ATTACHMENT A RFP 14-051

City of Naples
Semi-annual and Quarterly Stormwater Infrastructure Monitoring
Final Report

Prepared for:
City of Naples
Department of Streets and Stormwater

Prepared by:
AMEC Environment & Infrastructure, Inc.
404 SW 140th Terrace
Newberry, FL 32669

Taylor Kroll, EI
Project Engineer

William A. Tucker, PhD
Project Manager

AMEC Project No.: 6063-13-0225

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List of acronyms and abbreviations

AMEC	AMEC Environment & Infrastructure, Inc.
ASR	Aquifer Storage and Recovery
Atkins	Atkins North America, Inc.
BMP	Best Management Practices
CCWMP	Collier County Watershed Management Plan
CFU	Colony Forming Units
City	City of Naples
Cu	copper
DO	dissolved oxygen
FDEP	Florida Department of Environmental Protection
GORDEXT	Gordon River extension
mg/kg	milligrams per kilograms
µg/L	micrograms per liter
mg/L	milligrams per liter
mL	milliliter
MPN	Most Probable Number
ng/L	nanograms per liter
NNC	Numeric Nutrient Criteria
NPDES	National Pollution Discharge Elimination
Q1	Quarter 1
SOP	Standard Operating Procedures
TKN	total kjeldahl nitrogen
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TRPH	total recoverable petroleum hydrocarbons
TSS	total suspended solids
USDA	US Department of Agriculture
WBID	Water Body Identification

Glossary of Chemical Analysis Data Qualifiers Appearing in this Report

U and ND – These qualifiers have the same meaning, but different laboratories use different codes in conformance with their specific Quality Assurance procedures. Indicates that the compound was analyzed for but not detected. For example, if a chemical analysis result is shown as 0.10 U, 0.10 is the method detection limit. Therefore, "0.10 U" has an equivalent meaning as < 0.10. The chemical was not detected, and if the concentration were greater than 0.10, it could be detected.

I or J - These qualifiers have the same meaning, but different laboratories use different codes in conformance with their specific Quality Assurance procedures. Indicates the reported value is between the laboratory method of detection limit and the laboratory practical quantitation limit. Although the laboratory is confident the chemical is present in the sample, it is below the laboratory's practical quantitation limit, and therefore the concentration reported is less reliable.

B – used for bacterial counts. It is desirable that the number of colonies counted during the test is within 20 to 60 colonies per membrane. Counting the number of colonies is more reliable within the specified range – if too many it is hard to distinguish colonies; if too few, statistical uncertainty is higher. The laboratory may dilute samples to achieve the desired range, but it is not always possible to estimate the appropriate dilution prior to preparation of samples. The laboratory may rely on past results from the same facility/sample location to estimate the appropriate dilution.

Table of Contents (continued)

Glossary of Chemical Analysis Data Qualifiers Appearing in this Report (continued)

V – The analyte was detected in a laboratory blank sample. This may indicate contamination within the laboratory. Where the V qualifier is reported, AMEC has reviewed the concentration of contamination reported in the laboratory blank and compared that with the concentration in the environmental samples.

If the level in the blank is approximately equal to or greater than the concentration in the samples, AMEC overrides the laboratory's report by indicating the contaminant was not detected, annotating a higher detection limit in affected sample batches. If the level in the blank is much lower than the concentration in the environmental samples, the result is accepted and used as valid. For any data reported with a V qualifier under this contract, AMEC determined that the contamination level in the laboratory blanks was much lower than in the potentially affected environmental samples, and the reported data are usable.

Table of Common Names of Lakes compared with Lake Numbers

Lake #	Lake Name
1	Devils Lake
2	Swan Lake
3	Colonnade Lake
4	Hidden Lake
5	Lake Suzanne
6	Mandarin Lake
7	Naples Beach Club/Yucca Lake
8	North Lake
9	South Lake
10	Alligator Lake
11	Spring Lake
31	East Lake
12	Lake btw 14th & 15th Ave S
13	Lake btw 17th & 18th Ave S
14	Lantern Lake
15	Sun Lake Terrace
16	Thurner Lake
17	County Lake
18	
19	15th Ave N Lake (WTP Lake)
20	Forest Lake
21	Willow Lake
22	Lake Manor
23	Lowdermilk Lake
24	Half Moon Lake
25	Lake btw 16th & 17th Ave S
26	NCH Lake

1.0 Introduction

The City of Naples (City) has contracted AMEC Environment & Infrastructure, Inc. (AMEC) to conduct regular water quality monitoring of the City's stormwater lakes and conveyances. This report presents the results of stormwater and lakes monitoring conducted by AMEC during 2013 and the first quarter of 2014. Sampling conducted as part of this project and discussed in this report include the biannual lakes monitoring and source tracking efforts conducted in May and November of 2013, as well as the quarterly pump station monitoring conducted in May, August and November of 2013 and February of 2014. The results of this continued monitoring have been used to fill data gaps identified by the previous report (AMEC, 2013), continue monitoring of critical lakes and stormwater conveyances, and examine trends. Studies by others, particularly Collier County, were reviewed to better understand the City's contribution to loadings to Gordon River and Naples Bay.

1.1 Work Efforts Performed by AMEC

1.1.1 Quarter 1 Monitoring

From May 29, 2013 through June 3, 2013, AMEC, under the City's direction, conducted stormwater sampling in major stormwater conveyances associated with selected City stormwater lakes and infrastructure. Sampling locations were determined based on past sampling efforts and findings (see AMEC, 2013 for additional discussion of historic water quality and sampling efforts). Grab samples were collected from storm sewers, selected stormwater lakes, and pump stations. Sampling was performed in accordance with Florida Department of Environmental Protection (FDEP) Standard Operating Procedures (SOPs) FQ 1000 (Quality Control), FS 2100 (Surface Water Sampling) and FT 1000 (Field Testing General), and was conducted using methods and locations consistent with prior sampling conducted by AMEC (formerly MACTEC) for the City in 2009, 2010, 2011 and 2012.

During the May 2013 sampling event, 0.077 inches of rainfall occurred on May 28. Prior to the May 2013 sampling event, the most recent significant (greater than 0.10 inches) rainfall event occurred on April 12, 2013, at 0.134 inches. For analysis purposes, it can be assumed that antecedent conditions for all sampling locations occurred following a span of relatively dry conditions, which also coincided with the end of the local dry season.

1.1.2 Quarter 2 Monitoring

On August 29, 2013, AMEC collected water samples from the three pump stations located throughout the City. Sampling procedures were as described in Section 1.1.1.

Prior to the August 2013 sampling event, the most recent significant rainfall event occurred on August 20, 2013 at 0.31 inches. For analysis purposes, it can be assumed that antecedent moisture conditions were representative of the South Florida wet season, in which rainfall events generally occur more than once per week and do not allow significant "first flush" characteristics to build up within the watershed as compared to dry season events.

1.1.3 Quarter 3 Monitoring

From November 11 through 13, 2013, AMEC, under the City's direction, conducted stormwater sampling in major stormwater conveyances associated with selected City stormwater lakes and infrastructure. Sampling locations were similar to Quarter 1 locations, with the exception of the source tracking locations. Grab samples were collected from storm sewers, selected stormwater lakes, and pump stations. Sampling procedures were as described in Section 1.1.1.

There were no significant rain events for the month prior to the November 2013 sampling event. For analysis purposes, it can be assumed that antecedent conditions followed a span of dry conditions, representative of the onset of the local dry season.

1.1.4 Quarter 4 Monitoring

On February 5, 2014, AMEC collected water samples from the three pump stations located throughout the City. Additional samples requested by the City for the fourth quarter include an analysis of metals and petroleum hydrocarbons at the public works pump station and sampling of a lake located in the Parkshore Resort which has not been previously sampled by AMEC. Sampling procedures were as described in Section 1.1.1.

Prior to the February 2014 sampling event, 0.19 inches of rainfall occurred on January 31, 2014. For analysis purposes, it can be assumed that antecedent moisture conditions were representative of the South Florida dry season.

1.2 Current and Recent City Action

Over the past several years, the City has taken several approaches aimed at addressing some of the water quality issues affecting their stormwater. The City's Stormwater Division's annual report (Strakaluse, 2013) summarizes City actions to improve the City's stormwater infrastructure. Included here is a brief synopsis of some of the action items the City has implemented.

In 2012 the City adopted a Lake Management Plan for stormwater lakes. Components include prioritization of lakes for City actions. The highest priority (Tier 1) focuses on City-owned and maintained lakes to improve their health and ability to remove pollutants.

<u>Public Outreach</u>
A public outreach component was created that communicates with residents and businesses (but particularly those close to or adjacent to lakes) in an effort to educate and inform. Meetings were held with lake stakeholders at the following lakes: Swan Lake, Mandarin Lake, Lake Manor, Alligator Lake, Spring Lake, Half Moon Lake, Lake 16 (26th Ave N), Lake 12 (15th Ave S), and Devil's Lake. At every lake meeting the importance of the lake in terms of water quality removal efficiency is discussed. Also, recommendations are made as to what property owners can do to help improve the function of lakes such as reducing the amount of nutrients (fertilizers) and pollutants that runoff into the lakes. Other recommendations include shoreline plantings to help filter runoff prior to discharge into the lakes were made, and several property owners have taken the initiative to install their own lake bank plantings.

Stormwater staff worked with property owners at Swan Lake to collect a petition from a large majority of residents in exchange for the installation of an aeration unit and floating islands in the lake. Partnering with the lake owners who were treating algae with copper sulfate resulted in a significant reduction in copper concentrations in Swan Lake (see Section 3.5.1.1 for additional discussion).

<u>Exotic Vegetation Removal</u>
Exotic vegetation was removed from the perimeter of Lake Manor, Mandarin Lake, Fleischman Lake, Alligator Lake and the Filter Marsh on Riverside Circle. Removing exotic vegetation is important for several reasons. Invasives proliferate over native vegetation, and many exotic plants such as Brazilian pepper create excess leaf litter that increases the amount of debris that ends up in the lakes.

