for Clam Bay was derived based upon a relationship between salinity and nutrients that was initially established at one of FDEP’s “reference sites” in Estero Bay. The need to take into account salinity was based upon the finding that nutrient concentrations in estuaries and tidal rivers vary as a function of rainfall and runoff, as well as the amount of tidal influence. For example, even in FDEP’s reference sites, which were chosen to represent waterbodies with little or no human impacts, nutrient concentrations are lowest on high tides, in areas close to passes, and during dry periods with little rainfall-generated stormwater runoff. Even in these reference sites, nutrient concentrations increase as one moves farther away from passes, as the tide falls, and during wet seasons and wet years. Therefore, a single nutrient concentration criterion does not make much sense, if water quality data from even pristine locations could potentially pass or fail proposed criteria simply as a function of location, tidal stage or antecedent rainfall.

The SSAC for Clam Bay therefore considers the concentration of nutrients, while also taking into account the salinity, such that a finding of elevated nutrients in combination with higher salinities is considered more problematic than elevated nutrients in combination with lower salinities. As such, the relationship between nutrients and salinity is determined as part of the process to determine if the waters of Clam Bay are “impaired” or not. Also, the frequency with which values exceed NNC criteria is taken into account when determining the appropriate management response, as is the amount of time over which an exceedance has occurred. For example, if nutrient concentrations were to exceed NNC criteria by a relatively small percentage, and if such an exceedance was to only last a short period of time, the appropriate management response would be different than if water quality was to exceed criteria to a larger extent, and if the condition of exceedance was to have lasted for a greater period of time. Therefore, the management response associated with any impairment determination is proportional, and based upon both the magnitude and duration of any exceedances.

Based on prior work conducted in Clam Bay, it was found that the amount of floating microscopic algae (i.e., phytoplankton) in the bay was likely stimulated by both Total Nitrogen (TN) and Total Phosphorous (TP). Consequently, the amount of both TN and TP in Clam Bay is used to determine the degree of nutrient enrichment of Clam Bay’s waters.

As outlined in FAC 62-302.531, the water quality status of waterbodies is to be determined on an annual basis, preferably within a calendar year. For this report, the data collection effort comprised 12
months of effort, but the 12 months did not fall within a single calendar year. Nonetheless, the compilation of results and the interpretation of results presented in this report should be fully consistent with that which would have occurred if the full 12 months of data had been collected in a single calendar year.

As outlined in FAC 62-302.532, for each year, each individual TN and TP value collected within Clam Bay is compared to an “upper boundary” of the expected relationship between those two variables and salinity, which was originally informed by the water quality data from an FDEP-designated reference water body. The formal name of the upper boundary condition is the “90th percentile prediction limit” which was originally derived for the relationship between nutrient concentrations and salinity in Clam Bay, and which is based on the determination by FDEP that Clam Bay’s water (in 2012) was sufficient to protect its biological integrity. In other words, a TN or TP concentration higher than the 90th percentile prediction limit is a nutrient concentration higher than at least 90 percent of the values that would be expected, after taking into account the salinity value at the time that the water quality sample was collected.

The number of occasions when a nutrient concentration is higher than the 90th percentile prediction limit is quantified for each year, and an annual percent exceedance is then calculated. To be consistent with methods currently used by FDEP, if more than 13 percent of TN or TP concentrations exceed the 90th percentile prediction limit (for a given year) then the year as a whole is classified as one where water quality is out of compliance with the existing criteria. If fewer than 13 percent of the values exceed the 90th percentile prediction limit, then water quality is not considered to be out of compliance. If more than 15 percent of TN or TP values exceed the 90th percentile prediction limit, then the degree of impairment is determined (as per FDEP guidance) to be more problematic than if only 13 percent of values exceeded the established criteria. The screening of water quality data against the adopted NNC criteria is performed as outlined in Figure 1, where different outcomes are given different scores, depending on the frequency of impairment, as well as the duration that the impairment has lasted.

