South District • Everglades West Coast

Final Report Copper TMDLs Report for Naples Bay, Haldeman Creek and Rock Creek (WBIDs 3278R4, 3278R1, 3278R3)

Division of Environmental Assessment and Restoration
Florida Department of Environmental Protection

James Albright

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2600 Blair Stone Road
Mail Station 3000
Tallahassee, FL 32399-2400
https://floridadep.gov

Executive Summary

This report presents the total maximum daily load (TMDL) developed to address the copper impairments for Naples Bay, Haldeman Creek, and Rock Creek with waterbody identification numbers (WBID) 3278R4, 3278R1, and 3278R3. The waterbodies were identified as impaired based on exceeding the copper criterion in subsection 62-302.530(23), Florida Administrative Code (F.A.C.). Naples Bay, Haldeman Creek, and Rock Creek were included on the Verified List of Impaired Waters for the Everglades West Coast and were added to the 303(d) list by Secretarial Order on Feb. 12, 2013.

The TMDLs will be based on the copper criterion for marine waters in subsection 62-302.530(23), F.A.C. Percent reductions are made to achieve this copper criterion. **Table EX-1** lists supporting information for the TMDLs. The TMDLs were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the U.S. Environmental Protection Agency.

Table EX-1. Summary of TMDL Supporting Information for Haldeman Creek, Rock Creek, and Naples Bay

Type of Information	Description
Waterbody name/ WBID number	Haldeman Creek (3278R1), Rock Creek (3278R3), and Naples Bay (3278R4)
Hydrologic Unit Code (HUC 8)	03090204
Use classification/ Waterbody designation	Haldeman Creek and Rock Creek: Class III Marine Naples Bay: Class II Marine
Targeted beneficial uses	Fish consumption; recreation; and propagation and maintenance of a healthy, well-balanced population of fish and wildlife in all three waterbodies and, additionally, shellfish harvesting in Naples Bay.
303(d) listing status	Verified List of Impaired Waters for Everglades West Coast adopted via Secretarial Order dated Feb. 12, 2013.
TMDL pollutants	Copper
Generally applicable copper criterion	**Copper Marine Criterion:** 3.7 micrograms per liter (µg/L), never to be exceeded.
TMDLs	**Haldeman Creek (3278R1)**: 68% Cu reduction to meet the criterion for marine waters. **Rock Creek (3278R3)**: 47% Cu reduction to meet the criterion for marine waters. **Naples Bay (3278R4)**: 56% Cu reduction to meet the criterion for marine waters.

Acknowledgments

This analysis was accomplished thanks to significant contributions from staff in the Florida Department of Environmental Protection (DEP) Division of Environmental Assessment and Restoration, specifically, the Office of Watershed Services, Watershed Assessment Section, Standards Development Section, Water Quality Restoration Program, South Regional Operations Center, and Watershed Evaluation and TMDL Section. DEP would also like to particularly acknowledge staff at Collier County Pollution Control for the invaluable support they provided.

For additional information regarding the development of this report, please contact the Division of Environmental Assessment and Restoration office at:

2600 Blair Stone Road
Mail Station 3000
Tallahassee, FL 32399-2400

Phone: (850) 245-8668

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List of Acronyms and Abbreviations

μg/L	Micrograms Per Liter
AGM	Annual Geometric Mean
BMAP	Basin Management Action Plan
BMP	Best Management Practice
$CaCO_3$	Calcium Carbonate
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEP	Florida Department of Environmental Protection
DWM	Dispersed Water Management
EPA	U.S. Environmental Protection Agency
F.A.C.	Florida Administrative Code
FLUCCS	Florida Land Use, Cover and Forms Classification System
F.S.	Florida Statutes
HUC	Hydrologic Unit Code
ID	Insufficient Data
IWR	Impaired Surface Waters Rule
LA	Load Allocation
MDL	Method Detection Limit
mg/L	Milligrams Per Liter
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NA	Not Applicable
NAD	North American Datum
NPDES	National Pollutant Discharge Elimination System
PLRG	Pollutant Load Reduction Goal
POR	Period of Record
SWIM	Surface Water Improvement and Management (Program)
TMDL	Total Maximum Daily Load
WBID	Waterbody Identification (Number)
WLA	Wasteload Allocation
WWTF	Wastewater Treatment Facility

Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) developed to address the copper impairments of Naples Bay, Haldeman Creek, and Rock Creek, located in the Everglades West Coast Basin in Collier County. The TMDLs are established to achieve the copper criterion in subsection 62-302.530(23), Florida Administration Code (F.A.C.). The waterbodies were verified as impaired for copper using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.), and were included on the Verified List of Impaired Waters for the Everglades West Coast that was adopted by Secretarial Order Feb. 12, 2013.

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and provides water quality targets needed to achieve compliance with applicable water quality criteria based on the relationship between pollutant sources and water quality in the receiving waterbody. The TMDLs establish the allowable copper concentrations for Naples Bay, Haldeman Creek, and Rock Creek and associated reductions that would restore the waterbody so that it meets its applicable water quality criteria for copper.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (DEP) divided the Everglades West Coast Basin (Hydrologic Unit Code [HUC 8] 03090204) into watershed assessment polygons with a unique waterbody identification (WBID) number for each watershed or surface water segment. Naples Bay and its tributaries are in the Southwest Coast Planning Unit within the Everglades West Coast Basin. Naples Bay itself is WBID 3278R4, and it is the receiving waterbody for Haldeman Creek (WBID 3278R1) and Rock Creek (WBID 3278R3). **Figure 1.1** shows the location of the impaired WBIDs in the basin and the major geopolitical and hydrologic features surrounding them.

Naples Bay is an estuarine area surrounded by urbanized development including the City of Naples itself. Historically this was a shallow water bay considered unsuitable as a port for larger vessels (Schmid et al., 2006). Naples Bay was once a shallow and very productive estuary rimmed by mangrove forests, with benthic communities of seagrass and oyster bars. The most extensive oyster bars were found along the shoreline and the mouths of tidal creeks, especially Haldeman and Rock Creeks. The Naples pier was constructed in the late 1880s and with the completion of Tamiami Trail in 1926, rapid urban development commenced. The first dredging of the bay occurred in 1930 and these efforts to improve navigation and provide bay-access real estate culminated with extensive dredge-and-fill developments in the 1950s and 1960s. Naples Bay still functions as an estuary, albeit one extensively altered and heavily influenced by anthropogenic activities (Schmid et al., 2006).

1.3 Watershed Information

1.3.1 Population and Geopolitical Setting

Naples Bay, Rock Creek, and Haldeman Creek are all located entirely within Collier County, a moderately sized county with a population of 375,752 as of the 2020 census. Naples Bay proper is located entirely within the City of Naples, which had a population of 19,115 in the 2020 Census. The lower portions of Rock Creek are also located in the City of Naples, with their headwaters in unincorporated Collier County. Only the mouth of Haldeman Creek is located in the City of Naples, with the majority of the estuarine creek located in the unincorporated Collier County community of East Naples.

1.3.2 Hydrological Setting

Naples Bay extends in a north–south orientation with the head to the north and the Gulf of Mexico inlets to the south via the Gordon Pass inlet. At the head of Naples Bay, Gordon River flows from the north entering at the north end of the bay. Rock Creek flows from the east, just south of Gordon River, and enters Naples Bay just south of the mouth of the Gordon River. The final tributary, Haldeman Creek, flows in from the east and enters Naples Bay below the other two tributaries, at the approximate mid-point of Naples Bay.

