A Systematic Approach for Addressing Total Maximum Daily Loads Along the Halifax River

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Figure 1. Project Study Areas

The Halifax River is a 25-mi-long estuary located in eastern Volusia County (County) that extends from Tomoka Bay south to Mosquito Lagoon and connects to the Atlantic Ocean via the Ponce De Leon Inlet. It is part of the Intracoastal Waterway and has popular recreational uses, including boating, fishing, and wildlife viewing. The Halifax River watershed is highly urbanized and receives stormwater runoff from the unincorporated County and several municipalities, including Ormond Beach, Holly Hill, Daytona Beach, South Daytona, and Port Orange.

In 2013, the Florida Department of Environmental Protection (FDEP) adopted a total maximum daily load (TMDL) for nutrients for a portion of the Halifax River. The river was also listed as impaired for copper (Cu). The County road and bridge division has taken a proactive approach in identifying innovative solutions to address the impairments early on in this highly urbanized watershed prior to formal TMDL implementation by the state of Florida. The nutrient TMDL requires a 9 percent reduction in total nitrogen (TN) from nonpoint sources.

Project Objective

This project consisted of a stormwater outfall assessment to identify potential operation and maintenance (O&M) activities and best management practice (BMP) implementation to improve water quality of discharges to impaired waters in the Halifax River. The study area for this project focused on those unincorporated areas of the County with direct outfalls to the river from the Halifax Peninsula area, as shown in Figure 1. The systematic approach for addressing TMDLs included:

- A detailed inventory of the County's stormwater and septic tank infrastructure.
- Evaluation of current operation and maintenance (O&M) practices by the County within the study area.
- Investigation of potential pollutant sources within the study area causing the water quality impairment.
- Identification of best management practices (BMPs) to reduce nonpoint source pollution to the river from unincorporated areas.
- Overall recommended plan for implementation.

Stormwater Inventory

Available data from the County, FDEP, St. Johns River Water Management District (SJRWMD), and other government agencies that supported the evaluation as it pertained to County outfalls to the Halifax River were reviewed. The County provided a comprehensive inventory of its existing stormwater infrastructure and BMPs, which were field-verified for the project study area.

The collected data were used to assess current BMP effectiveness and calculate pollutant loadings to each of the outfalls. The loading values were then used in determining the most effective BMPs and pollutant reduction potential under proposed conditions. Table 1 summarizes the stormwater infrastructure inventory for the project study area.

Stormwater Inventory Component	Quantity (from GIS Datasets)
County Stormwater Conveyance Pipes	19 Miles
County Retention Ponds	17
Street Sweeping Routes	14.5 miles
Stormwater Outfalls	48
- Piped	45
- Open Channel	3
Stormwater Structures	1,095
- Inlets	863
- Manholes	154
- Headwalls	18
- Pipe End	21
- Other	39

Table 1. Study Area County Stormwater Inventory

Operation and Maintenance Practices and Recommendations

Currently, the County has a comprehensive O&M program that routinely addresses stormwater infrastructure components present in the Halifax River study area. An overview of the O&M practices for all of the County stormwater facilities in the study area is summarized in Table 2.

Table 2. County Operation and Maintenance Practices and Reported Frequencies Within Study Area

BMP	O&M Activity	Frequency
Swales	Mowing/Debris removal	As needed (regular visual inspections)
Retention Basins	Mowing and sediment cleanout	Mowing: 4 times per year Sediment Removal: Once every 5 years
Inlets, Pipes, and Outfalls	Blockage/Flood Control	Blockage: 5-6 times per year Cleanout: Once every 10 years
Stormwater Structures	Cleanout CDS unit for sediment and pollutants	2 times per year
Open Channels	Weed control, blockages, and sediment removal	Spray: 3 times per year Blockages: as needed Sediment Removal: once every 10 years
Street Sweeping	Mechanical sweeping of curbed streets	3 times per year

To support the County's O&M program, a database was created to provide critical O&M details for the tributaries upstream of each outfall to the Halifax River. The database contained attributes, such as land use, soil type, roads, relevant stormwater infrastructure, existing upstream BMPs, and O&M practices associated with each outfall subbasin. Google® Street View was used to summarize the curb type of the roads corresponding to each outfall subbasin and the County's street-sweeping geographic information system (GIS) layer to assess which curbed streets were on the County street-sweeping route. Observed O&M issues were also noted, which included any observations that were made during project field visits.

Recommendations meant to supplement or enhance the County's current program were provided for exfiltration trenches, street sweeping, and stormwater treatment structures.