**Figure 1. Flow chart for determining water quality compliance in Clam.**

The possible outcomes displayed in Figure 1 are then compared for both TN and TP, and the combined outcomes are converted into designations of “green”, “yellow” and “red” which correspond to an increasing need for concern (Figure 2).
Figure 2. Management response matrix using outcomes for TN and TP.

<table>
<thead>
<tr>
<th>Total Nitrogen</th>
<th>Outcome 0</th>
<th>Outcome 1</th>
<th>Outcome 2</th>
<th>Outcome 3</th>
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<tbody>
<tr>
<td>Outcome 0</td>
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<td></td>
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</tr>
<tr>
<td>Outcome 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As a final step, the appropriate management response to water quality within a given year is then identified based on the results from Figure 2. For example, if water quality data suggest that TN and TP concentrations are elevated, then it is important to determine if the ecological health of Clam Bay appears to be adversely impacted by those nutrient concentrations. As a test of the impact of potential nutrient enrichment, water quality data would then be tested to determine if phytoplankton levels are perhaps higher, or dissolved oxygen levels lower, based on nutrient concentrations (Figure 3).

Figure 3. Management response actions in response to various outcomes

In this manner, management responses are proportional to the frequency and duration of exceedance conditions, as well as the determination of whether or not nutrient supply appears to be causing adverse water quality conditions. With this information as background, the rest of this report will focus on the analysis of water quality data collected during the period of November 2016 to October 2017, at nine open water locations shown in Figure 4. In addition to the open water sample sites, a number of
sampling locations were located in the stormwater treatment ponds east of the mangrove fringe on the east side of Outer, Inner and Upper Clam Bays (Figure 4).

Figure 4. Locations of monthly monitoring stations sampled for Clam Bay and its directly adjacent watershed.

Data Analysis – Nutrient Status

The analysis conducted below was used to assess the water quality status of Clam Bay during the months of November 2016 to October 2017. While the period of analysis was not from a single calendar year, it does encompass twelve consecutive months of data collection. A monitoring event was not performed in September 2017 due to the landfall of Hurricane Irma in Immokalee, Florida. In addition, a sample was not collected at station Clam Bay 1 in October 2017 due to debris blocking access to the monitoring site. Therefore, a total of 98 water quality samples were reported within Clam Bay for the analysis period. Water quality data from Clam Bay and its watershed were provided by Turrell, Hall and Associates, Inc.

For comparison with the FDEP adopted SSAC for Clam Bay, as listed within FAC 62-302-532, the water quality data set provided by Turrell, Hall and Associates was analyzed based on the following:
"No more than 10 percent of the individual Total Phosphorus (TP) or Total Nitrogen (TN) measurements shall exceed the respective TP Upper Limit or TN Upper Limit."

The Upper Limits for TP and TN concentrations noted above are derived based on Equations 1 and 2, respectively:

Equation 1: TP Upper Limit (mg/L) = e^{(-1.06256 - 0.0000328465\times\text{Conductivity(\muS)})}

Equation 2: TN Upper Limit (mg/L) = 2.3601 - 0.0000268325\times\text{Conductivity(\muS)}

The nutrient dataset examined was supplemented with in situ water quality data (e.g., temperature, dissolved oxygen, pH, conductivity, and salinity) retrieved from the chain of custody forms for each sampling event. TN and TP concentrations were compared to the derived upper limit thresholds to quantify the presence or absence of elevated concentrations of TP and/or TN, with results listed in Appendix A.

Over the period analyzed (November 2016 to October 2017), a total of three (3) ambient water quality values for TN exceeded the respective TN Upper Limit, for an exceedance frequency of approximately 3 percent. In comparison, 33 of the 96 TP measurements (approximately 34 percent) exceeded their respective TP Upper Limit. Based on these results, the frequency of exceedance would not be high enough for the waters of Clam Bay to be determined to be impaired for TN, but those same waters would be determined to be impaired for TP.