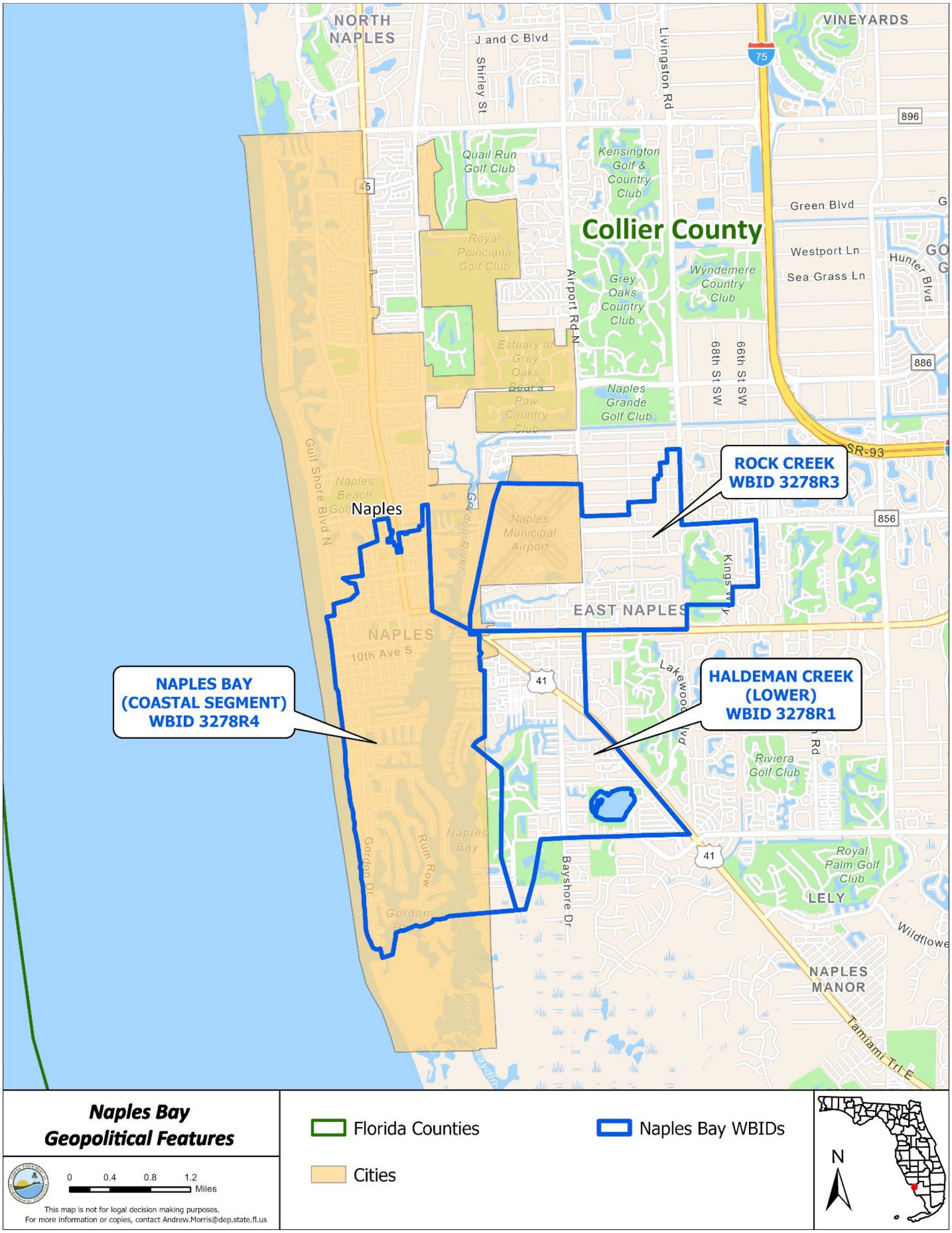

Figure 1.1. Location of Naples Bay, Rock Creek, and Haldeman Creek Hydrologic and Geopolitical Features in the Area

Chapter 2: Water Quality Assessment and Identification of Pollutants of Concern

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act (CWA) requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. DEP has developed such lists, commonly referred to as 303(d) lists, since 1992.

The Florida Watershed Restoration Act (section 403.067, Florida Statutes [F.S.]) directed DEP to develop, and adopt by rule, a science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the methodology as Chapter 62-303, F.A.C. (the IWR), in 2001. The rule was amended in 2006, 2007, 2012, 2013, and 2016.

The list of impaired waters in each basin, referred to as the Verified List, is also required by the subsection 403.067(4), F.S. In the past, the state's 303(d) list has been amended annually to include basin updates for 20% of the state every year, conducted as part of a rotating basin approach to cover the whole state every five years. However, beginning with the 2022 biennial assessment, the state's 303(d) list is now amended biennially and consists of a statewide assessment every two years.

2.2 Classification of the Waterbody and Applicable Water Quality Standards

Naples Bay is a Class II (marine) waterbody, with a designated use of shellfish propagation or harvesting and fish consumption; recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Haldeman Creek (Lower) and Rock Creek are Class III (marine) waterbodies, with a designated use of fish consumption; recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class II and III water quality criteria applicable to the verified impairments for these waterbodies is Florida's copper criterion in paragraph 62-302.530(23), F.A.C. The copper criterion for all marine waters, both Class II and Class III, is 3.7 micrograms per liter (µg/L), never to be exceeded. The state's marine criterion was derived from EPA's 2002 recommendation of a value of 3.1 µg/L dissolved copper, with a conversion factor of 0.83 to obtain total recoverable copper from dissolved copper. Note that marine copper criteria for Florida waters are expressed as total recoverable copper rather than dissolved copper in order to take the possibility of downstream transformations into account.

2.2.1 Basis for Criteria

Water quality criteria are intended to preserve a waterbody's designated uses. In the case of copper, the designated use to be protected is propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Copper is highly toxic to most aquatic species (EPA 2016). Dissolved copper in the form of free cupric (Cu^{2+}) ions is the most toxic form of copper. The main cause of copper toxicity to fish and aquatic invertebrates is through the rapid binding of copper to gill membranes, which causes damage and interferes with olfactory and osmoregulatory processes. Gill damage from elevated copper levels results in the loss of a fish's ability to regulate the transport of salts such as sodium chloride and potassium chloride into and out of its body. These salts are important for the normal functioning of the cardiovascular and nervous systems. When the salt balance is disrupted between the body of a copper-exposed fish and the surrounding water, the result can be lethal (Marshall and Grosell 2005).

The amount of cupric ion in the environment, and its toxicity to aquatic animals through gill damage, depends on several water quality parameters that affect the bioavailability of copper. They include pH, hardness, alkalinity, and dissolved organic carbon (DOC). In general, the toxicity of copper decreases with increasing hardness, increasing alkalinity, and higher DOC. Acidic waters (pH <6.0) dramatically increase the toxicity of copper.

The effects of copper on aquatic organisms can be directly or indirectly lethal. Fish rely on their sense of smell to find food, avoid predators, and migrate. Hard water and buffered water do not protect fish against copper impacts on olfaction. The loss of olfaction initially results in sublethal effects, such as a reduced ability to find prey or migrate to spawning grounds, that can become lethal if they persist. As an example from northern waters, rainbow trout and salmon are particularly sensitive to olfactory loss (Scott and Sloman 2004; Woody and O'Neal 2012).

2.3 Determination of the Pollutant of Concern

2.3.1 Data Providers

The Everglades West Coast verified assessment period of 2005–12 was used for the 2013 assessment. The sources of copper data used in the verified assessment periods for Haldeman Creek (2005–12) are stations sampled by the following organizations: South Florida Water Management District (SFWMD) (org code 21FLSFWM), Collier County Pollution Control (org code 21FLCOLL) and the City of Naples (org code 21FLNAPL). The verified period assessment of Rock Creek was also based on data from SFWMD (org code 21FLSFWM), Collier County Pollution Control (org code 21FLCOLL) and the City of Naples (org code 21FLNAPL) The data for the verified period assessment for Naples Bay were obtained from DEP (org code 21FLFTM), SFWMD (org code 21FLSFWM), Biological Research Associates (org code 21FLBRA) and the City of Naples (org code 21FLNAPL).

The locations of all stations sampled for copper in the waterbodies are shown in the following figures: **Figure 2.1** for Naples Bay, **Figure 2.2** for Rock Creek, and **Figure 2.3** for Haldeman Creek. Copper data from these stations was used to assess the WBIDs. These stations are not all currently sampled by the entities and may not reflect current and future sampling efforts.