<u>Street Sweeping</u>
During the reporting period, the Department acquired a new street sweeper to replace a 6-year old sweeper. The Department swept 3,336 curb-miles of City streets and removed over 1,057 cubic yards of debris that includes sand, leaves, paper, plastic, and other wastes that do NOT make it to Naples Bay or the Gulf of Mexico. A street sweeping operation prevents these pollutants from adding to the levels of total suspended solids, nutrients, heavy metals and other trash in our waterways. The City's National Pollution Discharge Elimination (NPDES) MS4 Permit identifies street sweeping as a required management program to reduce stormwater pollution.

Aerators

Aerators are designed to promote increased circulation and oxygenation to the entire water column, allowing the natural processes responsible for nutrient and pollutant sequestration to occur more efficiently and to reduce the chance of the bottom sediments becoming anoxic, which generally results in nutrient solubilization and release. They can be an effective first step in the overall remediation of a stormwater treatment pond, and should be used concurrently with steps to reduce overall external loading to the system. To date, the City has installed aerators in 10 of its stormwater lakes, of which 1 was installed in the 2013 fiscal year (FY) in Swan Lake.

Floating Islands

Floating Islands are a low cost way of providing additional treatment capacity within an existing stormwater treatment body or restoring the condition of a eutrophied lake or pond. With regular maintenance (harvesting) and coverage of just 5% of the targeted waterbody, FDEP is currently crediting floating islands with 20% removal of total nitrogen and total phosphorus. The City currently has a total of 17 floating islands installed in 7 of its stormwater lakes. The first of these was installed in July 2009, and the program has been growing, with four installed in Swan Lake FY 2013.

Roadside Stormwater Swales

Roadside stormwater swales are an effective way of increasing filtration and infiltration of the stormwater runoff generated on roads and sidewalks, and typically do not require large amounts of space. From 2010 to present, the City has restored or installed approximately 3.9 miles of swales, with approximately 1.4 miles constructed between October 1, 2012 and September 30, 2013.

Several of these projects have been installed so recently that AMEC has not collected enough post-installation water quality data to evaluate their benefits.

2.0 Background Information

One of the primary reasons for performing a water quality evaluation for the City's stormwater is there are multiple downstream waterbodies that are currently impaired for various pollutants. These waterbodies and other contributing waters within the same watershed are delineated and tracked by a waterbody identification (WBID) number. Some of these WBIDs within the City of Naples have been redefined recently. In addition, AMEC has determined that some waterbodies assigned to a WBID by the FDEP are in fact contributing to different watershed. A discussion of these changes and discoveries follows.

WBID boundaries currently occurring within the City of Naples include the Gordon River Extension (WBID 3278K), Naples Bay Coastal (WBIDs 3278R4 & 3278R5), and Naples Estuary, locally known as Moorings Bay (WBID 3278Q2), shown in Figures 2-1, 2-2 and 2-3, respectively. In previous reports, some of these waterbodies had different WBIDs. For instance, the Naples Bay Coastal WBID 3278R has been retired. FDEP has divided that WBID into five smaller WBIDs: 3278R1, 3278R2, 3278R3, 3278R4, and 3278R5. Only 3278R4 and 3278R5 are now within the City's boundaries. Only 3278R1, which is not within in the City boundaries, is identified as impaired for fecal coliforms. Thus, there are now no waterbodies within the City of Naples that are impaired for fecal coliforms. Similarly, WBID 3278Q was retired and has been replaced by WBIDS 3278Q1 and 3278Q2. Throughout this report WBID 3278Q2 is referred to as Moorings Bay. Only WBID 3278Q2 is within the City's boundaries.

AMEC has also discovered a subset of ponds and lakes that do not discharge into their WBID boundaries as reported by FDEP. Figure 2-4 shows 2013 sample locations that discharge into the Gulf of Mexico not into Moorings Bay (WBID 3278Q2). Sample locations from this and previous years (BC, BC-Pond, BCG, Lakes 7, 8, 9, and 10) all discharge through Lake 10 to a beach outfall. Lake Manor that is shown to contribute to WBID 3278K (Gordon River Extension) actually discharges into Naples Bay Coastal (WBID 3278R5).