Table 1 displays the results in a manner intended to allow for a quick visualization or results by month and by station. Sampling locations and months are color coded as to the results, with green representing "passing" values, boxes with an "x" representing data that numerically exceed established criteria. In addition, boxes in yellow represent values within the error rate (i.e., ± 5 percent) of threshold criteria, whether in exceedance, or slightly below exceedance.

**Table 1. Representation of frequency of impairment for TN and TP for different site and date combinations.** Green represents sample clearly not out of compliance with criteria. Boxes with "x" represent values out of compliance with criteria. Boxes in yellow with "x" represent data out of compliance, but within the range of resolution of laboratory values (i.e., ± 5 percent) and/or rounding errors. Boxes in yellow but without "x" represent values in compliance, but also within range of resolution of laboratory values (i.e., ± 5 percent) and/or rounding errors. Clear cells represent a lack of data.
The overall pattern shown in Table 1 is that of reduced frequencies of exceedance of criteria for TN, compared to TP. As well, the months of November 2016 to January 2017 and then July to August 2017 had relatively low rates of exceedance. The months of February to May had, on average, the highest rates of exceedance of nutrient criteria, usually for phosphorus. These results suggest that nutrient impairment may not be driven by stormwater runoff alone, as the months of February to May are typically some of the drier months in Southwest Florida. In contrast, the months of July and August of 2017 exhibited lower rates of exceedance, even though they typically represent times of maximal runoff of stormwater from the Clam Bay watershed.

A possibility, worthy of further investigation, is whether or not the trend of elevated phosphorus concentrations might reflect seasonal changes in the abundance of wading birds, and in particular the nesting habits of wading birds. In a study titled “South Florida Wading Bird Report” it was noted that wood storks (Mycteria americana) typically initiate nesting in South Florida in the months of February to March (Cook 2016). Other species, such as White Ibis (Eudocimus albus) and herons within the genus Egretta nest somewhat later, up to April, but they extend their nesting behavior until May or June, if the wet season starts later in the year (Cook 2016). Thus, the abundance of wading birds, particularly nesting pairs and their offspring, may have an influence on water quality not only in Clam Bay, but in the nearby ponds that drain into Clam Bay. Bird guano has an exceptionally high phosphorus content, which could explain the apparent concurrence between those months with the greatest frequency of impairment for phosphorus (February to June) and those months where wading bird nesting in South Florida is at a seasonal high (February to May).

Since the TP exceedances have occurred in two consecutive reporting periods, the outcome from the flowchart shown in Figure 1 would that of a score of “3” for TP, compared to a score of “0” for TN (Figure 2). With two years’ worth of data, the combination of outcome “3” for TP and outcome “0” for TN would result in a “yellow” management response, as illustrated in Figure 3. Since the TP exceedance rate was greater than 15 percent, then the “yellow” management response would be the outcome for this first year’s data collection effort. Consequently, the following additional data investigations were conducted:

- Determining the relationship, if any, between TP and chlorophyll-a
- Determining the relationship, if any, between TP and dissolved oxygen
- Determining the relationship, if any, between chlorophyll-a and water clarity

Depending upon the findings of the analyses listed above, management implications would be developed, which could include the need to determine the basis for a potential adverse impact on water quality.

A review of the last 12 months of data indicated a direct relationship between TP and chlorophyll-concentrations (Figure 5) as well as an inverse relationship between TP and DO (Figure 6). As measurements of water clarity were not available for review, water clarity data was not included in the reviewed data sheets. Unfortunately, this did not allow for the determination of whether or not there was a correlation between chlorophyll-a concentrations and water clarity. As such, we were unable to evaluate the influence of chlorophyll-a on water clarity in Clam Bay.
Figure 5. Relationship between total phosphorus and chlorophyll-a over the period of November 2016 to October 2017 in Clam Bay (p<0.0001).

Figure 6. Relationship between total phosphorus and dissolved oxygen over the period of November 2015 to October 2016 in Clam Bay (p<0.001).