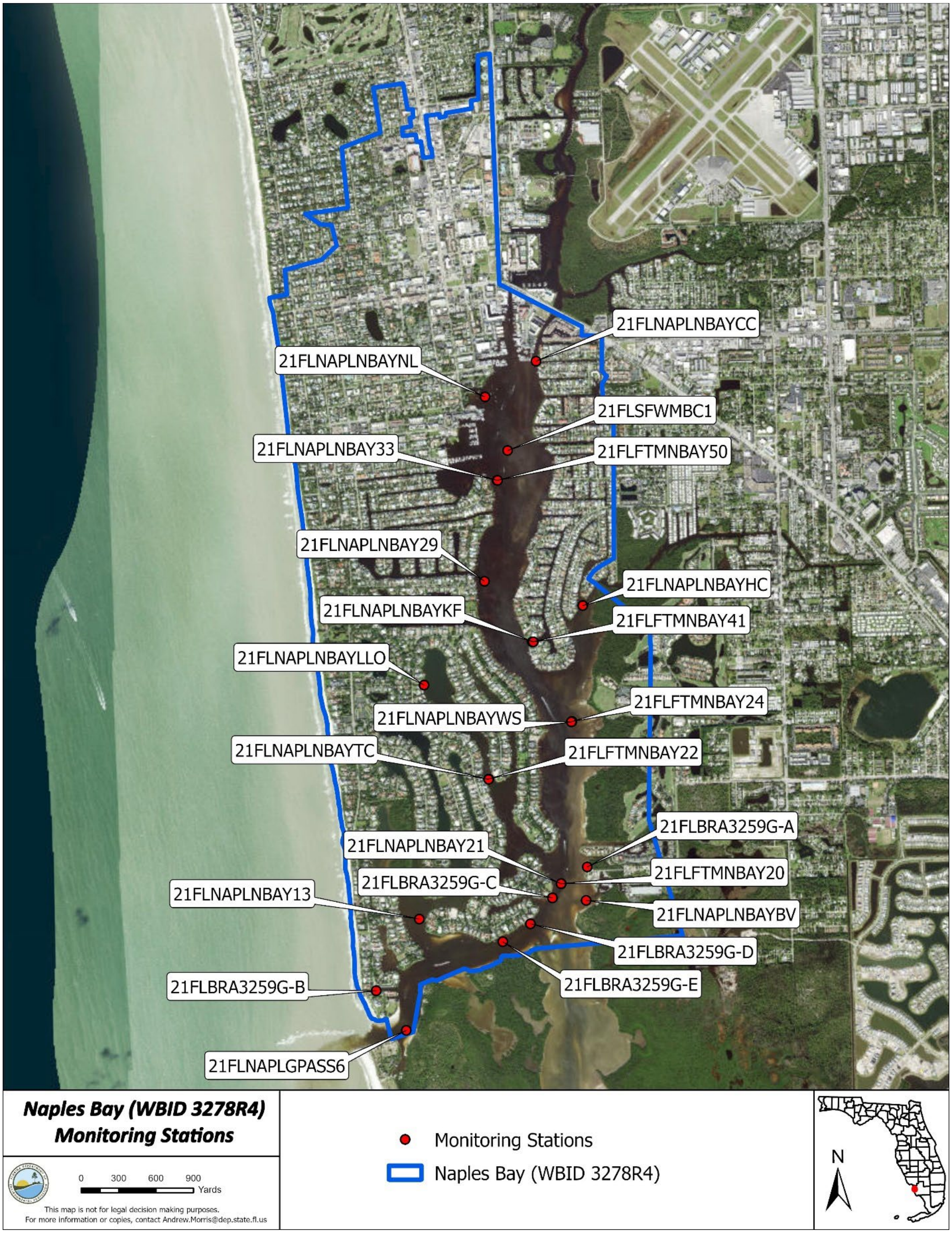

Figure 2.1. Water Quality Monitoring Stations in Naples Bay

Figure 2.2. Water Quality Monitoring Stations in Rock Creek

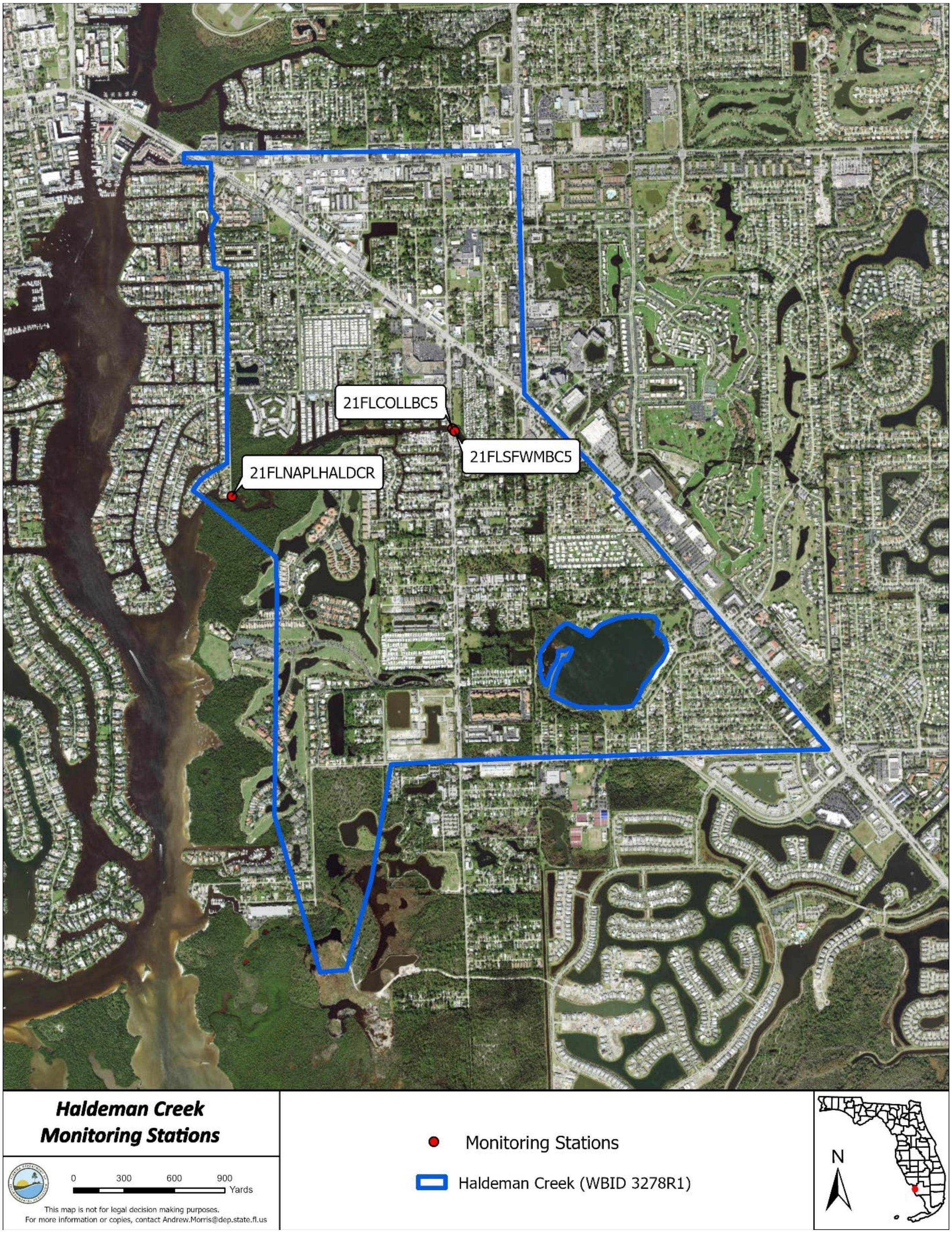

Figure 2.3. Water Quality Monitoring Stations in Haldeman Creek

2.3.2 Information on Verified Impairment

The three waterbodies had previously been assessed as a single WBID designated Naples Bay Coastal (WBID 3278R). In 2009, this WBID was listed as impaired for copper. Subsequently, this WBID was divided into multiple WBIDs to better account for the variation in water quality conditions between Naples Bay and its primary tributaries. These daughter WBIDs were re-assessed for the 2013 assessment and were determined to be impaired for copper. The retired WBID, WBID 3278R, was removed from the verified list, and Haldeman Creek (3278R1), Rock Creek (3278R3), and Naples Bay (3278R4) were added to the 2013 verified list of impaired waters. The verified period for the 2013 IWR assessment was January 1, 2005, through June 30, 2012. Data for this assessment is stored in the IWR Run 47 Access database, which is available on request.

At the time of the assessment for Haldeman Creek, there were 32 samples in the verified period. Of these, 25 exceeded the marine copper criterion. For a sample size of 32, a minimum of six exceedances are needed to place a waterbody on the verified list. At the time of the assessment for Rock Creek, there were 29 samples in the verified period. Of these, 10 exceeded the marine copper criterion. For a sample size of 29, a minimum of six exceedances is needed to place a waterbody on the verified list. At the time of the assessment for Naples Bay, there were 444 samples in the verified period. Of these, 117 exceeded the marine copper criterion. For a sample size of 444, a minimum of 54 exceedances are needed to place a waterbody on the verified list.

Chapter 3: Assessment of Sources

3.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the target watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point sources or nonpoint sources. Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernable, confined and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. Point sources also include certain urban stormwater discharges, such as those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs). In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture and mining, discharges from septic systems, and atmospheric deposition.

To be consistent with CWA definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring a National Pollutant Discharge Elimination System (NPDES) stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 5.1** on **Expression and Allocation of the TMDL**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

3.2 Point Sources

3.2.1 Wastewater Point Sources

There are no NPDES-permitted wastewater facilities that discharge to Naples Bay, Rock Creek, and Haldeman Creek or that discharge to surface waters in the watershed.

3.2.2 Municipal Separate Storm Sewer System (MS4) Permittees

Naples Bay, Rock Creek, and Haldeman Creek are covered by two NPDES MS4 Phase II permits: Collier County and the City of Naples. Only co-permittees whose jurisdictions are included, wholly or in part, within the boundaries of Naples Bay, Rock Creek and Haldeman Creek are listed here. Also note that while these permittees are located wholly or partially within the watershed, the permittees do not have jurisdiction over the entire contributing areas, nor are they responsible for any discharge if they do not have an outfall discharging to the watershed. For more information on MS4s in the watershed, send an email to NPDES-stormwater@dep.state.fl.us. **Table 3.1** lists the permittees/co-permittees and their MS4 permit numbers.

Table 3.1. NPDES MS4 permits with Jurisdiction in Naples Bay, Rock Creek, and Haldeman Creek

Permit Number	Permittee/Co-Permittees	Phase
FLR04E037	Collier County	II
FLR04E080	City of Naples	II

3.3 Nonpoint Sources

Pollutant sources that are not NPDES wastewater or stormwater dischargers are generally considered nonpoint sources. Copper loadings to Naples Bay, Rock Creek, and Haldeman Creek are primarily generated from nonpoint sources. Nonpoint sources addressed in this analysis primarily include loadings from surface runoff, baseflow, and precipitation directly onto the lake surface (atmospheric deposition).