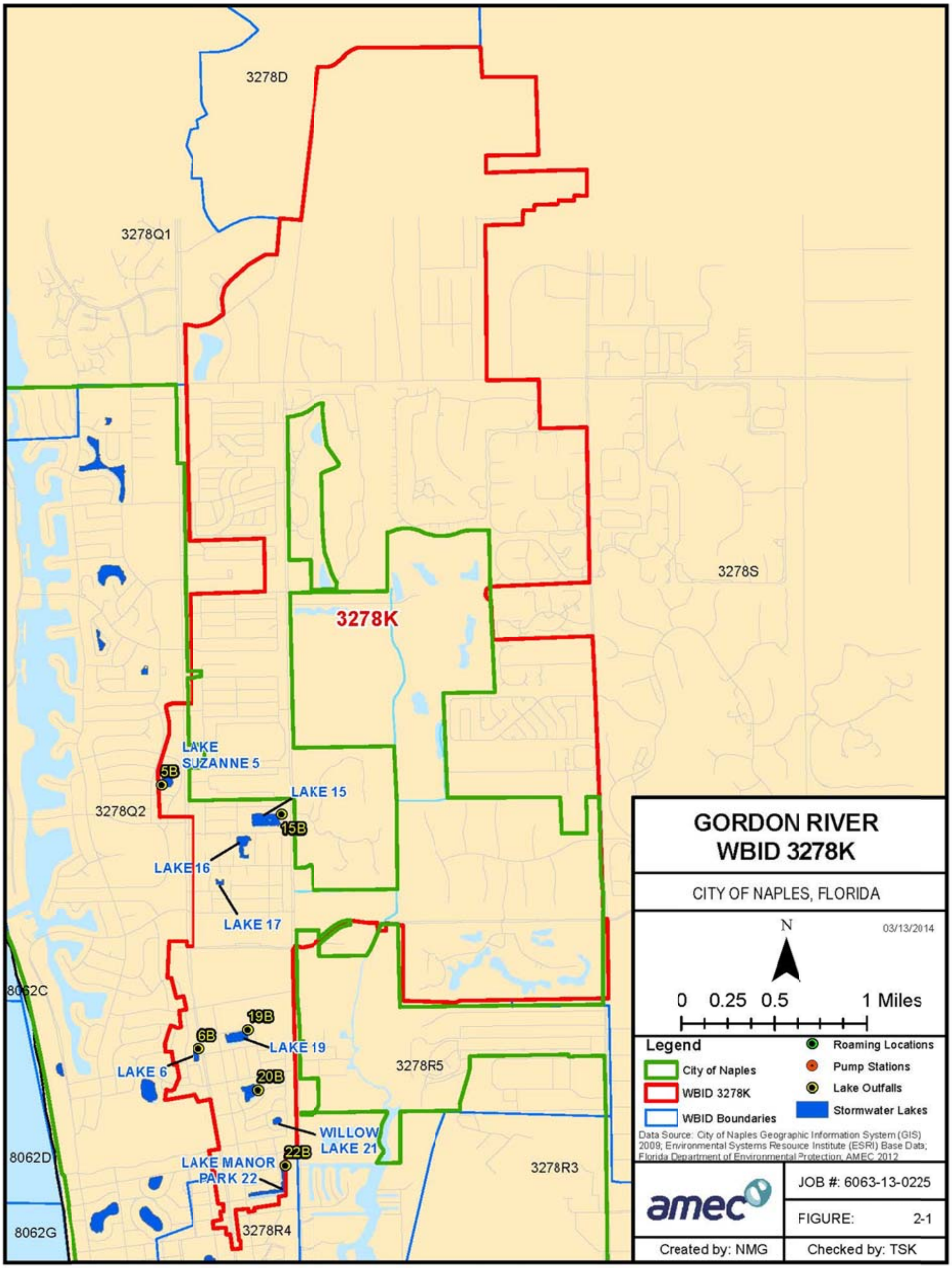
2.1 Impaired Waters

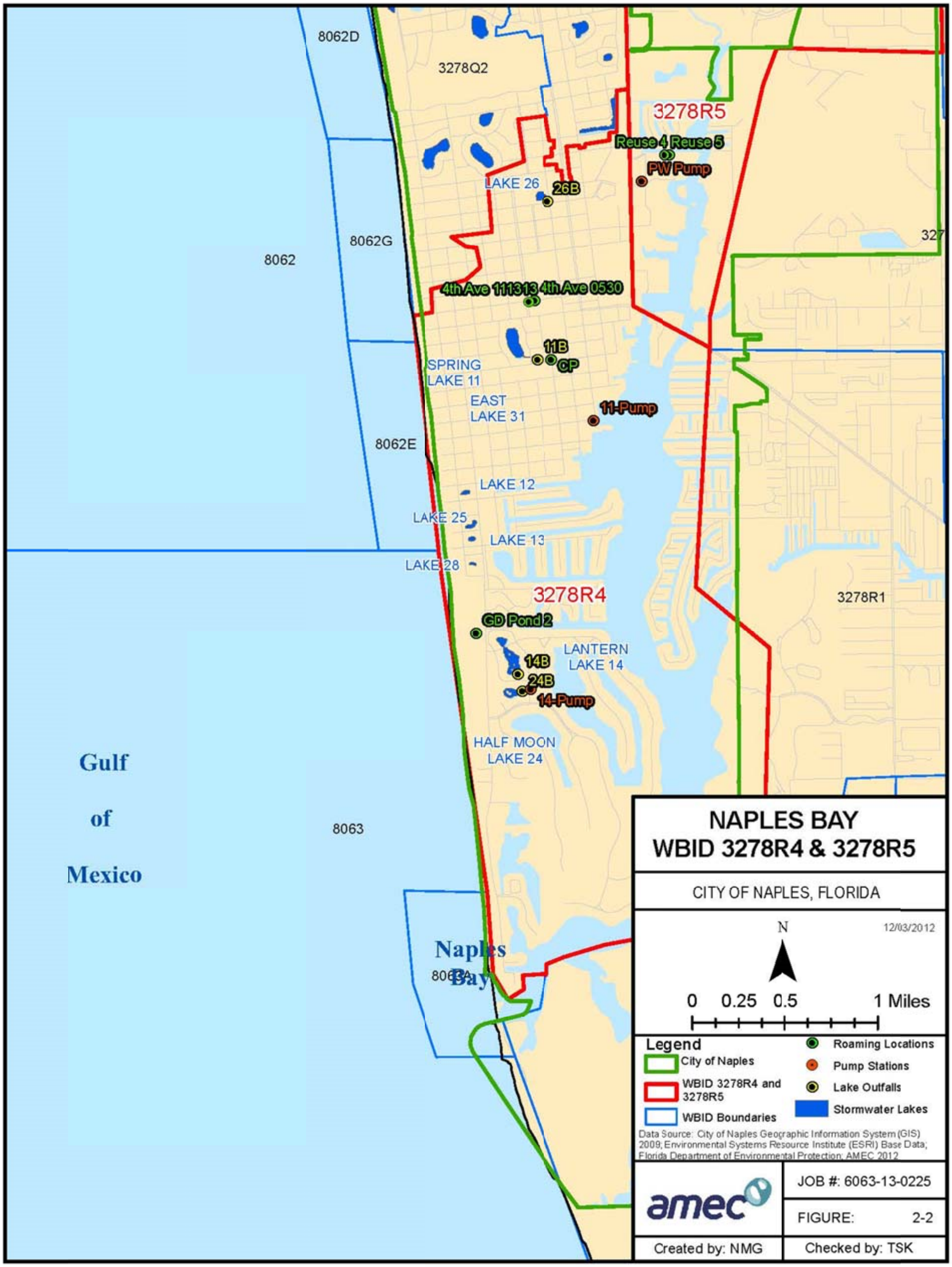
Waterbodies are impaired under the Clean Water Act if they fail to meet their water quality standards. The state is obligated to develop a plan to restore water quality in impaired waterbodies. Moorings Bay (WBID 3278Q2), the Gordon River Extension (WBID 3278K) and Naples Bay Coastal (WBIDs 3278R4 & 3278R5) are impaired according to the Everglades West Coast Group 1 Basin/ South District verified list published by FDEP (2014a).

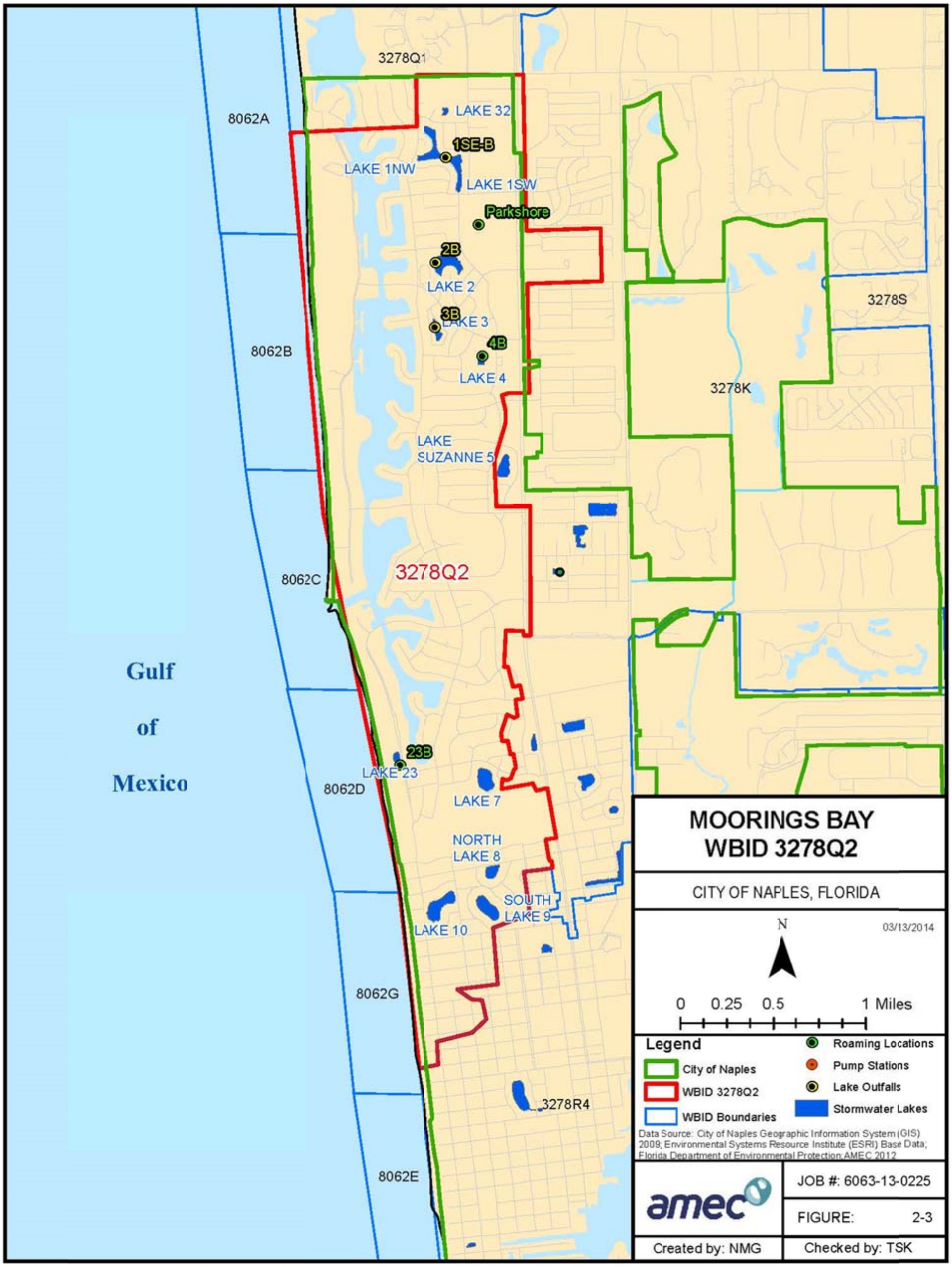
The current status for impairment of waterbodies within the City of Naples is as follows. Moorings Bay (WBID 3278Q2) is impaired for mercury. The concentration causing the impairment for mercury is Hg > 0.3 milligrams per kilograms (mg/Kg). A statewide mercury TMDL has been developed, but not yet adopted, and will be used as guidance to reduce mercury loads throughout the state.

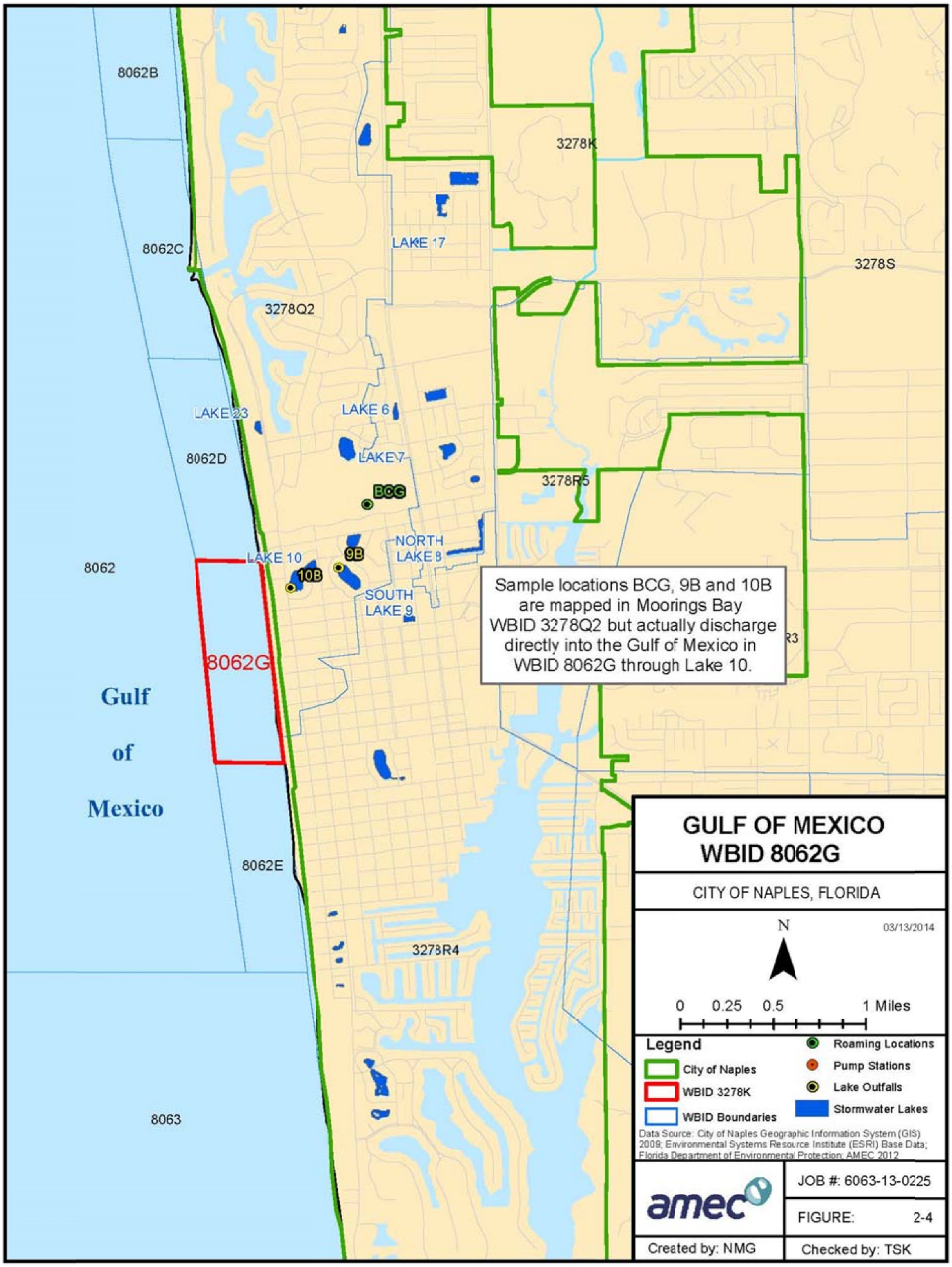
Naples Bay WBID 3278R4 is impaired for copper, iron, and mercury. The concentration causing impairment for copper is > 3.7 micrograms per liter (µg/L), iron is > 0.3 milligrams per liter (mg/L), and mercury is Hg > 0.3 mg/Kg.