Street Sweeping

Recommendations with respect to street sweeping were based on literature review, observation of the study area, and laboratory analysis of collected street-sweeping samples. The County street-sweeping program only includes curbed streets, which assists with containing the debris within the right of way (ROW). Additional curbed routes upstream of outfalls with curbs that were not being swept were identified and recommended for inclusion into the program. Also, recommendations for optimal performance based on guidance from American Public Works Association (APWA, 2009), including speed, frequency, target pollutants, and sweeping locations, were included as part of the overall recommended plan:

- Frequency of sweeping residential streets with low traffic volumes should be at least quarterly.
- Analyze the sediment (<2,000 microns) for key pollutants, such as total petroleum hydrocarbon (TPH), metals (zinc, copper, and lead), phosphorus, and nitrogen to obtain value (mg/kg).
- Calculate average amount of material per curb mi swept.
- Regenerative air and vacuum sweepers have higher removal rates and are more effective at removing small particles than mechanical sweepers.

As part of the analysis, a composite sample of street-sweeping-collected materials were sent to a laboratory to quantify the nutrient content. The purpose was to determine if there would be additional benefit by increasing the frequency and/or modifying the types of street-sweeping equipment. The County had samples of its street sweepings from three different areas analyzed. The results of the samples, along with guidance from a municipal separate storm sewer system (MS4) study sponsored by the Florida Stormwater Association (University of Florida, 2011), were used to estimate street-sweeping load removals, as shown in Table 3. The results suggest that increasing the frequency and including the additional sweeping routes would provide additional benefit in the removal of nutrients from the County's MS4 and, ultimately, the Halifax River.

Table 3. Estimated Street Sweeping Load Removal Within Study Area (14.5 mi/29 curb mi swept)

Constituent	Concentration (mg/kg)	Recovery of PM per mile (kg)[1]	Frequency per Year	Load Removed (kg/yr)
Total Nitrogen (TN)	1,650 mg/kg	147 kg	3	21.1
			4	28.1
Total Phosphorus (TP)	609 mg/kg	147 kg	3	7.8
			4	10.4
Copper (Cu)	5.8 mg/kg	147 kg	3	0.07
			4	0.1

1. Estimates based on guidance obtained from MS4 Assessment Project (University of Florida, 2011)

Exfiltration Trenches

The County's current maintenance practices for exfiltration trenches are identical to that

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of the inlets, pipes, and outfalls. Several of the exfiltration systems in the Halifax watershed were constructed with a fixed concrete weir wall located in the downstream catch basin, which increased detention time and allowed for effective exfiltration to occur. Due to the constricted ROW, the County is limited to junction boxes no larger than type C, which are unable to provide adequate space to house a fixed weir structure and also allow room for proper maintenance.

Eventually, the fixed weir structures were demolished in order to obtain access for debris removal, subsequently impacting exfiltration performance. Based on these constraints, one recommendation is to retrofit the fixed and/or demolished weirs with stop log weir structures (e.g., aluminum or reinforced plastic) that can be removed for maintenance purposes and then replaced afterwards. Stop logs are typically long rectangular beams or boards that are placed on top of each other and dropped into premade slots inside a weir. Another option, which would be more costly, is to include an additional manhole on the downstream side of the junction box to house the fixed weir if a stop log weir structure is not permitted.

Baffle Boxes

The County is anticipating the installation of baffle boxes within the study area as a component of ongoing projects and to reduce overall pollutant load to the river. Several baffle boxes were also recommended as part of this study. Maintenance recommendations are based on guidance from FDEP and previous experience:

- Cleanout schedule based on the observed needs of the individual baffle boxes, rather than a set quarterly or monthly cleanout schedule.
- Better tracking of the amount of organic material removed from the boxes can also aid in directing more maintenance efforts toward boxes that need frequent cleanouts and optimizing effectiveness.
- Routine maintenance is key for baffle box performance, as sediment accumulates in the box, the chance for resuspension of accumulated material increases, and pollutant removal efficiencies can decline.
- Manholes should be located within 15 ft of a paved surface to allow access by vacuum trucks for box maintenance.
- Standing water that accumulates in the baffle box may become stagnant, leading to odor and/or mosquito breeding problems. Bottom weep holes to drain standing water should be considered, if existing groundwater conditions allows for it.

Potential Pollutant Source Evaluation

The parameters of concern for the Halifax River include TN and Cu. The TN was identified as the limiting nutrient in the adopted TMDL, which requires a 9 percent reduction from nonpoint (stormwater) sources. The Halifax River is also currently impaired for Cu. Potential pollutant sources for nutrients and Cu were evaluated as part of this study.

Commercial and Industrial Facilities

Commercial and industrial businesses within the study area were reviewed based on the Standard Industrial Classification (SIC) code and North American Industrial Classification System (NAICS) code in order to identify potential pollutant sources. The search results did not produce any facilities within the unincorporated area that could potentially contribute any significant amount of Cu or nutrients to the Halifax River. Further review of the ambient water quality data indicated that it may be coming from a localized source to the river outside of the study area. The County indicated that it did not use copper sulfate, a commonly used herbicide, as part of its O&M practices within the study area.