3.3.1 Land Uses

Land use is one of the most important factors in determining potential copper loadings from the respective watersheds of Naples Bay, Rock Creek, and Haldeman Creek. Copper can be flushed into receiving water through surface runoff and stormwater conveyance systems during stormwater events. Both human land use areas and natural land areas generate copper. However, human land uses typically generate more copper loads per unit of land surface area than natural lands can produce. **Tables 3.2–3.4** list land use in 2017–19 for each of the following WBIDs (Naples Bay, Rock Creek, and Haldeman Creek), based on a 2022 retrieval of data from SFWMD. **Figures 3.1–3.3** show the information graphically for each of the WBIDs respectively (Naples Bay, Rock Creek, and Haldeman Creek).

Table 3.2. SFWMD land use in Naples Bay (WBID 3278R4) in 2017–19 (Retrieved 2022)

FLUCCS = Florida Land Use, Cover and Forms Classification System

FLUCCS Code	Land Use Classification	Square Kilometers	% of WBID
1100	Residential Low Density	0.30	2%
1200	Residential Medium Density	5.13	39%
1300	Residential High Density	1.11	8%
1000	Urban and Built-Up	2.05	16%
4000	Upland Forest	0.01	0%
5000	Water	3.66	28%
6000	Wetlands	0.77	6%
8000	Transportation, Communication, and Utilities	0.06	0%
		13.09	100%

Table 3.3. SFWMD land use in Rock Creek (WBID 3278R3) in 2017–19 (Retrieved 2022)

FLUCCS = Florida Land Use, Cover and Forms Classification System

FLUCCS Code	Land Use Classification	Square Kilometers	% of WBID
1000	Urban and Built-Up	0.76	9%
1200	Residential Medium Density	1.41	16%
1300	Residential High Density	0.78	9%
1000	Urban and Built-Up	2.39	28%
3000	Rangeland	0.05	1%
4000	Upland Forest	0.21	3%
5000	Water	0.34	4%
6000	Wetlands	0.28	3%
8000	Transportation, Communication, and Utilities	2.36	28%
		8.58	100%

Table 3.4. SFWMD land use in Haldeman Creek (WBID 3278R1) in 2017–19 (Retrieved 2022)

FLUCCS = Florida Land Use, Cover and Forms Classification System

FLUCCS Code	Land Use Classification	Square Kilometers	% of WBID
1200	Residential Medium Density	2.27	32%
1300	Residential High Density	1.45	21%
1000	Urban and Built-Up	1.78	25%
3000	Rangeland	0.02	0%
4000	Upland Forest	0.24	3%
5000	Water	0.47	7%
6000	Wetlands	0.49	7%
7000	Barren Land	0.03	0%
8000	Transportation, Communication, and Utilities	0.24	3%
		7.00	100%