Naples Bay WBID 3278R5 is impaired for copper, iron, DO, and mercury. The concentration causing impairment for copper is > 3.7 µg/L, iron is > 0.3 mg/L, and mercury is Hg > 0.3 mg/Kg. Although this portion of Naples Bay is identified as impaired for DO (DO is < 4.0 mg/L), the causative agent for the impairment cannot be identified; it is thus placed in Category 4d. In a DEP Responsiveness Summary Concerning Public Comments on Chapters 62-302 and 62-303, F.A.C., the District stated: "the Department concluded that the anthropogenic issues in Naples Bay involve physical alteration (dredge and fill) and inappropriate freshwater delivery, not nutrients. In fact, the nutrients and


3278D
3278Q1
3278S
3278K
LAKE SUZANNE 5
5B
LAKE 15
15B
3278Q2
LAKE 16
LAKE 17
8062C
19B
6B
LAKE 19
LAKE 6
20B
3278R5
WILLOW LAKE 21
22B
LAKE MANOR PARK 22
8062D
3278R3
8062G
3278R4
GORDON RIVER
WBID 3278K
CITY OF NAPLES, FLORIDA
N
03/13/2014
0 0.25 0.5 1 Miles
Legend
City of Naples
WBID 3278K
WBID Boundaries
Roaming Locations
Pump Stations
Lake Outfalls
Stormwater Lakes
Data Source: City of Naples Geographic Information System (GIS) 2009; Environmental Systems Resource Institute (ESRI) Base Data; Florida Department of Environmental Protection; AMEC 2012
JOB #: 6063-13-0225
FIGURE: 2-1
Created by: NMG
Checked by: TSK


NAPLES BAY
WBID 3278R4 & 3278R5
CITY OF NAPLES, FLORIDA
12/03/2012
N
0 0.25 0.5 1 Miles
Legend
City of Naples
WBID 3278R4 and 3278R5
WBID Boundaries
Roaming Locations
Pump Stations
Lake Outfalls
Stormwater Lakes
Data Source: City of Naples Geographic Information System (GIS) 2009; Environmental Systems Resource Institute (ESRI) Base Data; Florida Department of Environmental Protection; AMEC 2012
JOB #: 6063-13-0225
FIGURE: 2-2
Created by: NMG
Checked by: TSK
Gulf
of
Mexico
Naples Bay
8062D
3278Q2
3278R5
Reuse 4
Reuse 5
PW Pump
LAKE 26
26B
8062G
8062
4th Ave 111313
4th Ave 0530
11B
CP
SPRING LAKE 11
EAST LAKE 31
11-Pump
8062E
LAKE 12
LAKE 25
LAKE 13
LAKE 28
3278R4
3278R1
GD Pond 2
LANTERN LAKE 14
14B
24B
14-Pump
HALF MOON LAKE 24
8063


MOORINGS BAY
WBID 3278Q2
CITY OF NAPLES, FLORIDA
03/13/2014
N
0 0.25 0.5 1 Miles
Legend
City of Naples
WBID 3278Q2
WBID Boundaries
Roaming Locations
Pump Stations
Lake Outfalls
Stormwater Lakes
Data Source: City of Naples Geographic Information System (GIS) 2009; Environmental Systems Resource Institute (ESRI) Base Data; Florida Department of Environmental Protection; AMEC 2012
JOB #: 6063-13-0225
FIGURE: 2-3
Created by: NMG
Checked by: TSK
Gulf
of
Mexico
3278Q1
3278Q2
3278S
3278K
3278R4
8062A
8062B
8062C
8062D
8062G
8062E
LAKE 32
1SE-B
LAKE 1NW
LAKE 1SW
Parkshore
2B
LAKE 2
3B
LAKE 3
4B
LAKE 4
LAKE SUZANNE 5
23B
LAKE 23
LAKE 7
NORTH LAKE 8
SOUTH LAKE 9
LAKE 10


8062B
8062C
8062D
8062
8062G
8062E
8063
Gulf
of
Mexico
3278K
3278S
3278Q2
3278R5
3278R4
LAKE 17
LAKE 23
LAKE 6
LAKE 7
BCG
9B
10B
LAKE 10
NORTH LAKE 8
SOUTH LAKE 9
Sample locations BCG, 9B and 10B are mapped in Moorings Bay WBID 3278Q2 but actually discharge directly into the Gulf of Mexico in WBID 8062G through Lake 10.
GULF OF MEXICO
WBID 8062G
CITY OF NAPLES, FLORIDA
N
03/13/2014
0 0.25 0.5 1 Miles
Legend
City of Naples
WBID 3278K
WBID Boundaries
Roaming Locations
Pump Stations
Lake Outfalls
Stormwater Lakes
Data Source: City of Naples Geographic Information System (GIS) 2009; Environmental Systems Resource Institute (ESRI) Base Data; Florida Department of Environmental Protection; AMEC 2012
JOB #: 6063-13-0225
FIGURE: 2-4
Created by: NMG
Checked by: TSK

chlorophyll in Naples Bay are lower than many other minimally disturbed estuary segments to the south." Thus, Waterbodies placed into Category 4d, such as WBID 3278R5, will then be targeted for monitoring for the impairment before the next cycle of assessments.

The Gordon River Extension (WBID 3278K) is impaired for DO (DO is < 5.0 mg/L). A final TMDL has been proposed for DO for the Gordon River Extension but is as of yet not adopted. The TMDL identified TN as the causative pollutant for the low DO; a median TN concentration of 0.755 mg/L was calculated during the verified period. The target concentration for TN for the Gordon River is 0.74 mg/L and is believed to be the concentration at which DO for the river will meet Class III freshwater guidelines. For the remaining WBID parameters, all were identified as Medium Priority for Total Maximum Daily Load (TMDL) Development (EWC, 2009).

Finally, none of these water body WBIDs were found to be impaired for nutrients. However, as required by Chapter 2013-71, Law of Florida, as Part of the "Path Forward" Agreement with EPA, the state is required to establish Numeric Nutrient Criteria (NNC) for all estuaries by December 1, 2014. Further, it states "the current conditions of unimpaired waters will be the nutrient standards until NNC are adopted." In other words, until a NNC for estuaries is established, the current TN, TP, and chlorophyll a concentrations in unimpaired City of Naples estuaries will be considered acceptable concentrations.

2.2 Caffeine Sampled as Indicator of Human Wastes

In 2012, AMEC and the City began analyzing selected samples for caffeine, which was selected as an indicator of anthropogenically derived bacterial sources. Caffeine sampling has continued in the 2013 monitoring events. Caffeine is relatively ubiquitous in human waste streams and is often found in concentrations that can be easily detected given current analytical methods, thus it can be used in source tracking efforts where anthropogenic bacterial contamination is suspected. Caffeine concentrations that have been observed in sanitary effluents, stormwater, and surface waters are summarized in Table 2-1. Although concentrations range widely, most observations of sanitary effluent exceed 1,000 nanograms per liter (ng/L), while effective treatment systems in the US (Oppenheimer, *et al.*, 2011) generally reduce average caffeine levels in treated sanitary effluents to 127 ng/L; surface water bodies with little or no anthropogenic input are likely to have concentrations less than 50 ng/L. Stormwater was characterized by Sankararamakrishnan and Guo (2005) who found very high concentrations in one stormwater sample from Asbury Park, NJ, a location with a very old sanitary sewer system, but more typical values observed were from 200 to 500 ng/L.

Table 2-1. Summary of Caffeine Concentrations Observed in Surface Waters and Effluents

Reference	Sample Type	Caffeine (ng/L)
Buerge, *et al.* (2003)	Untreated effluent	7,000-73,000
	Treated effluent	30-9,300
	Lakes and rivers	60-250
	Mountain lakes	< 2
Glassmeyer, *et al.* (2005)	rivers	40-2,600
	Treated effluent	53-7,990
Sankararamakrishnan and Guo (2005)	Stormwater	144-44,700
Oppenheimer, *et. al.* (2011)	Treated effluent	127
	Surface water affected by effluent	64
	Surface water no effluent	ND
Kolpin, *et a*l. (2002)	Streams	81-6,000

Created By: WAT Checked By: SCA
ND – Not Detected

3.0 Monitoring Results

Included in this section is a discussion of sampling locations and results. Locations were determined based on previously identified data gaps, as well as areas that, based on past data, may represent potentially elevated pollutant sources. Although the majority of samples taken represent non-storm related base flow conditions, the results of these sampling efforts provide useful information that allow for the characterization of long-term water quality and stormwater lake condition. Ultimately, the results will be used to identify those areas that will benefit most from targeted structural and non-structural BMPs.

3.1 Pump Station Monitoring Results

As a quarterly effort, each of the City's three main pump stations (PW-Pump, 11-Pump, and 14-Pump) have been sampled for TN, TP, total suspended solids (TSS), copper, fecal coliform, and enterococcus. These stations have been sampled regularly because they represent significant dry and wet weather nutrient loading to downstream impaired waters. Caffeine has been used selectively at these locations where source identification is desired. Table 3-1 shows the results from the current year monitoring efforts at each of the three pump stations.