In addition to the data assessments described above, data from Clam Bay outfall monitoring stations were compared to the proposed Downstream Protective Values (DPV) derived for Clam Bay (PBS&J 2011). Outfall TN and TP concentrations were compared to the median and 90th percentile DPV values to determine if elevated concentrations were found at those locations (Appendix B). The median DPV quantity represents a value that would be expected to be exceeded approximately 50 percent of the time, while the 90th percentile value represents a concentration sufficiently high that only 10 percent of values would be expected to be higher. Using this approach, the amount of TN or TP in the water
column at stations sampled in the Clam Bay watershed can be compared to criteria that are meant to be protective of the open waters of Clam Bay. The TN and TP concentrations in DPV estimates are expected to be higher than concentrations in the open waters of Clam Bay, as the influence of the more saline and lower nutrient content waters of the Gulf of Mexico would not yet have diluted the higher nutrient concentrations found in freshwater inflows from the watershed. The median and 90th percentile DPVs for TN are 1.31 and 1.8 mg/L, respectively. The median and 90th percentile DPVs for TP are 0.10 and .25 mg/L, respectively.

For data collected at the outfall monitoring sites, 53 and 17 percent of the TN concentrations exceeded the median and 90th percentile UHV values for TN, respectively (Table 2). For those same outfall monitoring sites, 83 and 32 percent of the TP concentrations exceeded the median and 90th percentile DPV values, respectively (Table 1).

Table 2. Percentage of TN or TP concentrations from outfall stations which exceeded the median or 90th percentile DPV values.

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<th>DPV</th>
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<th>Total Phosphorus</th>
</tr>
</thead>
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<td>Median 90th Percentile</td>
<td>Median 90th Percentile</td>
</tr>
<tr>
<td>Below</td>
<td>47 83</td>
<td>17 68</td>
</tr>
<tr>
<td>Exce</td>
<td>53 17</td>
<td>83 32</td>
</tr>
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</table>

Results – Nutrient Status

Based on the data collected from this year’s monitoring efforts, the waters of Clam Bay do not appear to be problematic in terms of nitrogen, but they do exceed regulatory criteria for phosphorus. The abundance of phosphorus positively correlates with chlorophyll-a concentrations in Clam Bay, which suggests that the availability of phosphorus influences the amount of phytoplankton in Clam Bay. Also, increased phosphorous concentrations are inversely correlated with levels of dissolved oxygen in Clam Bay.

Data collected from the outfall monitoring stations suggest that nitrogen concentrations are somewhat elevated, but that most of the elevated concentrations of nitrogen are from the highest values recorded, rather than there being a “typical” condition of elevated nitrogen enrichment. For phosphorous, elevated concentrations are found both in typical conditions and also amongst the highest concentrations, compared to guidance criteria.

These results strongly support the recommendation that the watershed and open waters of Clam Bay should continue to be monitored on a regular basis, as there is the possibility that phosphorous loads, in particular, could become problematic to the water quality and ecosystem health of Clam Bay, particularly if phosphorous concentrations were to increase over time.

Additionally, as nutrients concentrations vary as a function of the balance between stormwater runoff and mixing with the waters of the Gulf of Mexico, the tidal prism for the Clam Bay system should be maintained such that it continues to allow for sufficient tidal exchange of the waters of Upper, Inner and Outer Clam Bay.

Results – Dissolved Oxygen

For levels of DO the applicable regulatory criterion, as outlined in FAC 62-302.533, is that minimum DO levels (for Class II waters like Clam Bay) shall not be lower than 42 percent saturation more than 10
percent of the time (for average daily values) or that 7-day average values shall not be below 51 percent saturation more than once in any 12-week period, or that the 30-day average DO percent saturation shall not be below 56 percent more than once per year.

The less-restrictive 7-day and 30-day criteria require DO measurements to be made over a 24 hour period, which is not applicable for comparison with water quality data collected at a single time of day, once a month. As such, the more restrictive criterion was used for Clam Bay, and DO values (in units of percent saturation) were compared against the 42 percent saturation value.

Results are shown in Figure 7.

**Figure 7.** Dissolved oxygen values (percent of 100 percent saturation) for nine stations in Clam Bay, over the period of November 2016 to October 2017.