Domestic and Industrial Wastewater Point Sources

Another resource used to identify potential Cu and nutrient contributions to the Halifax River is the FDEP wastewater facility regulation (WAFR) database. The database consists of domestic and industrial wastewater facilities and provides key information, such as address, National Pollutant Discharge Elimination System (NPDES) facility designation, ownership, facility type, and treatment process.

The nutrient contributions from point sources (domestic wastewater) have been documented in the 2013 TMDL report, appeared to be meeting advanced wastewater (AWT) standards, and did not receive a wasteload allocation from FDEP. Several discharge monitoring reports (DMRs) for the wastewater treatment facilities (WWTFs) and water reclamation facilities (WRFs) with discharge to the Halifax River were reviewed to see if monitoring of Cu in the effluent discharge is part of the facility's permit condition. Review of the DMRs indicated that only TN, total phosphorus (TP), dissolved oxygen (DO), biochemical oxygen demand (BOD), and total suspended solids (TSS) are monitored and reported for the facilities.

Septic Tanks

There are approximately 1,475 septic tanks within the North Peninsula and 300 septic tanks in the South Peninsula. The 2013 TMDL report estimated 19.3 lbs-N per drainfield and assumed that loading from all 1,030 septic tanks reached the Halifax River (water body identification unit [WBID] 2363B) without any denitrification. Based on these assumptions, the TMDL report estimated the septic tank loading to the WBID to be 19,845 lbs-N per year.

Since the study area has relatively uniform soil and topographic gradients, the conditions were suitable for a limited desktop study to be performed to estimate septic tank contributions. This approximation suggested that septic tank contributions as part of the TMDL were likely overestimated, as calculations suggest that the 1,475 septic tanks in the study area contributed approximately 5,000 lbs-N per year. In order to verify these estimates, site-specific geotechnical and groundwater data, in conjunction with complex computational modeling, would be required to more accurately assess and confirm the nitrogen fate and transport for the septic tanks in the study area. Detailed fate and transport analysis were not included as of this study.

Potential sources of Cu associated with septic tanks were also considered. Copper sulfate dosing in septic tanks is a common practice to control root growth and destroy existing roots impacting the system. There was not enough information to determine if privately owned septic tanks receive dosing of copper sulfate in the study area. For public outreach purposes, the recommended copper sulfate dosage rates are 2 lbs per 300 gal of tank capacity and no more than two applications per year.

Pollutant Source Conclusions

The study area consisted of primarily residential land uses, which typically have higher nutrient loading rates compared to other land uses. After reviewing the potential sources listed previously, the findings were consistent with the findings of the nutrient TMDL report for the Halifax River. The TMDL report indicated that surface runoff, groundwater inflow, and septic tanks are the sources for nonpoint source nutrient load.

As a result of the potential source review, this study focused on identifying and recommending BMPs in subbasins that currently do not have treatment and have direct connections to the existing outfalls. As indicated in the TMDL report, septic tanks in the study area likely have some influence on TN concentrations, especially due to the higher discharges of nitrates associated with septic tanks. Areas immediately along the Halifax River should be considered by the County as candidates for septic tank phase-out over time.

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As it relates to Cu impairments in the Halifax River, the unincorporated portion of the County does not appear to be a significant contributor. Through tracing monitoring stations provided in the impaired waters rule (IWR) database available from FDEP, the source of Cu impairment is located outside the County's jurisdiction.

Best Management Practices Evaluation

Based on a review of the stormwater inventory, discussions with the County, and information collected during the site visit, priority subbasins were identified in both the North and South Peninsula study areas. As several outfalls in the study area currently have some form of BMP treatment in place, the priority subbasins were primarily selected based on the lack of existing stormwater treatment. Thus, 15 recommended BMP alternatives were developed, their net benefit in terms of pollutant load reductions to the Halifax River were assessed, and conceptual cost estimates were also developed.

Best Management Practices Selection

The BMPs were selected by assessing the characteristics of the study area and having active discussions with the County. The study areas are almost entirely built out, which requires BMPs that have little to no footprint. The County prefers BMPs that it is familiar with and fit into its current capital and O&M program. Additional information is included to support each decision.

Exfiltration Trenches

As part of its maintenance program, the County has been systematically replacing older (mostly corrugated metal pipe) outfall systems with exfiltration. It is recommended to continue this practice in the priority subbasins indicated.