AMEC was asked by the City to perform additional metals and hydrocarbon sampling at the PW-Pump during 2013 to support evaluation of diversion of a portion of the flow from PW-Pump to the City's Aquifer Storage and Recovery (ASR) system. Table 3-2 shows the results of the additional metals and hydrocarbon sampling conducted at PW-Pump. None of the metals exceed either Primary or Secondary Drinking Water Standards, and Total Recoverable Petroleum Hydrocarbons (TRPH) were not detected.

Sample locations are given in Figures 2-2. PW-Pump is also commonly referred to as the Public Works Pump, 11-Pump as Cove Pump, and 14-Pump as Lantern Lane Pump.

Table 3-1. 2013 Quarterly Pump Station Monitoring

Sample ID		**TKN**	**NOx**	**TN**	**TP**	**TSS**	**Cu**	**FC**	**Ent.**	**Caff.***
Units		**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(µg/L)**	**(cfu/100 mL)**	**(MPN)**	**(ng/L)**
PW-Pump	Q1	0.92	0.25	1.17	0.081	1.3	6.3	18	594	
	Q2	0.88	0.20	1.08	0.173	1.8	14.6	470	140	
	Q3	0.82	0.35	1.17	0.088	1.0 U	3.9	5400	49	
	Q4	0.84	0.298	1.14	0.091	1.2	6.9	5200	437	
11-Pump	Q1	1.03	0.275	1.31	0.12	2.5	1.4	61	472	
	Q2	1.01	0.247	1.26	0.154	1.1	1.7	210	60	
	Q3	1.12	0.424	1.54	0.115	1.0 U	2.2	115	961	
	Q4	1.35	0.457	1.81	0.141	1.2	1.0 IV	450 B	501	50 U
14-Pump	Q1	0.74	0.046	0.79	0.149	26.3	3.2 I	2000	1400	
	Q2	1.11	0.106	1.22	0.205	8.6	2.5	800 B	3400	
	Q3	1.37	0.134	1.50	0.26	8.6	3.9 I	16 B	961	
	Q4	1.67	0.291	1.96	0.681	3.1	3.0	360 B	550	

U - Indicates that the compound was analyzed for but not detected
B - Results based upon colony counts outside the acceptable range
I - Indicates the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
V- Indicates that the analyte was detected in both the sample and the associated method blank
* Caffeine not analyzed in all samples

Created By: TSK
Checked By: WAT

Table 3-2. 2013 Metals and Hydrocarbon Results for PW-Pump

Sample ID	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	TRPH
Units	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)
PW-Pump	3.2	15.5	0.1 U	5.0	0.12 U	0.02 U	1.1 U	0.06 U	0.125 U

TRPH – Total Recoverable Petroleum Hydrocarbons by method FL-PRO

Created By: TSK
Checked By: WAT

3.2 Biannual Sampling Locations

A significant portion of the 2013 monitoring efforts include continued monitoring of 18 stormwater lakes. Locations were identified by AMEC and the City based on the findings of AMEC (2013) addressing areas with relatively high pollutant loading, poorly functioning stormwater lakes, and/or data gaps. Results from these locations will be used to substantiate future structural and non-structural BMPs targeted at treatment of stormwater lake quality. Table 3-3 shows the results from the current year efforts of each monitored lake, while Figures 2-1 through 2-4 show sample locations by major drainage basin. A photo log of 2013 sample locations is also given in Appendix C.

Table 3-3. 2013 Biannual Lakes Condition Assessment

Sample ID		TKN	NOx	TN	TP	TSS	Cu	FC	Ent.	Caf.*
Units		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(cfu/100 mL)	(MPN)	(ng/L)
2B	Q1	0.98	0.002 U	0.98	0.0805	7.5	7.0	3900	400	
	Q3	0.85	0.021	0.87	0.144	4.4	4.2	132	17	
3B	Q1	1.04	0.006 I	1.05	0.135	4.8	10.3	3300	156	
	Q3	1.04	0.08	1.12	0.122	1.7	3.5	250	33	
5B	Q1	1.08	0.057	1.14	0.147	4.8	35.0	188 B	600	
	Q3	1.10	0.075	1.18	0.127	5.6	6.1	44	71	
6B	Q1	0.97	0.002 U	0.97	0.258	18.1	0.5 I	96 B	331	
	Q3	0.70	0.026	0.73	0.0275	4.2	0.7 I	133	30	
9B	Q1	3.78	0.002 U	3.78	0.416	34	54.6	400	208	
	Q3	1.22	0.002 U	1.22	0.0825	3.6	164	13 B	4	
10B	Q1	1.83	0.004 I	1.83	0.111	79.4	3.9	23	1 U	
	Q3	1.64	0.002 U	1.64	0.0929	11.4	1.2 I	128	81	
11B	Q1	0.84	0.002 U	0.84	0.0954	10.4	5.0	645	649	
	Q3	0.62	0.045	0.67	0.0853	1.6	10.6	132	40	
14B	Q1	1.56	0.002 I	1.56	0.540	28	5.0	178 B	1120	
	Q3	1.16	0.002 I	1.16	0.213	23.2	2.7	430	164	
15B	Q1	0.99	0.002 U	0.99	0.0256	7.3	8.6	2000	85	
	Q3	0.97	0.319	1.29	0.0652	1.3	27.7	46	8	
19B	Q1	1.21	0.002 U	1.21	0.0517	10.7	0.5 I	92 B	298	
	Q3	1.24	0.043	1.28	0.141	15.2	0.5 I	3 B	6	
20B	Q1	1.23	0.002 U	1.23	0.0625	69.7	1.5	72 B	57	
	Q3	4.06	0.058	4.12	0.398	8.0	0.5 I	28	1	
22B	Q1	0.65	0.002 U	0.65	0.0550	3.9	0.7 I	128 B	132	
	Q3	0.72	0.097	0.82	0.118	1.3	0.8 I	54	35	20 U
24B	Q1	3.33	0.002 U	3.33	0.621	82	14.9	520	980	
	Q3	2.29	0.061	2.35	1.42	30	17.5	76	132	
26B	Q1	0.87	0.002 U	0.87	0.0620	8.2	55.4	290	1 U	
	Q3	0.56	0.003 I	0.56	0.0326	6.8	76.7	42	35	

U - Indicates that the compound was analyzed for but not detected
B - Results based upon colony counts outside the acceptable range
I - Indicates the reported value is between the laboratory method of detection limit and the laboratory practical quantitation limit
* Caffeine not analyzed in all samples.

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3.3 Roaming Sampling Locations

Roaming samples, also referred to as source identification samples, are intended to identify possible sources in areas where past sampling have indicated relatively high concentrations of one or more stormwater contaminants of interest. During this year's stormwater characterization program, caffeine has been added as an indicator of the significance of human waste, such as leaking sewers or septic systems. Table 3-4 shows the results from current year monitoring efforts at each of the selected roaming locations, while Figures 2-1 through 2-4 show sample locations by major drainage basin. A photo log of 2013 sample locations is also given in Appendix C.

Table 3-4. 2013 Roaming Location Samples

Sample ID		**TKN**	**NOx**	**TN**	**TP**	**TSS**	**Cu**	**FC**	**Ent.**	**Caf.***
Units		**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(µg/L)**	**(cfu/100mL)**	**(MPN)**	**(ng/L)**
CP	Q1	1.42	0.009 I	1.43	0.102	1.0 U	0.9 I	3200	1730	86
GDPOND2	Q1	0.65	0.002 U	0.65	0.0348	12.6	4.2	300	150	
BCG	Q3	2.60	0.002 U	2.60	0.301	11.5	13.3	105	16	
23B	Q3	0.92	0.003 I	0.92	0.102	5.4	3 I	48	65	
4B	Q3	0.78	0.147	0.93	0.117	1.9	3.8	74	1	23
1SE-B	Q1	1.03	0.012	1.04	0.0690	13.0	45.6	1000 B	80	
	Q3	0.87	0.311	1.18	0.085 I	1.6	11.4	40	14	
4th Ave.	Q1	4.18	0.002 U	4.18	0.494	4.6	14.9	8500 B	11600	100000
	Q3	2.90	0.010 I	2.91	0.477	3.4	4.2	1820 B	72	8500

U or ND - Indicates that the compound was analyzed for but not detected
B - Results based upon colony counts outside the acceptable range
I or J - Indicates the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
V - Chemical detected in laboratory blank indicating potential contamination in the laboratory. The levels observed in the blank were much lower than found in environmental samples.
* Caffeine not analyzed in all samples.

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3.4 Reclaimed Water

As part of the 2013 sampling program, two samples were allocated to the City reclaimed water distribution system. Due to the increasing use of reclaimed water for residential and commercial irrigation, the City has become interested in managing the resource effectively and responsibly. AMEC collected two samples from the reclaimed water distribution system, both during the Q1 sampling event. Reuse 4, collected at the water treatment plant prior to mixing with Golden Gate, is plant effluent that has been nitrogen treated and phosphorus treated but has not been filtered or disinfected. Reuse 5 was collected at the water treatment plant after mixing with Golden Gate water and after being filtered and disinfected. Table 3-5 shows the results from the reclaimed water sample locations. A photo log of 2013 sample locations is also given in Appendix C.

Table 3-5. 2013 Reclaimed Water Sample Results

Sample ID		**TKN**	**NOx**	**TN**	**TP**	**TSS**	**Cu**	**FC**	**Ent.**	**Caff.***
Units		**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(µg/L)**	**(cfu/100mL)**	**(MPN)**	**(ng/L)**
Reuse 4	Q1	1.00	1.41	2.41	0.666	1.9	2.3	52	6	
Reuse 5	Q1	0.85	0.999	1.85	0.464	1.0 U	1.7			

U - Indicates that the compound was analyzed for but not detected
ND - Not detected at the reporting limit (or MDL if shown)
I - Indicates the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
* Caffeine not analyzed in any samples.