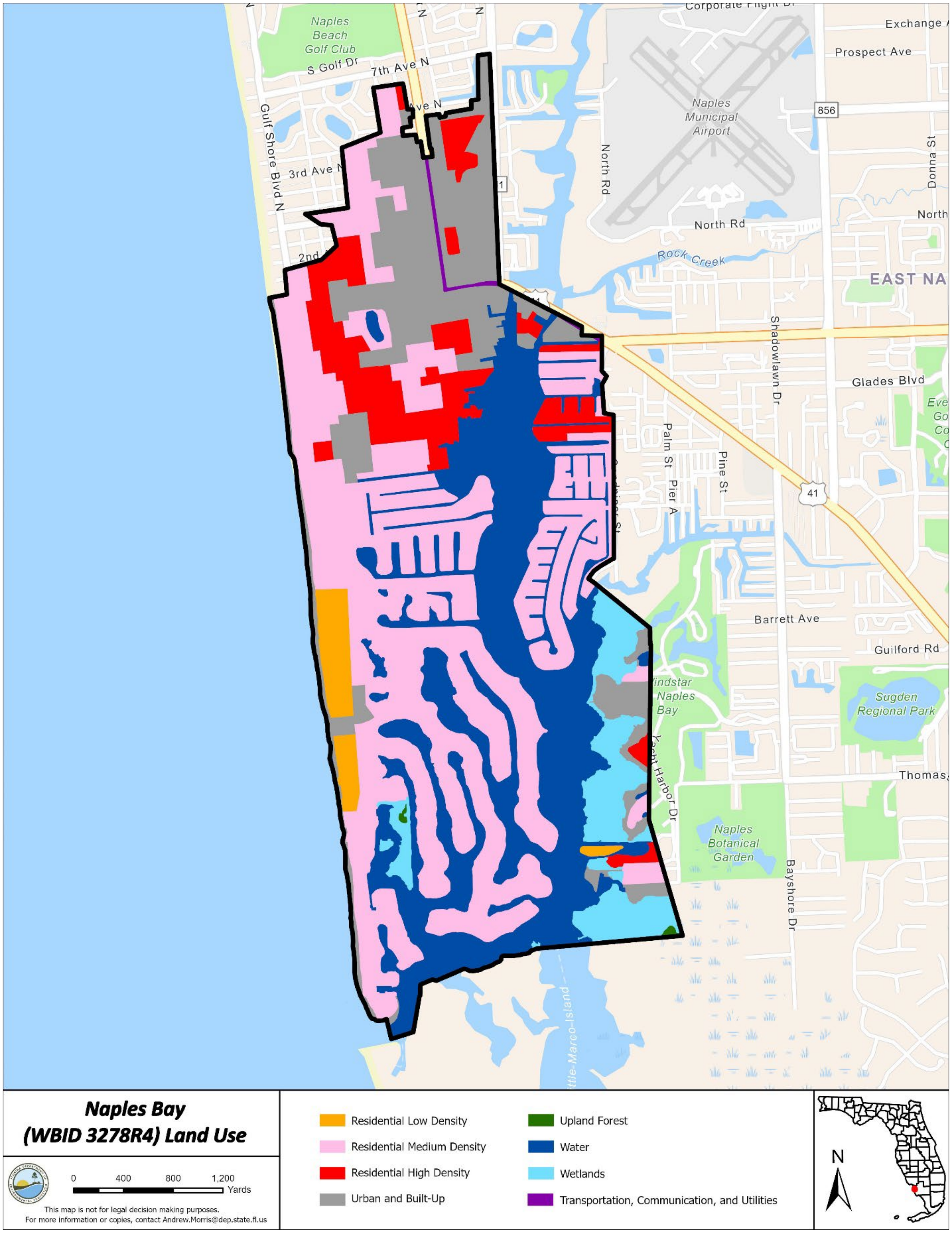

Figure 3.1. Land Use in Naples Bay (WBID 3278R4), 2017–19

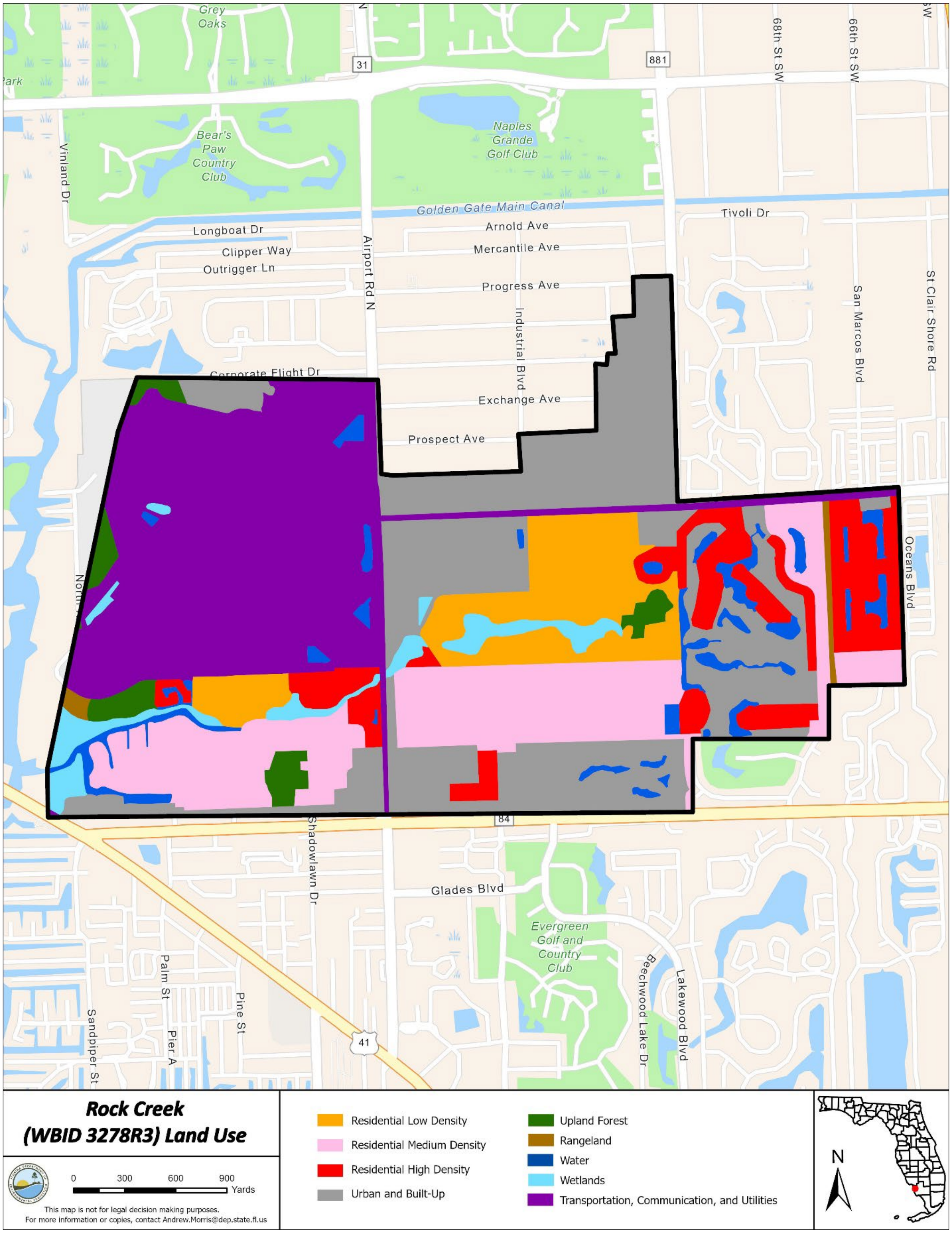

Figure 3.2. Land Use in Rock Creek (WBID 3278R3), 2017–19

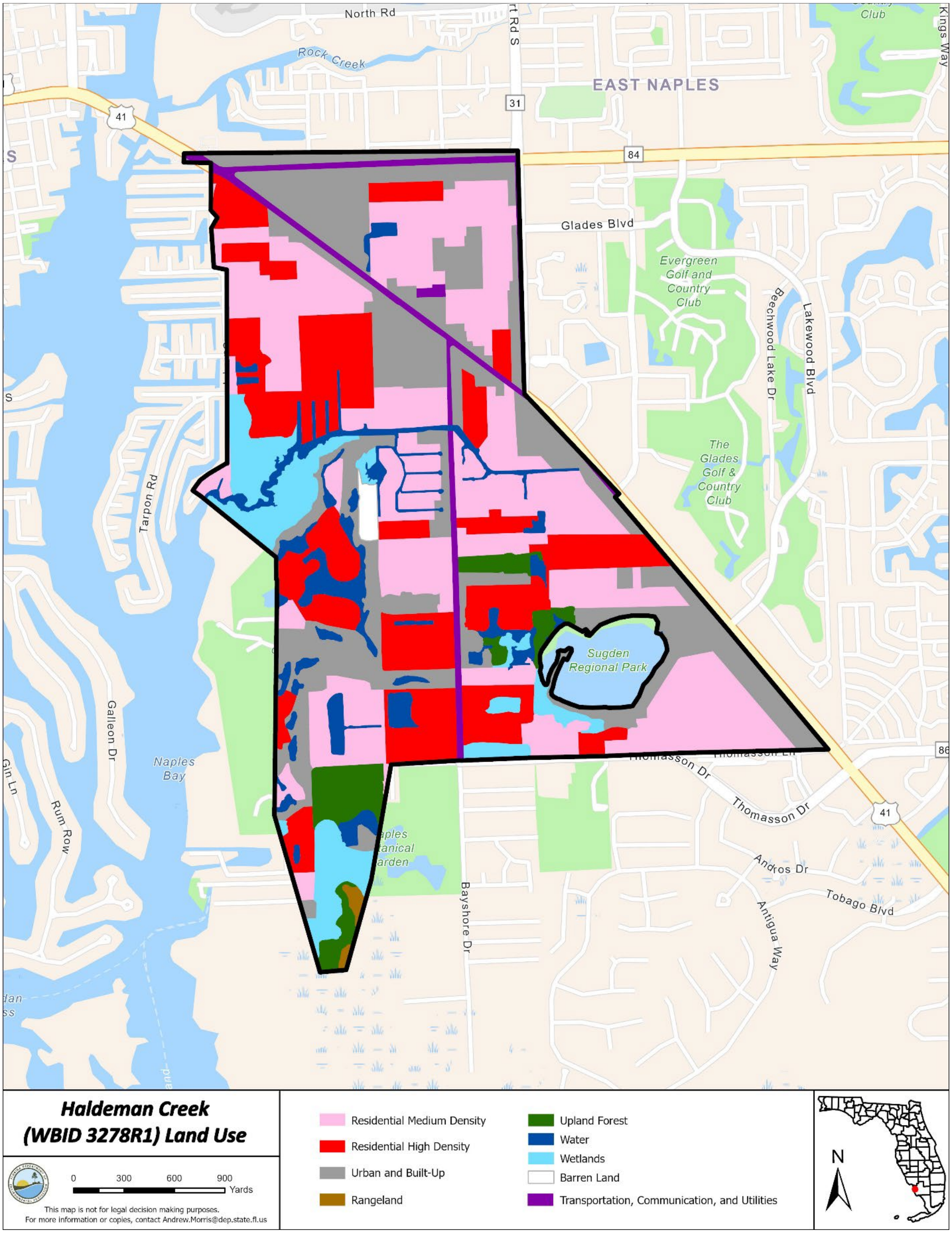

Figure 3.3. Land Use in Haldeman Creek (WBID 3278R1), 2017–19

3.3.2 Potential Anthropogenic Nonpoint Source Copper Pollution

Copper is used in a number of industries, including construction, agriculture and transportation. Because of its widespread use, anthropogenic sources of copper are found in both rural and densely populated areas. The following section of the report details the principal potential copper sources based on human activities.

3.3.3 Construction

Copper can be found in several different building materials. Sheet roofs, composition shingles containing copper biocide, gutters, and downspouts may contain copper (Rosselot 2006a). Coastal areas with elevated chloride ions in rainfall can increase copper in runoff from these materials (He et al. 2001).

Pressure-treated wood containing copper is used in both marine and terrestrial construction. The amount of copper found in pressure-treated wood depends on its intended use, with above-ground wood containing the least and wood used in saltwater immersion containing the most (Hinkley 1999). Chromated copper arsenate (CCA) has historically been a widespread treatment option for construction wood in Florida. For example, in 1996, 28 million cubic feet of CCA-treated wood were sold in Florida, equating to 920 tons of copper (Hinkley 1999). However, because of potential arsenic leaching, CCA has been phased out and replaced by other copper-based alternative chemicals (Solo-Gabriele et al. 2017).

Other sources of copper in building materials include copper wiring and plumbing. Copper plumbing corrosion can be especially elevated if hydrogen sulfide is present in the source water, which is common in Florida's coastal areas and along the Interstate 4 corridor (ICPCP 2001).

3.3.4 Agriculture

Copper is a micronutrient and is thus included in many fertilizers. It has been used in fertilizer and fungicide in Florida for over 90 years (Alva et al. 1995; Driscoll 2004). Copper concentrations may also be elevated in hog manure, sewage sludge and biosolids (Schulte and Kelling 1999; Karathanasis et al. 2005; Chen et al. 2017). The amount of copper in fertilizer varies from 0 to 39 grams per kilogram (g/kg) (U.S. Environmental Protection Agency [EPA] 1999; Rosselot 2006a). Copper use is particularly prevalent in the citrus industry, with more than 500,000 kilograms (kg) applied to approximately 260,000 hectares (ha) in Florida in 2005 (U.S. Department of Agriculture [USDA] 2006). Surface soils in mature citrus groves may contain as much as 540 kg Cu/ha (Reuther and Smith 1952).

According to Dewdney et al. (2019), citing 30 years of research evaluating alternatives, copper-based fungicides remain the most effective tool against citrus canker (*Xanthomonas citri* subsp. *citri*). Copper is also the most widely used agent to control melanose (a fungal disease) and is the only stand-alone active ingredient used to treat brown rot (EPA 2016). It is also extensively used in grape, cucurbit, onion, pepper and rice production (EPA 2016).

Livestock operations are another potential source of copper. For example, hogs are commonly given copper sulfate as a growth supplement (Richert 1995). Cows, especially dairy cows, are given copper sulfate footbaths to control hoof infections (Epperson and Midla 2007).

Copper-based herbicides and algaecides are also used to control invasive aquatic plants, algae and protozoans in Florida waters. This includes recreational swimming pools, aquaculture ponds, and stormwater ponds, among other surface waters. The Florida Department of Agriculture and Consumer Services (DACS) is the state agency designated to regulate pesticides used in Florida following the Florida Pesticide Law (Chapter 487, Part I, Florida Statutes [F.S.]), while DEP is responsible for implementing the NPDES regulations, which include a Generic Permit for pesticides applied to surface waters in Florida.

Exceptions to requiring permits to use copper-based herbicides and algicides are outlined in Rule 68F-20.0035, Florida Administrative Code (F.A.C.). These exemptions include use on private property, artificial waters, and waters that are less than 160 surface acres, provided there is no direct connection to Waters of Special Concern. According to Mossler and Langeland (2006), algal control in exempted waters is the major aquatic use of copper in the state, and annual elemental copper use is less than 1 million pounds—although actual quantities remain unknown. A possible avenue to explore private copper herbicide use is coordinating with DACS to examine copper herbicide/algaecide sales in Florida.

3.3.5 Transportation

Copper can also enter the environment from transportation activities, namely from antifouling paint and automobiles.