Since DO values were collected at nine stations for eleven months (n = 98) it would take 10 values below 42 percent saturation for Clam Bay to be considered to be out of compliance with the DO criteria listed in FAC 62-302.533. Thirteen values show DO at lower than 42 percent saturation, the majority of which occurred during the months of July to October. Based on these results, the waters of Clam Bay would be considered to be out of compliance with existing DO criteria. Of the thirteen depressed values, five were reported at the Clam Bay 2 monitoring location, which is located in a narrow channel between Upper Clam Bay and Inner Clam Bay (Table 3).
Table 3. Dissolved Oxygen Saturation values at sites Clam Bay 1 to 9, in units of %. Values highlighted in yellow are below the criteria for Class II waters (42%).

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<td><strong>50.2</strong></td>
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</table>

Results - Copper

For levels of copper, there are different criteria used for marine waters vs. freshwater systems such as stormwater ponds. For marine waters, the standard, as listed in FAC 62-302.530, is that concentrations are not to exceed 3.7 µg/liter. However, the State of Florida's Impaired Waters Rule (FAC 62-303) allows for a certain amount of "exceedances" to occur, before water quality is considered to be out of compliance. Table 4 summarizes the data collected from all stations, from November of 2016 to October of 2017, for Stations Clam Bay 1 to Clam Bay 9, all of which are located in the open waters of Upper, Inner or Outer Clam Bay.
Table 4. Copper values at sites Clam Bay 1 to 9, in units of μg/liter. Values highlighted in yellow exceed copper criteria for Class II waters (3.7 μg Cu/liter).

<table>
<thead>
<tr>
<th>Station</th>
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<td>4.08</td>
<td>2.50</td>
<td>2.44</td>
<td>2.37</td>
<td>2.38</td>
<td>2.21</td>
</tr>
<tr>
<td>8/14/2017</td>
<td>4.29</td>
<td>3.81</td>
<td>3.22</td>
<td>2.65</td>
<td>1.40</td>
<td>1.22</td>
<td>1.47</td>
<td>1.02</td>
<td>0.70</td>
</tr>
<tr>
<td>10/4/2017</td>
<td>.</td>
<td>2.68</td>
<td>1.27</td>
<td>0.60</td>
<td>0.80</td>
<td>12.60</td>
<td>1.61</td>
<td>0.60</td>
<td>0.60</td>
</tr>
</tbody>
</table>

- mean: 3.99, 3.93, 2.87, 1.75, 1.28, 2.28, 1.34, 1.43, 1.36
- median: 3.34, 3.56, 2.3, 1.24, 0.894, 1.14, 1.27, 1.11, 1.1
- N: 10, 11, 11, 11, 11, 11, 11, 11, 11
- #> 3.7: 5, 5, 4, 1, 0, 1, 0, 0, 0
- % > 3.7: 50%, 45%, 36%, 9%, 0%, 9%, 0%, 0%, 0%

Of the 98 samples collected for copper, 16 of them exceeded the established criteria of 3.7 μg/liter. Based on guidance in Table 3 of FAC 62-303, if a water body has between 97 and 104 samples collected, it would be determined to be out of compliance if 15 values exceed established criteria. For Clam Bay, 16 of 98 samples collected in Upper, Inner and Outer Clam Bay exceeded FDEP’s criterion for copper, which is sufficient for Clam Bay to be determined to be out of compliance for copper.

Elevated copper concentrations were observed more frequently stations 1, 2, and 3, which are located in Upper Clam Bay down to Inner Clam Bay, and where the immediate shoreline is that of a natural mangrove fringe. It would be helpful to determine the reason(s) for elevated copper at these stations, as they are responsible for more than 90 percent of the exceedances of copper criteria in the entire Clam Bay system.

The determination of copper exceedances in freshwater sampling sites in the watershed requires the simultaneous collection of data on "hardness". Unfortunately, most of the copper values from freshwater locations do not appear to have been accompanied by hardness values, so the degree of impairment cannot be fully investigated. However, 35 of the 61 samples from freshwater locations included results on hardness, and those data are analyzed below.