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3.5 Summary of Available Data

One goal of the current year's contract was to fill in any data gaps identified in past reports for the purpose of developing a comprehensive database of City water quality data. AMEC compiled all available data, which include sampling efforts conducted by the City in 2008 and 2009, sampling efforts conducted by MACTEC in 2009, and sampling efforts conducted by MACTEC/AMEC in 2010 and 2011. Table 3-6 is a summary of said data, organized by major drainage basin. Each value represents the mean of all available data (or geometric mean for fecal coliform and *Enterococcus*), with the number of samples (n) each mean is based on and a description of the type of sample location. Sample locations are provided in Figures 2-1 through 2-4, which correspond to the major drainage basin groupings given in the table. Sample locations provided in Figures 2-1 through 2-4 are also inclusive of sample locations discussed in Sections 3.1 through 3.4. During this program samples of stormwater conveyances discharging to City lakes have been assigned an ID using the lake number followed by "A". Samples from City lakes near the lake outfall are identified by the lake number followed by "B". "Lake-effluent" or "B" samples are indicative of lake water quality, while "A" samples indicate stormwater qualiy flowing into the lake. When describing lake water quality, only "B" samples are evaluated.

Table 3-6. Means of Water Quality Data: 2008 - 2011 (page 1 of 2)

Sample ID				**TN[1]**	**TP**	**Cu**	**FC**	**Ent.**	**Caff.[2]**
Basin	**Sample ID**	**Type**	**(n)**	**mg/L**	**mg/L**	**µg/L**	**cfu/100mL**	**MPN**	**ng/L**
Gordon River	22A3	Conveyance	1	0.76	0.12	1.0	2450	162	**
	US41	Conveyance	4	1.7	0.33	3.8	727	858	
	15A	Lake - Influent	4	1.3	0.071	8.7	327	665	
	20A	Lake - Influent	4	1.5	0.13	4.2	366	298	
	22A	Lake - Influent	5	0.98	0.078	4.2	1801	300	
	6B	Lake - Effluent	5	1.0	0.099	3.3	491	33	
	15B	Lake - Effluent	9	1.0	0.028	15.4	240	41	
	16B	Lake - Effluent	3	1.0	0.024	0.89	561	20	
	17B	Lake - Effluent	1	1.3	0.090	0.30	520	50	
	19B	Lake - Effluent	7	1.2	0.059	1.01	161	126	
	20B	Lake - Effluent	9	1.9	0.116	0.77	284	95	
	21B	Lake - Effluent	3	1.1	0.019	3.4	481	14	
	22B	Lake - Effluent	11	0.71	0.070	1.6	355	123	20 U
Naples Bay	11A1	Conveyance	1	1.2	0.23	2.3	2000	1990	
	11A2	Conveyance	1	0.90	0.084	2.2	33	461	
	11A3	Conveyance	1	4.5	0.50	25	3600	7330	
	11A4	Conveyance	1	1.0	0.046	2.6	5200	378	
	11B1	Conveyance	1	1.1	0.15	2.3	1190	534	
	11B2	Conveyance	1	8.0	0.94	16	4700	11800	
	11B3	Conveyance	1	4.3	0.47	22	4200	6110	
	11B4	Conveyance	1	0.65	0.13	6.9	60	10	
	11D	Conveyance	4	1.5	0.17	1.4	944	1517	
	14A1	Conveyance	1	3.1	0.71	1.2	2900	2420	
	14A2	Conveyance	1	3.1	0.62	2.0	134	100	
	14A3	Conveyance	1	1.1	0.39	14	1530	4710	
	14A4	Conveyance	1	1.6	0.79	0.38	15200	158	
	14B2	Conveyance	1	2.6	0.98	2.7	1320	2990	
	14B3	Conveyance	1	1.4	0.16	8.7	2000	4820	
	14B4	Conveyance	1	1.8	0.28	0.38	2500	980	
	4th Ave 3	Conveyance	1	1.2	0.16	3.2	508	107	**

Table 3-6. Means of Water Quality Data: 2008 - 2011 (page 2 of 2)

Sample ID				**TN[1]**	**TP**	**Cu**	**FC**	**Ent.**	**Caff.[2]**
Basin	**Sample ID**	**Type**	**(n)**	**mg/L**	**mg/L**	**µg/L**	**cfu/100mL**	**MPN**	**ng/L**
Naples Bay (cont.)	4th Ave. Alley	Conveyance	1	1.1	0.18	6.2	2160	100	550
	4th Ave. Garage	Conveyance	1	0.31	0.057	2.9	100	6	
	4th Ave. 0530	Conveyance	1	4.18	0.494	14.9	8500	11600	100000
	4th Ave. 111313	Conveyance	1	2.91	0.477	4.2	1820	72	8500
	CP	Conveyance	2	1.6	0.121	1.3	2713	2046	**86
	GD	Conveyance	1	3.2	0.56	11.0	43000	500	120
	GDPond2	Private Lake	1	0.65	0.035	4.2 I	300	150	
	PW2	Conveyance	1	2.0	0.058	3.9	5800	3830	
	PW3	Conveyance	1	0.80	0.068	12	2300	1480	
	PW4	Conveyance	1	0.79	0.10	5.6	1200	78	
	11A	Lake - Influent	1	1.9	0.11	3.9	1080	185	440
	11B	Lake - Effluent	13	1.1	0.077	5.2	344	357	
	12B	Lake - Effluent	1	1.7	0.025	0.3	490	50	
	13B	Lake - Effluent	1	1.7	0.056	8.4	3600	130	
	14B	Lake - Effluent	5	1.5	0.459	2.7	86	196	13 U
	24B	Lake - Effluent	4	2.9	0.995	9.6	883	128	
	25B	Lake - Effluent	1	1.8	0.069	5.6	2300	13	
	26B	Lake - Effluent	5	0.76	0.244	53.8	238	13	
	28B	Lake - Effluent	1	1.8	0.13	5.4	5300	110	
	GD3	Private Lake	1	0.46	0.020	3.5	84	28	16
	11-Pump	Pump Station	12	1.6	0.18	1.8	1188	519	273
	14-Pump	Pump Station	9	1.3	0.37	7.9	535	1545	32
	PW-Pump	Pump Station	9	1.2	0.11	10	1185	521	14
Moorings Bay	1A3	Conveyance	1	0.71	0.13	3.3	673	152	
	1A	Lake - Influent	1	1.1	0.10	9.6	180	96	
	2A	Lake - Influent	4	1.2	0.11	25	414	455	
	5A	Lake - Influent	4	1.1	0.18	6.7	97	52	
	1NW-B	Lake - Effluent	2	0.98	0.026	6.7	120	8	
	1SE-B	Lake - Effluent	4	1.0	0.069	21	174	22	
	2B	Lake - Effluent	9	0.9	0.077	13	363	219	
	3B	Lake - Effluent	5	1.1	0.125	5.0	633	37	
	4B	Lake - Effluent	2	0.94	0.093	3.0	39	3	23
	5B	Lake - Effluent	9	1.6	0.153	10.3	163	47	
	23B	Lake - Effluent	2	0.80	0.062	3.4	116	39	
	Parkshore	Private Lake	1	0.64	0.037	7.2	280	112000	ND
Gulf of Mexico	**BC**	Conveyance	4	3.1	0.26	5.2	791	105	
	BC-Pond	Private Lake	1	2.5	0.27	6.5	100	961	
	BCG	Private Lake	1	2.6	0.301	13.3	105	16	
	8A	Lake - Influent	4	1.3	0.16	1.5	784	144	
	7B	Lake - Effluent	2	2.7	0.13	13	39	56	
	8B	Lake - Effluent	5	1.3	0.112	2.4	132	154	
	9B	Lake - Effluent	5	1.9	0.183	47.6	91	42	
	10B	Lake - Effluent	9	1.2	0.065	2.4	75	101	

Bold = Direct Discharge
[1]Calculated as the sum of NOx and TKN
[2](n) = 3 for 11-Pump Caffeine, (n) = 1 for all other caffeine results
** At least one caffeine analysis was not usable due to unusually high detection limit.
Caffeine was not analyzed in all samples.

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3.5.1 Notable Observations and Trends in Lake Effluent and Pump Station Quality

This section summarizes notable observations from the 2013-4 monitoring results and evaluates trends in lake discharge and pump station stormwater quality. Trend analysis focused on lakes considering three criteria:

- Lakes that discharge to waters of the state
- Lakes that have been monitored repeatedly since 2009
- Lakes where the City has implemented BMPs intended to improve stormwater quality.

Trends were also examined in three pump stations because they discharge significant volumes of stormwater to Naples Bay, and each has at least 9 monitoring events over three years.

3.5.1.1 Lake Effluents

The number of samples analyzed and the limited duration of the City's lake monitoring program limits the ability to detect statistically significant or environmentally meaningful trends in water quality. Copper (Cu) levels in several lakes fluctuate to such an extent that the maximum concentrations, presumably resulting from application of copper as an algaecide, exceed the minimum concentrations by more than a factor of 50. With this magnitude of variation, it is difficult to identify trends with the relatively limited data sets – Lakes Lantern and Manor, with 25 and 12 samples, respectively, have been sampled more frequently than other City lakes, yet it is difficult to identify significant trends even in these relatively well studied lakes. The exception has been Lake Lantern TN trends. A statistically significant trend toward decreasing TN in the lake has been shown since BMPs have been implemented.

Devil's Lake (1SE) has been sampled 4 times, in August 2009, September 2012, and twice in 2013. Copper was quite high at 45.6 µg/L in May 2013, but otherwise water quality is consistent with past data and other City lakes. Note the state of Florida water quality standard for copper is 3.7 µg/L.

City Streets and Stormwater Division staff reached out to residents near Swan Lake (2) in 2012 regarding application of copper algaecides to Swan Lake following monitoring results in March 2011 with copper at 63 µg/L. Residents agreed to reduce or eliminate applications of copper algaecides. Monitoring data show that copper concentrations averaged 9.1 µg/L in 2012 and 5.6 µg/L in 2013, less than the 2011 average of 26.7 µg/L indicating the Swan Lake residents responded effectively to the City's outreach effort. Swan Lake nutrient concentrations in 2013 were consistent with past values observed in this lake.