Antifouling paints are used on the underwater hulls of commercial and personal marine watercraft to prevent or retard the attachment of marine organisms (i.e., biofouling). Biofouling can affect vessel durability and performance, as well as introducing exotic species. Until the 1980s, tributyltin was the most commonly used antifouling paint. However, because of its effect on nontarget organisms and persistence in the environment, tributyltin was phased out in favor of less harmful copper-based antifouling (CBAF) paint. The two most commonly used CBAF paint types used on California recreational boats are ablative and epoxy-based coatings (Port of San Diego 2006; Earley et al. 2014). Ablative paints are designed to wear away over time and contain around 38% cupric oxide (Earley et al. 2014). Epoxy-based coatings are designed to slowly release copper via a diffusion-controlled process and contain around 65% cupric oxide (Earley et al. 2014).

According to a limited survey of marinas and boat owners along Florida's eastern seaboard, the epoxy-based Pettit Trinidad® is the most commonly used paint (Srinivasan and Swain 2007).

These authors, citing Naval Sea Systems Command (1997) and Seligman and Zirino (1998), estimated average copper leach rates from wetted boat surfaces of 17 micrograms per square centimeter per day ($\mu g/cm^2/day$) for Florida waters along the eastern seaboard. Earley et al. (2014) studied in situ copper release from CBAF in California and found that, after 30 days of immersion, ablative paint had a total copper release rate of 4.16 $\mu g/cm^2/day$, while epoxy paint had a rate of 4.01 $\mu g/cm^2/day$ under steady-state conditions. Earley et al. (2014) also noted copper release rates peaked (>40 $\mu g/cm^2/day$) three days following initial exposure to marine water and cleaning events.

Earley et al. (2014) calculated that total copper loading from both paint types was reduced by around 33% if best management practices (BMPs) were followed (such as cleaning with soft-pile carpet and not abrasive pads). A list of copper leach rates for common CBAF paints, using the International Organization for Standardization (ISO) 10890:2010 method, entitled *Paints and Varnishes – Modeling of Biocides Release Rate from Antifouling Paints by Mass Balance Calculation*, was compiled by the California Department of Pesticide Regulation (Gutierrez 2015) (see also **Section 2.2**).

Automobiles are another potential source of anthropogenic copper to Florida's surface waters. Current literature indicates that the largest source of copper from automobiles is brake pads, which have an average copper content of 5% (Rosselot 2006b). Copper flakes became a common additive to brake pads, after asbestos use was discontinued, because of copper's durability and ability to quickly dissipate heat. With each use of the brake pad, a small amount of copper-containing material is released and deposited nearby. Brake pads may be responsible for 50% to 75% of total atmospheric copper emissions in Western Europe (van der Gon et al. 2007). Brake pads were found to be a significant contributor of copper to urban runoff in San Francisco (Looker 2007). Whiley (2011) estimated that brake pads on cars contribute 0.66 milligrams per kilometer (mg/km) or 425 grams per kilometer per year (g/km/yr) of copper in the Puget Sound Basin (see also **Section 2.2**).

Chapter 4: Determination of Assimilative Capacity

4.1 Determination of Loading Capacity

The copper TMDLs for Naples Bay, Haldeman Creek and Rock Creek are based on the applicable copper criteria in Chapter 62-302, F.A.C., used to verify impairment (see **Chapter 2**). The goal of this TMDL analysis is to determine the necessary reductions in copper to meet the existing copper criterion for marine waters to maintain their function and designated uses. These percent reductions represent the relative difference between the existing and target copper concentrations.

4.2 Determination of Percent Reductions

To show the difference between the existing copper concentrations and the applicable target concentrations in verified impaired waters, a needed percent reduction was calculated. This is the reduction that is needed in the three estuarine WBIDs to meet the marine copper criterion. To be protective of the waterbody, the calculated percent reductions were to reduce the maximum of the observed copper concentrations to the marine criterion of 3.7 µg/L.

The equation used to calculate the percent reduction is as follows:

$$\frac{[\text{marine criterion - maximum exceedance}]}{\text{maximum exceedance}} \text{ X } 100$$

For all three estuarine WBIDs, the period of 2011–20 was selected for the calculation because this ten-year period represents the most recent continuous data record. The copper data in Naples Bay ranged from 0.1 to 8.4 µg/L, in Rock Creek the data ranged between 0.14 and 7.03 µg/L, and in Haldeman Creek the copper data range was from 0.48 to 23.8 µg/L.

Before calculating the percent reduction based on a maximum observation, it is essential to assess whether the highest concentrations are potential outliers or are representative of the highest magnitude of the actual range of concentrations in order to obtain reductions based on measured copper concentrations. To provide a conservative test for outliers, the distribution of copper data was examined based on a fit to a normal curve, and the distribution of the data was represented as box and whisker plots. Box plots are a common means of showing the distribution of data where the upper and lower borders of the box represent the 75^{th} and 25^{th} percentile of the data and the middle 50% of the data around the median is captured in the interquartile ranges (IQR). **Figure 4.1** shows the distribution of observed copper concentrations in Naples Bay for the 10-year period on the left and **Figure 4.2** shows the copper data distributions for Haldeman Creek and Rock Creek.

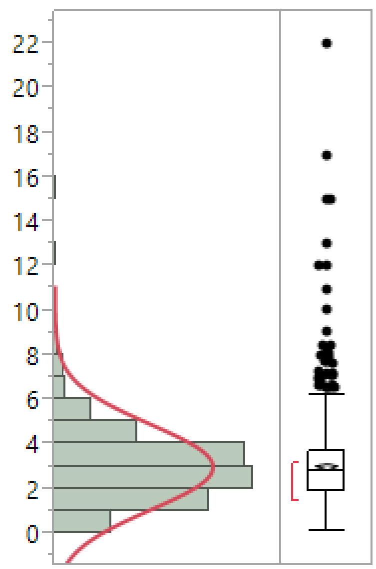

Figure 4.1. Distribution of Observed Copper Concentrations From 2011–20 for WBID 3278R4 (Naples Bay)

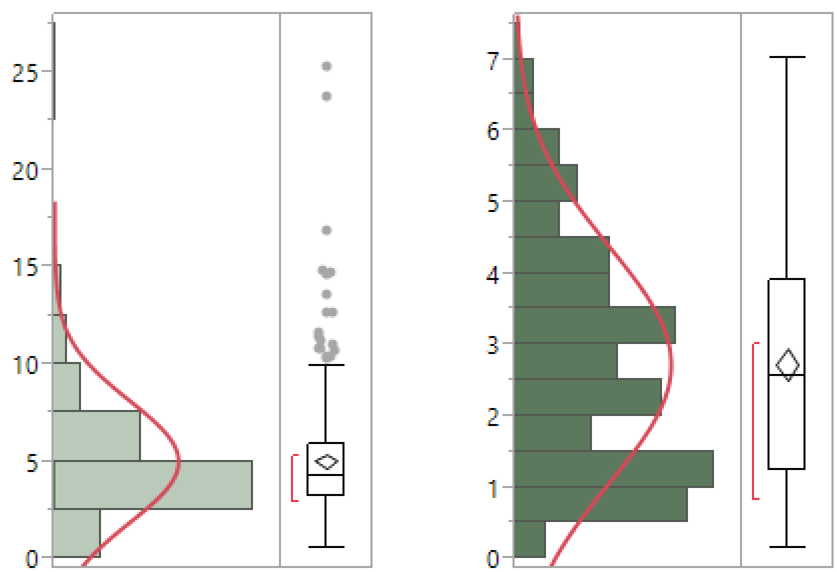

Figure 4.2. Distribution of Observed Copper Concentrations From 2011–20 for WBID 3278R1 (Haldeman Creek) on the Left in Light Green and for WBID 3278R3 (Rock Creek) on the Right in Dark Green

In this approach to detecting outliers, a set of bounds, or "fences", is determined for the distribution. Upper fences are set above the upper border of the box plot and lower fences are set below the lower border of the box plot. Each pair of fences brackets the data above and below the IQR. Data between the fences can be assumed to be within the normal range of variation of the data and data outside the area bounded by the fences are marked as potential outliers. For this analysis, the upper fences were used to determine whether the maximum values were potential outliers. Outlier low concentrations were not necessary. Data above the inner fence but below the outer fence can be considered mild outliers and data above the outer fences are extreme outliers. Considering only the upper inner and outer fences, the inner fence corresponds to the third quartile of the data plus 1.5 * IQR and the outer fence corresponds to the third quartile of the data plus 3 * IQR. For instance, in Naples Bay the IQR is 1.96 and based on this analysis the inner fence would be set at 6.50 µg/L and the outer fence would be set at 9.44 µg/L. As a conservative assumption, only the extreme outliers above the upper outer fence of 9.44 µg/L would be identified in this analysis. **Table 4.1** lists the IQR and respective inner and outer upper fences for each of the three estuarine WBIDs. **Figures 4.3–4.5** display the observed copper concentrations over the 2011–20 period as well as the inner and outer fences for Naples Bay, Rock Creek, and Haldeman Creek, respectively. None of the data in Naples Bay or Rock Creek are above the outer fences for their distributions. No outliers were detected and the maximum observed copper concentrations in the most recent 10-year period were used to set the percent reduction in those two WBIDs. In Haldeman Creek there are a total of six observations above 12.67 µg/L that are identified as potential outliers. The calculated percent reduction using the maximum value of 11.62 µg/L that was not a statistical outlier results in a 68% reduction in copper concentration for Haldeman Creek.