The water quality standard for copper differs between predominately marine waters and freshwater. As classified by FDEP, open waters of Clam Bay have a water quality standard for copper of < 3.7 μg/liter.
liter. In contrast, the copper standard for freshwater is more complicated, as it requires the concurrent recording of a value for “hardness” in units of mg CaCO₃/liter. The toxicity of copper is mostly restricted to the abundance of the copper ion, and the greater the abundance of other dissolved compounds, the lower the probability that free copper ions will be available to bind with cell membranes, etc. and cause direct and indirect biological impacts. Briefly stated, the higher the hardness level of a water sample, the lower the probability that a given level of copper will be toxic.

Once the level of hardness is determined, the copper criterion for a sample collected from freshwater is derived as:

\[
\text{Copper standard (mg/liter)} = e^{(0.8545[H]-1.702)}
\]

Where:

- \(e\) = the base of the natural logarithm (ca. 2.718281), and
- \(\ln[H]\) = natural log of hardness (in units of mg CaCO₃/liter)

Thus, the determination of whether a sample meets or exceeds the water quality standards for copper only requires determination of the concentration of copper for marine samples; a concurrent value for hardness is required to determine compliance with freshwater criteria.

In the data set examined it appears that there were only 35 date and location combinations for freshwater stations where both hardness and copper levels were analyzed. Those stations and date combinations include the following:

- The site “PB-13” on the dates of 6/22/2017, 7/12/2017, 8/15/2017 and 10/3/2017
- The site “St. Lucie” on the dates of 5/22/2017, 6/22/2017, 7/12/2017, 8/15/2017 and 10/3/2017
- The site “N-41 PIPE” on the dates of 6/22/2017 and 7/12/2017

Copper concentrations at the sites Glenview, N-Berm, N-Boardwalk and St. Lucie exceeded the hardness-normalized copper criteria for Class III freshwater systems during at least one monitoring period. Typically, levels of copper were many times higher than impairment thresholds. These stations are located within the series of open water features on the west side of the Pelican Bay development, just east of the mangrove fringe that separates Clam Bay from its developed watershed. In contrast, none of the copper values from sites N-41, PIPI, PB-11, or PB-13 exceeded criteria for Class III freshwaters.

**Recommendations**

For the waters of Upper, Inner and Outer Clam Bay, water quality monitoring should continue at the same nine stations locations sampled in the reviewed data set. For determining compliance with nutrient criteria, chlorophyll-a should continue to be collected (and be corrected for phaeophytin) along with both Total Nitrogen and Total Phosphorous. To ensure results can be compared to NNC criteria
established specifically for Clam Bay, values of specific conductance also need to be collected, as they were here.

Future sampling should include measurements of water clarity for Clam Bay sites 1 through 9, through the use of a Secchi disk or through the direct measurement of light attenuation coefficients.

If phosphorous concentrations continue to be elevated, a more detailed pollutant loading model should be developed, so that loading sources could be identified and appropriate management responses developed. This loading model should include the potential for wading bird populations to be a significant factor, since the overall temporal pattern appears to be that phosphorus concentrations correlate better with presumed populations of wading birds than with stormwater runoff.

For copper, the sampling sites in Upper and Inner Clam Bay should be investigated in greater detail as that these three stations (of 9 total stations) are responsible for more than 90 percent of copper impairments in the Clam Bay system. As well, measurements of copper in freshwater ponds need to have concurrent measurements of hardness, as impairment determination in freshwater samples requires the "normalization" of copper values to the level of hardness in the water. Based on the locations where copper and hardness values were both recorded, it appears that levels of copper are elevated (often to a considerable degree) in the open water features to the east of the mangrove fringe that separates the developed watershed of Clam Bay from the marine waters of Clam Bay. The source(s) of the copper in these ponds should be determined, as those sources could also be impacting the waters of Clam Bay itself, particularly in the wet season.