Hidden Lake (4) was sampled in November 2013, and had not been sampled since 2009. Results in 2013 were consistent with the 2009 observations.

Lake Suzanne (5) has been sampled 9 times since 2009, and the 2013 results were consistent with past data with the exception of copper in May 2013, at 35 µg/L, more than 3 times the highest concentration observed in the other 8 sampling events.

Mandarin Lake (6) exhibited a relatively high copper concentration of 14 µg/L back in 2009, but copper has remained much lower, less than 1 µg/L, in 4 samples collected in 2012 and 2013. Otherwise water quality in Mandarin Lake has remained consistent, with no apparent trend.

South Lake (9) reported the highest copper concentration observed in 138 lake samples collected in all 28 City lakes monitored since 2009, at 164 µg/L in November 2013, and was also relatively high at 54.6 µg/L in May 2013. The November 2013 copper concentration was more than 50 times higher than observed in September 2012.

Alligator Lake (10) with 9 samples taken since 2009, exhibits a statistically significant trend of increasing concentrations in both TP and TN. The highest concentrations of both TP and TN at Alligator Lake were observed in May 2013 and remained elevated in November. Copper levels remained relatively low in Alligator Lake in 2013, averaging less than 3 µg/L.

Water quality has remained relatively steady in Spring Lake since 2008.

The City installed three floating islands and four aerators in Lantern Lake (14) in 2012 (floating islands in March and aerators in September). City staff monitored Lantern Lake water quality monthly in 2012 and 2013 (except February through April 2013). These data were supplemented by the biannual monitoring conducted by AMEC in 2012 and 2013 and a single sample collected in 2009. These efforts have yielded 25 water quality samples for Lantern Lake, the most intensively monitored City lake. These data indicate a statistically significant trend (90% confidence) of decreasing TN in Lantern Lake. The concentration of TN in Lantern Lake has been reduced from an initial concentration of approximately 2 mg/L in 2009 to approximately 1 mg/L by the end of 2013. The reduction in TN also appears to be related to the City's actions: TN average 2.1 ± 0.1 mg/L prior to implementation of the City's BMPs in March 2012, and 1.2 ± 0.1 mg/L after all the floating islands and aerators had been installed in September 2012.

Sun Lake Terrace (15) has relatively good water quality for nutrients TN and TP, and the recent data are consistent with prior sampling. Sun Lake Terrace exhibits relatively high copper levels. Of nine samples collected since 2009, all have exceeded the state of Florida water quality standard of 3.7 µg/L. In November 2013 copper was recorded at 27.7 µg/L.

Lake 19 (WTP Lake) has generally good water quality, with no apparent trend. Forest Lake (20) generally has good water quality, however the November 2013 sample had very high levels of nutrients TP and TN.

No trend is apparent in water quality of Lake Manor. With a data set of 11 samples from February 2008 to November 2013, its average TP is 0.070 ± 0.012 mg/L, TN = 0.71 ± 0.04 mg/L, and its copper concentration has never exceeded 3.7 µg/L.

Half Moon Lake (24) exhibits very high levels of nutrients, with the highest average TP and TN concentrations of any City lake. Its copper concentration was more than 5 times greater in 2013 than in 2012, with 17.5 µg/L in November 2013.

The NCH Lake (26) has exhibited the highest average copper concentration of any City lake at 54 µg/L, and the highest copper concentration observed at NCH Lake was recorded in November 2013 at 76.7 µg/L.

3.5.1.2 Pump Station Stormwater Quality

Copper (Cu) concentrations appear to be trending downward at a rate of approximately 4 percent per year (%/yr); however the apparent trends are not statistically significant. Considering the variability in the data and the slow rate of improvement, establishment of conclusive trends would probably require several additional years of steady improvement.

Total Nitrogen (TN) concentrations at Cove and Lantern Lane pump stations (11-Pump and 14-Pump, respectively) do not exhibit a significant trend. TN concentrations have trended downward at the Public Works pump station at a rate of 9 %/yr, and that trend is significant at the 0.05 level of significance. Considering all pump station data together, TN concentrations appear to be declining at a rate of approximately 4 %/yr; however that apparent improvement is not statistically significant. TN trends may be easier to detect because TN concentrations do not fluctuate as widely as Cu and TP. Illustrating the steadiness of TN concentrations, the maximum of 9 samples at PW-Pump is 1.6 mg/L while the lowest concentration is 1.08 mg/L, a range of less than a factor of two.

Considering all the pump station data, TP concentrations appear to be declining at a rate of approximately 6 %/yr, but the apparent downward trend is not statistically significant. Public Works pump discharge appears to be declining at a greater rate than Cove and Lantern Lane pump stations, with an apparent reduction of 15 %/yr, but even that rate of reduction is not statistically significant due to variability in observed TP concentrations. Contrasting the low variability in TN concentrations discussed in the previous paragraph, the range of TP concentrations at PW-Pump is greater than a factor of three. The greater variability in TP concentrations makes detection of trends more difficult.

Fecal coliforms vary even more than the inorganic pollutants discussed above, and no significant trend is fecal coliforms can be detected. However each pump station appears to be improving in bacteria counts.

With the exception of TN at Public Works pump station, no statistically significant trends were detected; however nearly each pump station appears to be improving very gradually for each pollutant evaluated. Copper and fecal coliforms appear to be declining at each pump station. TN appears to be declining at two of the three pump stations (Lantern Lane pump appears to be increasing, but not significantly). TP appears to be improving at two of the three (Cove pump appears to be increasing, but not significantly). Although nearly all of these trends are not convincing at this time (not statistically significant), the consistency of slow apparent improvement across several key stormwater pollutants at most of the pump stations suggests that City actions, as well as South Florida Water Management District stormwater permit requirements for new construction, may be having a positive effect on stormwater loadings to Naples Bay and other waters of the State affected by City sources.

4.0 Pollutant Loading Allocation

As part of the 2013 SOW, AMEC was asked by the City to review and evaluate available data for the hydrologic, nutrient, and pollutant loading analyses performed for the Gordon River and Naples Bay contributing drainage basins. Loadings will be summarized by jurisdiction, including City of Naples and Unincorporated Collier County. Documents reviewed as part of this analysis include the Collier County Watershed Management Plan, FDEP TMDL reports, previous AMEC loading analyses and records of water quality sampling in the Gordon River and Naples Bay.

The watershed area contributing to Gordon River and Naples Bay evaluated comprises approximately 136 square miles (mi^2). Of that total area approximately 8% (10 mi^2) is within City limits, while the remainder (82% or 126 mi^2) is in Collier County outside the City.

AMEC requested data related to the Collier County Watershed Management Plan (CCWMP) from Atkins North America, Inc. (Atkins) who authored the CCWMP, for use in this analysis. AMEC received usable data related to TN, TP and TSS loading from Atkins that was included in the CCWMP. AMEC used these data to summarize and categorize loadings by jurisdiction, specifically from City of Naples and unincorporated Collier County. Due to the fact that this model was developed for the entire county, the resolution is rather coarse with a cell size of 51.6 acres. Model results and analysis should therefore be treated as approximate values and should not be heavily relied on for decision making purposes. The results of the CCWMP model analysis are presented below in Table 4.1. The CCWMP model indicates that stormwater generated from areas within the City contributes approximately 11% of the total TN loading to Gordon River and Naples Bay, with the remainder from unincorporated Collier County. For TP the City's contribution to total loading is approximately 10%. The CCWMP indicates that City sources contribute approximately 15% of the total loading of suspended solids to these water bodies, with the remainder from the County.

These results obtained from the CCWMP loadings model were checked against two independent sources of information. These are:

a) AMEC's estimated loadings to City lakes originally presented by AMEC (2012) and updated by AMEC in 2013. The CCWMP provides comparable estimates for 23 of the lake watersheds included in the AMEC (2013) loading model.
b) Stormwater pollutant discharges entering the City from the Golden Gate Canal at the boundary between the City and unincorporated Collier County. These loadings can be estimated by multiplying stormwater parameter concentrations near the mouth of Golden Gate Canal at the City boundary times the average flow of the Golden Gate Canal.

Comparison (b) is presented in Table 4-1 in the far right column. This estimate of loading from unincorporated Collier County to the Gordon River was calculated as follows. Water quality data from the Gordon River extension (GORDEXT) sampling location, which is in the Gordon River directly downstream from the mouth of the Golden Gate Canal at the boundary of the City of Naples and unincorporated Collier County (Figure 4-1), were downloaded from the FDEP STORET water quality monitoring database (FDEP, 2014b). Loading was estimated using the average concentration as measured over the period of record (2012-2013) times the assumed average flow of 200 million gallons per day for the Golden Gate Canal from the Naples Bay Twenty Year Plan (City of Naples, 2013). These pollutant discharges should be approximately related to the loading from unincorporated Collier County as calculated from the CCWMP. Loadings estimated from the CCWMP (**From Outside City Limits** column are compared with **Total Loading from Outside City Limits Based on Golden Gate Canal Monitoring Data)** are in Table 4-1.

Table 4-1. CCWMP Naples Bay Loading Analysis

Pollutant	Total Loading (lb/yr) from CCWMP Model		Total Loading (lb/yr) from Outside City Limits Based on Golden Gate Canal Monitoring Data
	From Within City Limits	From Outside City Limits	
TN	26,090	213,106	394,051
TP	4,040	35,213	33,935
TSS	475,340	2,664,483	8,955,067

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Comparing the CCWMP loadings model and the loadings estimate based on Golden Gate Canal monitoring data, the most notable difference are the values for total suspended solids. The actual values from sampling far exceed model results. The model results for TP loading were very similar to the observed values, only 4% difference. The TN loading estimates from the model, however, were 46% lower than the values observed from sampling. The reason for these discrepancies cannot be evaluated without further investigation into how model inputs were developed and applied as well as consideration of "instream" processes that lead to differences between model-estimated loadings and "instream" water quality.