Table 4.1. IQRs and Inner and Outer Upper Fences for Each WBID

Waterbody	IQR	Inner Upper Fence	Outer Upper Fence
Naples Bay	1.96	6.50	9.44
Rock Creek	2.68	7.90	11.92
Haldeman Creek	2.41	9.05	12.67

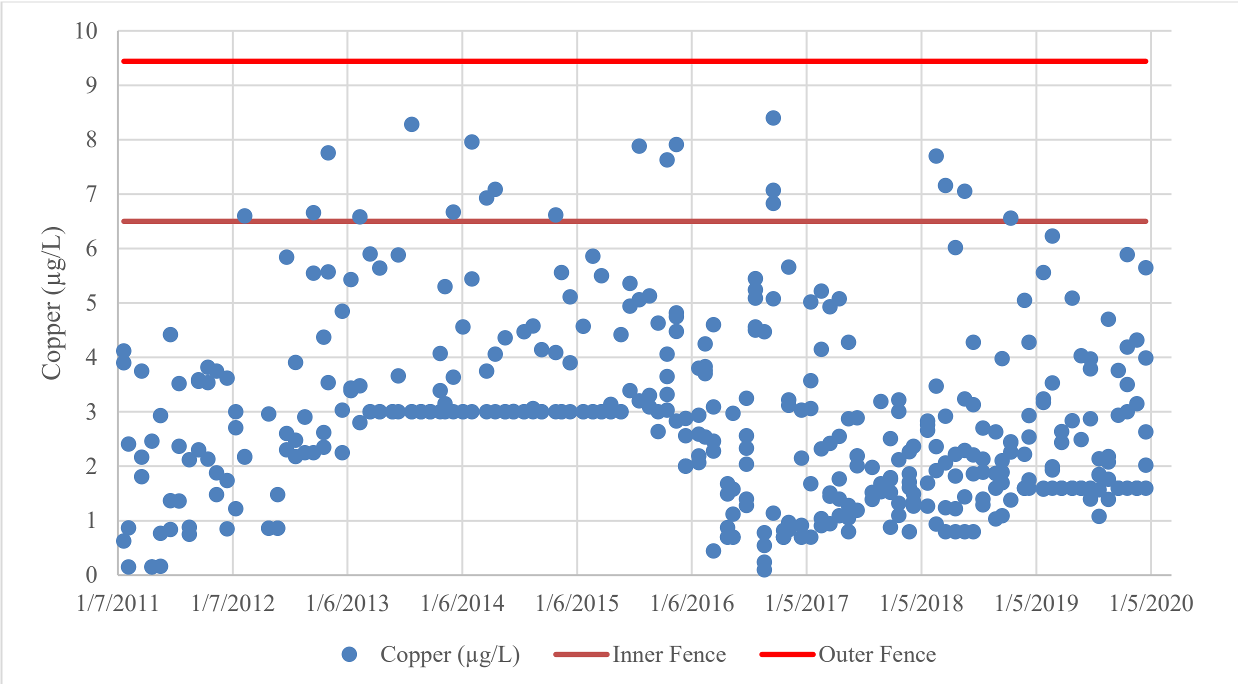

Figure 4.3. **Time-series of Observed Copper Concentrations in Naples Bay from 2011–20 with the Upper Fences Shown (Outer Fence in Red And Inner Fence In Orange)**

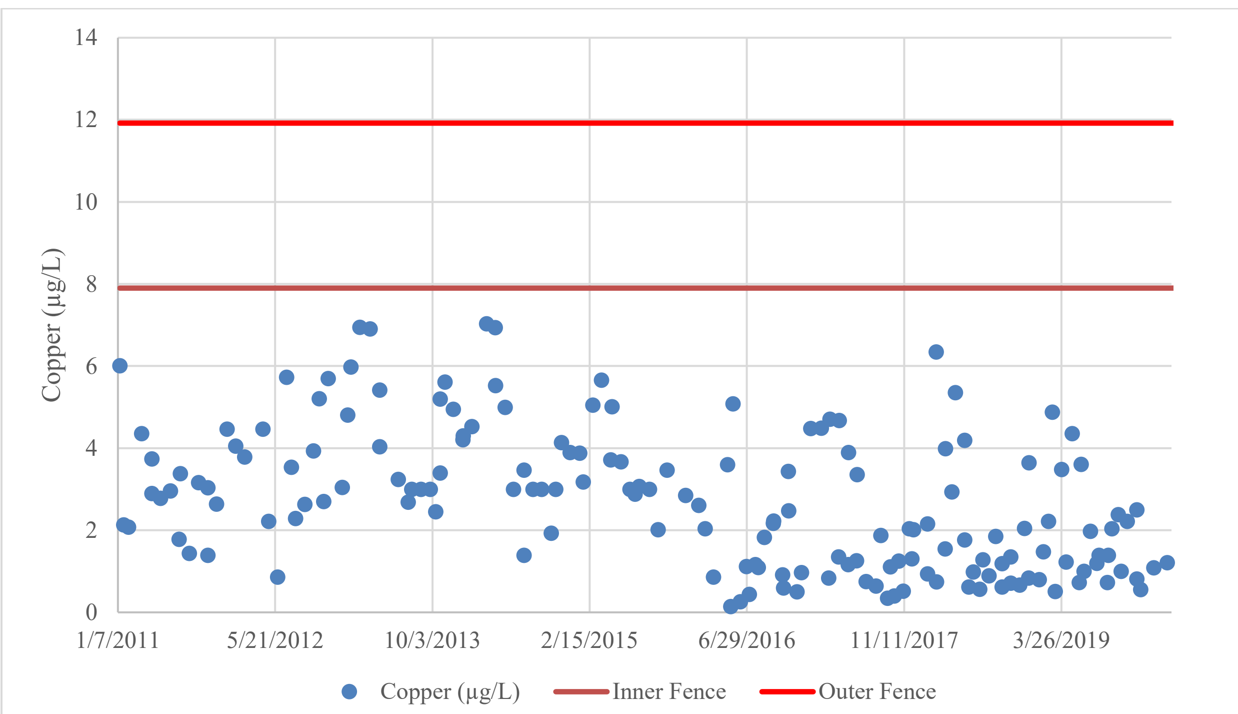

Figure 4.4. **Time-series of Observed Copper Concentrations in Rock Creek from 2011–20 with the Upper Fences Shown (Outer Fence in Red And Inner Fence In Orange)**

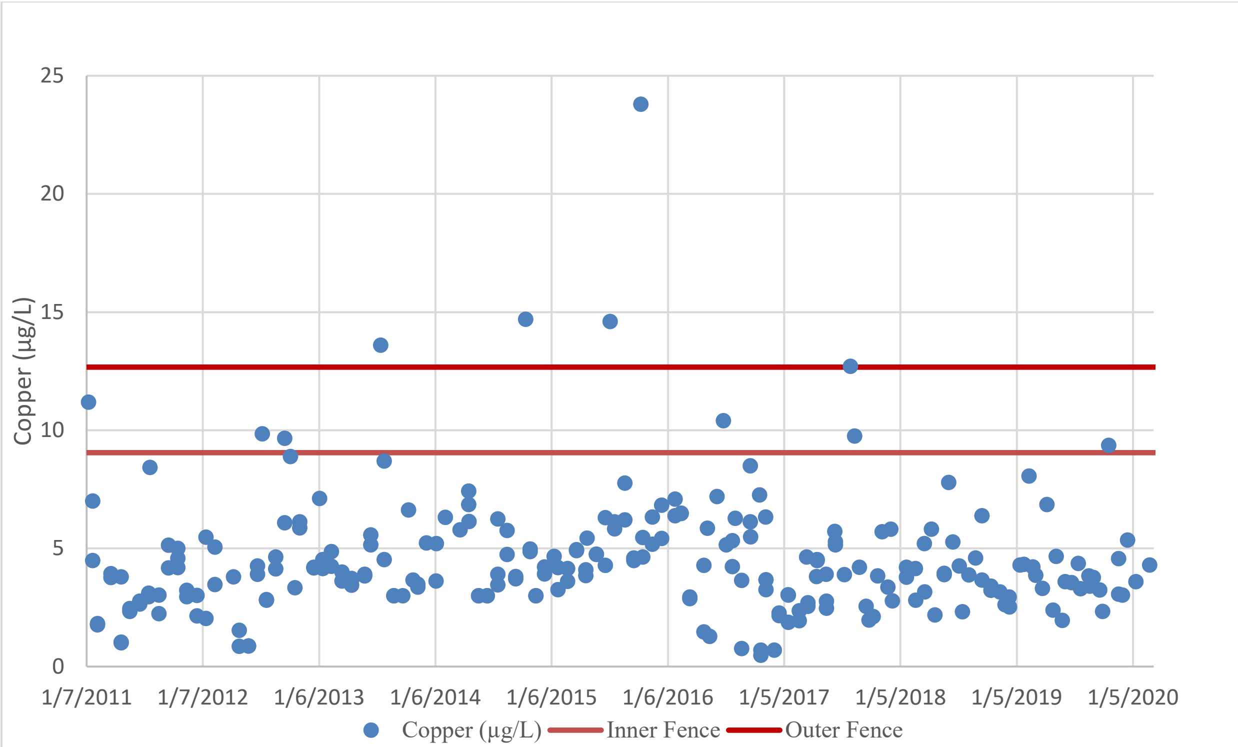

Figure 4.5. Time-Series of Observed Copper Concentrations in Haldeman Creek From 2011–20 With The Upper Fences Shown (Outer Fence in Red and Inner Fence in Orange)