An additional check on the reasonableness of both the CCWMP and AMEC (2013) loading models was investigated by comparing CCWMP and AMEC loading estimates for 23 City lake watersheds. AMEC compared loading estimates from the CCWMP to previous loading models developed for the City's stormwater lakes. Again, the coarseness of this CCWMP data makes it a very rough approximation of loading to stormwater lakes, especially considering the small size of many of the lake watersheds. Also note that the area within which both CCWMP and AMEC calculated loadings, the area for which this comparison was feasible, is approximately 1.7 mi^2, considerably less than the area included in the estimates in Table 4-1. Nonetheless these indicate the general reliability of these loading estimates, which were developed using generally consistent methods. The loading estimates are compared in Table 4.2. The two models are relatively consistent, with estimated loadings of TP and TSS varying less than 10% between the two models. The difference between the two models is somewhat greater for TN, at 31%. For each stormwater pollutant the AMEC (2013) model estimates are higher than the estimates from the CCWMP model.

Table 4-2. Comparison of CCWMP and AMEC Loading Estimates (lb/yr) to 23 City Lakes

Pollutant	Loading from CCWMP Model	Loading from AMEC Model	Difference Between the Models
TN	3635	4974	31%
TP	550	602	9%
TSS	90774	92294	2%

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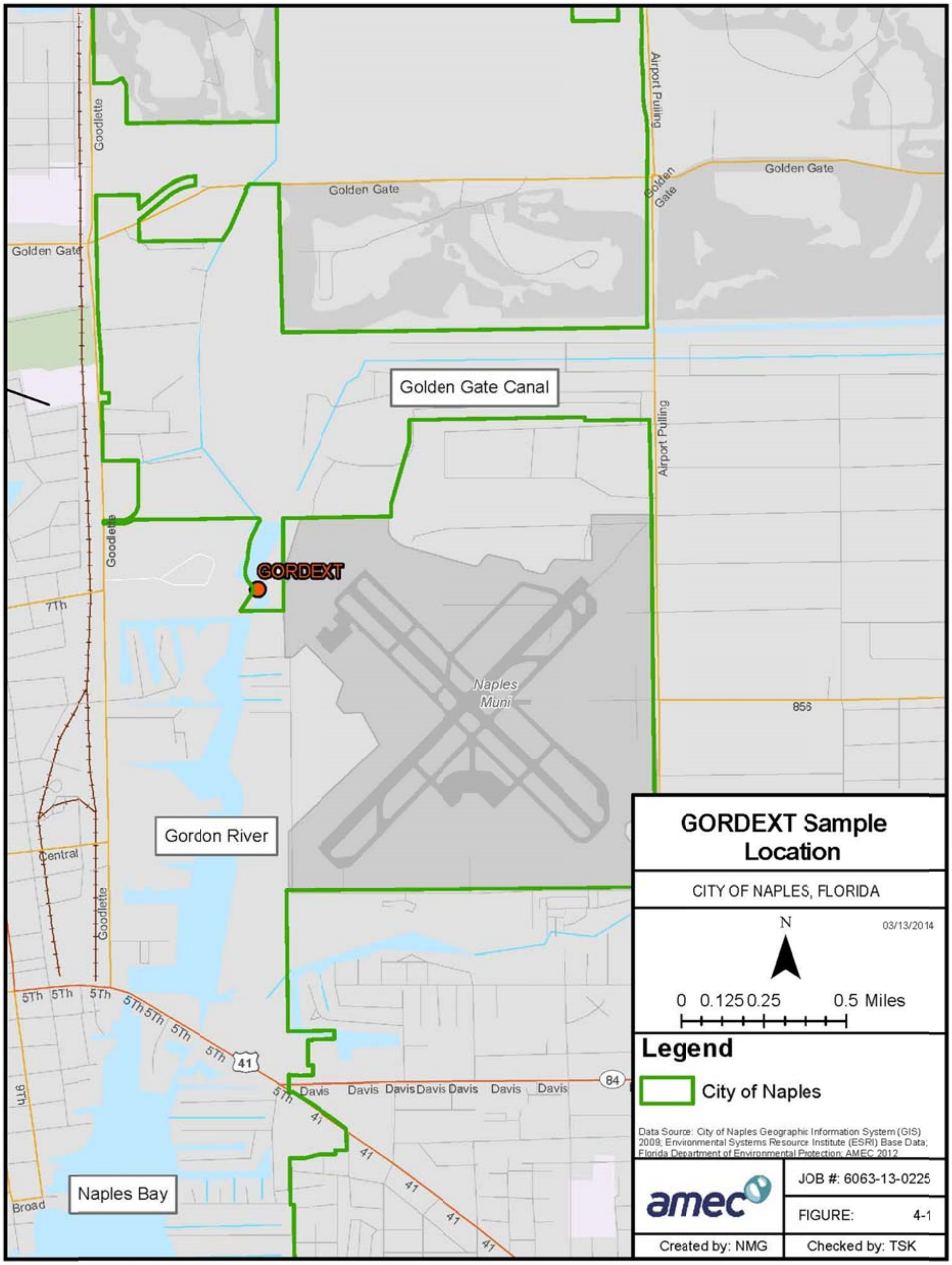
The differences between various methods of calculating loading are significant. Nonetheless the evaluation supports a conclusion that the majority of nutrients and suspended solids reaching Naples Bay originates outside the City limits in Collier County and enters the Gordon River and Naples Bay via the Golden Gate Canal. This is the reason that much of the Naples Bay Twenty Year Plan focuses on diverting water from the Golden Gate Canal in order to keep it from reaching Naples Bay.


GORDEXT Sample Location
CITY OF NAPLES, FLORIDA
N
03/13/2014
0 0.125 0.25 0.5 Miles
Legend
City of Naples
Data Source: City of Naples Geographic Information System (GIS) 2009; Environmental Systems Resource Institute (ESRI) Base Data; Florida Department of Environmental Protection; AMEC 2012
amec
JOB #: 6063-13-0225
FIGURE: 4-1
Created by: NMG
Checked by: TSK
Golden Gate Canal
Gordon River
Naples Bay
GORDEXT
Naples Muni
Golden Gate
Airport Pulling
Goodlette
Davis
856
84
41

5.0 Conclusions and Recommendations

The results of the current year monitoring efforts were able to fill in critical data gaps. Analysis of results were generally consistent with prior monitoring data. Since this monitoring program has been operated consistently for several years, the entire data set was examined to determine if trends have been detected, and whether there is evidence that trends were the response of City actions or other identifiable causes.

Copper concentrations fluctuate over a wide range in several lakes, presumably due to application of copper sulfate as an algaecide. Unusually high concentrations of copper were observed in one or more sampling events in Lakes 1SE, 5, 9, 15, 24, and 26. Of these, Lake 15 (Sun Lake Terrace) discharges directly to Gordon River, while Lakes 24 (Half Moon) and 26 (NCH) are in the Naples Bay watershed. Lake Suzanne (5) discharges directly to Moorings Bay. Copper concentrations have been lower in Swan Lake since the City reached out to Swan Lake area residents regarding adverse water quality effects of application of copper-based algaecides.

The City installed three floating islands and four aerators in Lantern Lake (14) in 2012 (floating islands in March and aerators in September). City staff monitored Lantern Lake water quality monthly in 2012 and 2013 (except February through April 2013). These data were supplemented by the biannual monitoring conducted by AMEC in 2012 and 2013 and a single sample collected in 2009. These efforts have yielded 25 water quality samples for Lantern Lake, the most intensively monitored City lake. The concentration of TN in Lantern Lake has been reduced from an initial concentration of approximately 2 mg/L in 2009 to approximately 1 mg/L by the end of 2013. The reduction in TN appears to be related to the City's actions: TN averaged 2.1 ± 0.1 mg/L prior to implementation of the City's BMPs in March 2012 then 1.2 ± 0.1 mg/L after all the floating islands and aerators had been installed in September 2012.

Three City-operated pump stations have been monitored regularly since December 2010. Potential trends in significant stormwater pollutants (Cu, TN, TP, and fecal coliforms) were examined. For the most part pollutant discharges appear to be declining, but those trends are not statistically significant. Copper and fecal coliforms appear to be declining at each pump station. TN appears to be declining at two of the three pump stations (Lantern Lane pump appears to be increasing, but not significantly). TP appears to be improving at two of the three (Cove pump appears to be increasing, but not significantly). Although nearly all of these trends are not convincing at this time (not statistically significant), the consistency of slow apparent improvement across several key stormwater pollutants at most of the pump stations suggests that City actions (see Section 1.2), as well as South Florida Water Management District stormwater permit requirements for new construction, may be having a positive effect on stormwater loadings to Naples Bay and other waters of the State affected by City sources.

Loadings estimates developed to support the Collier County Watershed Management Plan shows that more than 75% of TN, TP, and TSS discharging to Gordon River and Naples Bay comes from unincorporated portions of Collier County via the Golden Gate Canal.

AMEC recommends the biannual monitoring of priority City stormwater lakes, and quarterly monitoring of pump station discharges should continue to develop a statistically valid and consistent data base characterizing effectiveness of the City's stormwater management facilities. The caffeine monitoring that has been undertaken in 2012 and 2013 has demonstrated that some human waste is entering the City's stormwater and is a significant source of bacterial contamination in stormwater. Relatively costly analysis of caffeine can be reduced in future monitoring efforts. Monitoring of Lake Manor should be extended to permit evaluation of the water quality effects of the Lake Manor Restoration project currently in design, with expected construction in 2015.

6.0 References

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Appendix A
Ambient Water Quality

Quarter 1

Quarter 2

Quarter 3

Quarter 4

Appendix B
Analytical Lab Reports

Quarter 1

Quarter 2

Quarter 3

Quarter 4

Appendix C
Photo log - 2012 Sampling Locations

Appendix D
Field Notes

Quarter 1

Quarter 2

Quarter 3

Quarter 4