Naples Bay Percent Reduction

$$\left|\frac{\textit{marine criterion } (3.7) - \textit{maximum exceedence } (8.5)}{\textit{maximum exceedence } (8.5)} x100\right| = 56\%$$

Rock Creek Percent Reduction

$$\left|\frac{\textit{marine criterion } (3.7) - \textit{maximum exceedence } (7.0)}{\textit{maximum exceedence } 7.0} x100\right| = 47\%$$

Haldeman Creek Percent Reduction

$$\left|\frac{\textit{marine criterion } (3.7) - \textit{maximum exceedence } (11.62)}{\textit{maximum exceedence } (11.62)} x100\right| = 68\%$$

Chapter 5: Determination of Loading Allocations

5.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating loads to all the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS), which accounts for uncertainty in the relationship between effluent limitations and water quality:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (1) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day). Stormwater reductions are included in both the MS4 WLA and LA, as applicable. However, in determining the overall stormwater reductions needed, DEP does not differentiate between the MS4 WLA and LA, and instead applies the same overall reductions to both as if the two categories were a single category source, unless otherwise specified.

WLAs for stormwater discharges are typically expressed as "percent reduction" because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the "maximum extent practical" through the implementation of BMPs.

This approach is consistent with federal regulations, which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure—see 40 Code of Federal Regulations (CFR) § 130.2(i). The TMDLs for Haldeman Creek, Rock Creek, and Naples Bay are expressed in terms of percent reductions of copper concentrations necessary to meet the marine criterion for copper (see **Table 5.1**). These TMDLs are expressed as maximum copper concentrations that are not to be exceeded.

Table 5.1. TMDL Components for Nutrients in Haldeman Creek, Rock Creek, and Naples Bay

Note: The TMDL target concentration is simply the marine criterion for copper of 3.7 µg/L
NA = Not applicable; margin of safety is implicit.
* The required percent reductions listed in this table represent the reductions from all sources

Waterbody (WBID)	Parameter	TMDL Target Concentration (µg/L)	WLA Wastewater (% reduction)	WLA NPDES Stormwater (% reduction)*	LA (% reduction)*
3278R1	Copper	3.7	NA	68%	68%
3278R3	Copper	3.7	NA	47%	47%
3278R4	Copper	3.7	NA	56%	56%

5.2 Load Allocation

To achieve the LA for Haldeman Creek (WBID 3278R1), a 68% reduction in current copper concentrations is necessary. For Rock Creek (WBID 3278R3), a 47% reduction in current copper concentrations is required. To achieve the LA for Naples Bay (WBID 3278R4), a 56% reduction in current copper concentrations is necessary. The needed reduction from anthropogenic inputs will be calculated based on more detailed source information when a restoration plan is developed. It should be noted that the LA includes copper sources from stormwater discharges regulated by DEP, the water management districts, and other entities that are not part of the NPDES stormwater program (see **Appendix A**).

5.3 Wasteload Allocation

5.3.1 NPDES Wastewater Discharges

As noted in **Chapter 3**, no active NPDES-permitted facilities discharge into Haldeman Creek, Rock Creek, or Naples Bay. Therefore, a WLA for wastewater discharges is not applicable.

5.3.2 NPDES Stormwater Discharges

The MS4 permittees/co-permittees in the Naples Bay, Rock Creek, and Haldeman Creek watershed are Collier County and the City of Naples. The Phase II NPDES MS4 permits are FLR04E037 (Collier County) and FLR04E080 (City of Naples). Areas within these jurisdictions in the watershed are responsible for an 68% reduction in copper concentrations into Haldeman Creek, a 47% reduction in copper concentrations into Rock Creek, and a 56% reduction in copper concentrations into Naples Bay. The stormwater reductions for the TMDLs are those necessary (along with other sources) to meet the copper criterion for marine waters.

It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over. It is not responsible for reducing other nonpoint source loads in its jurisdiction.

5.4 Margin of Safety (MOS)

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of these TMDLs. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody (CWA, Section 303(d)(1)(c)). Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as in predicting water quality response. The effectiveness of management activities in reducing loading is also subject to uncertainty. Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of the TMDLs because of the conservative assumptions that were applied. One such conservative assumption is that the percent reductions were calculated from the highest measured copper concentration.

Chapter 6: Implementation Plan Development and Beyond

6.1 Implementation Mechanisms

Following the adoption of a TMDL, implementation takes place through various measures. The implementation of TMDLs may occur through specific requirements in NPDES wastewater and MS4 permits, and, as appropriate, through local or regional water quality initiatives or basin management action plans (BMAPs).

Facilities with NPDES permits that discharge to the TMDL waterbody must respond to the permit conditions that reflect target concentrations, reductions or WLAs identified in the TMDL. NPDES permits are required for Phase I and Phase II MS4s, as well as domestic and industrial wastewater facilities. MS4 Phase I permits require a permit holder to prioritize and act to address a TMDL unless management actions to achieve that particular TMDL are already defined in a BMAP. MS4 Phase II permit holders must also implement the responsibilities defined in a BMAP or other restoration plan (e.g., a reasonable assurance plan).

6.2 BMAPs

Information on the development and implementation of BMAPs is available in section 403.067, F.S. DEP or a local entity may initiate and develop a BMAP that addresses some or all of the contributing areas to the TMDL waterbody. BMAPs are adopted by DEP Secretarial Order and are legally enforceable.

BMAPs describe the fair and equitable allocations of pollution reduction responsibilities to the sources in the watershed, as well as the management strategies that will be implemented to meet those responsibilities, funding strategies, mechanisms to track progress, and water quality monitoring. Local entities, such as wastewater facilities, industrial sources, agricultural landowners, county and city stormwater systems, military bases, water control districts, state agencies, and individual property owners usually implement these strategies. BMAPs can also identify mechanisms to address potential pollutant loading from future growth and development.

Additional information about BMAPs is available online.

6.3 Implementation Considerations for the Waterbody

The goal of these TMDLs is to achieve the copper criterion for marine waters in support of aquatic life support. In the case of copper, there are a number of potential non-traditional anthropogenic sources that need to be accounted for. The principal nonpoint sources include copper-containing herbicides and algicides as well as marine antifouling agents. These sorts of nonpoint sources are amenable to behavioral changes as opposed to infrastructure investment.

Such changes would include applying algicides and herbicides only as needed and selecting appropriate non-cuprous herbicide and algicide alternatives.

The MS4 entities of Collier County and the City of Naples have identified potential copper sources in the local watersheds. They have determined that the majority of copper in local waterways is dissolved rather than suspended and have concluded that most of this copper is likely entering via treated stormwater ponds. They have taken steps to reduce copper through education and outreach and by stopping all copper-herbicide applications on properties owned and maintained by Collier County and the City of Naples. However, additional actions are still needed to address copper impairments.

Additional actions may include reducing or eliminating cupric algicide applications in private stormwater systems. Current evaluations of existing data have identified private stormwater ponds as one likely source of copper to impaired waters in Collier County. Homeowners' associations and individuals operating private stormwater ponds should follow BMPs and preferentially use non-copper algicides when dealing with algal blooms. The long-term management approach should also include reducing nutrient pollution which ultimately fuels blooms in stormwater ponds. Reducing nutrients at the source, such as limiting fertilizer application, is one effective way of limiting the need to use copper based algicides. In addition, structural nutrient removal projects may be necessary to reduce nutrient runoff associated with impervious surfaces. Finally, there are a number of products that can reduce nutrient concentrations in a waterbody if the above approaches are insufficient to fix the problem.

Another important restoration tool would be to reduce copper coming from antifouling agents on boats and marine infrastructure. DEP's Clean Marina Program and Clean Boater Program may be integral to those efforts. Individuals and entities removing and applying copper based antifouling paints should follow BMPs to contain and cleanup paint to limit runoff to waterbodies. Further mitigation measures above the BMPs may be needed where this source is demonstrated to be a significant contributor to copper impairments.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C. In 1994, DEP stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations, as authorized under Part IV of Chapter 373, F.S.

Chapter 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) Program plan, another watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal CWA Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990 to address stormwater discharges associated with industrial activity, including 11 categories of industrial activity, construction activities disturbing five or more acres of land, and large and medium MS4s located in incorporated places and counties with populations of 100,000 or more.

However, because the master drainage systems of most local governments in Florida are physically interconnected, EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 special districts, community development districts, water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. DEP received authorization to implement the NPDES stormwater program in 2000. The authority to administer the program is set forth in section 403.0885, F.S.

The Phase II NPDES stormwater program, promulgated in 1999, addresses additional sources, including small MS4s and small construction activities disturbing and one to five acres, and urbanized areas serving a minimum resident population of at least 1,000 individuals. While these urban stormwater discharges are technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility. It should be noted that Phase I MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.