Inverted Crowns

Another concept recommended to the County to address the space limitations is to install the exfiltration trench (inlets and/or piping) along the center of the road, taking care to avoid utility conflicts. The crown of the road is inverted to capture and convey water toward the inlet. Care should be taken to maintain a slope on the road, such that long-term ponding does not occur; the Florida Department of Transportation Type V inlets can be used to avoid differential settlement. This type of installation can be constructed in parallel with existing stormwater infrastructure to help avoid conflicts during construction with driveways, resident yards, and other potential utilities. Inverted crowns create less disturbance to the residents' yards, can provide cost savings, and have been successfully implemented in other communities.

Biosorption Activated Media

The County has expressed interested in incorporating an innovative biosorption activated media (BAM) into existing and proposed BMPs, as applicable. Typical BAM components include tire crumb, expanded clay, and existing soil. Field studies using BAM as a component of various stormwater BMPs have reported excellent performance measures for nutrient reduction, which report up to 73 percent reduction in TN from a 24-in. layer of BAM (Wanielista et al, 2015).

The County currently has 19 existing retention basins in the study area. One retention basin proposed as part of this study would potentially increase nutrient removal rates by incorporating BAM. Other applications include upflow filters, septic drainfield media, and offline filtration.

Baffle Boxes

The County is planning on constructing baffle boxes in the study area as part of current ongoing projects and several boxes were recommended as part of the BMP evaluation for this study. Baffle boxes are viable options for nutrient reduction, which fits the goal of the study area. The study area also has curb and gutter systems that are set up to support end-of-pipe treatment, such as baffle boxes, which can handle the large amount of trees and vegetation, as they are designed to collect and retain leaves and other organic debris.

Best Management Practices Analysis

In order to evaluate the benefit provided by the recommended BMPs, the pollutant load reduction was estimated and quantified for each of the proposed projects within their priority subbasins. The Best Management Practices Treatment for Removal on an Annual Basis Involving Nutrients in Stormwater (BMPTRAINS) model (Version 7.4) developed by the Stormwater Management Academy at the University of Central Florida was used. The tool is a Microsoft® Excel spreadsheet model that is used to evaluate stormwater runoff nutrient loads, as well as treatment efficiencies of BMPs based on the findings of studies conducted in recent years within Florida. The 15 projects were ranked using a qualitative assessment criteria-screening matrix. Criteria selected to evaluate recommended conceptual projects included:

- Nutrient load reduction benefits
- Flood benefits
- Cost-effectiveness (in terms of nutrient removal)
- Condition of existing infrastructure
- O&M costs
- Halifax River TMDL limits (discharge to impaired water body segments)

A summary of the 15 projects that include load reductions, conceptual costs, and project rankings are provided in Table 4.

Projected TN removal efficiencies ranged from 45 to 85 percent for TN, depending on the BMP type and acreage of treated area. The conditions at most project locations were similar, therefore the recommended BMPs were consistent. The proposed projects each had some combination of exfiltration trenches, inverted

Table 4. Summary of Proposed Projects and Ranking Results

Project	Description	TN Load Reduction (lbs/yr)	% TN Reduction	Conceptual Estimated Capital Cost	Annual O&M Cost	Rank
10	Exfiltration Trench/Baffle Box	193	75.4%	$479,000	$7,900	1
7	Exfiltration Trench	97	69.5%	$324,000	$2,800	2
2	Exfiltration Trench/Dry Retention Basin retrofit	66	75.5%	$137,000	$5,900	3
11	Exfiltration Trench	100	59.1%	$237,000	$4,400	4
9	Exfiltration Trench	109	68.1%	$364,000	$6,400	5
3	Exfiltration Trench/Baffle Box	161	74.3%	$497,000	$9,800	6
8	Exfiltration Trench	97	66.5%	$352,000	$5,900	7
5	Exfiltration Trench	116	68.5%	$536,000	$7,500	8
4	Exfiltration Trench	91	64.8%	$263,000	$4,400	9
1	Exfiltration Trench	47	69.7%	$124,000	$3,600	10
13	Exfiltration Trench	134	75.6%	$417,000	$6,400	11
15	Exfiltration Trench	79	70.6%	$266,000	$6,100	12
6	Exfiltration Trench/Baffle Box	98	45.3%	$313,000	$7,800	13
12	Exfiltration Trench	32	84.6%	$242,000	$4,200	14
14	Exfiltration Trench	38	84.9%	$106,000	$2,300	15
Totals	-	**1,458**	-	**$4,657,000**	**$85,400**	-

Project Description: Replace existing CMP w/2,740 LF exfiltration trench along Roberta Rd; install weir structures at downstream ends of proposed exfiltration; and, Outfall 22 to be retrofit with a baffle box.

Proposed BMP Type: Exfiltration trench and baffle box	**Receiving WBID:** WBID 2363B
Subbasin Area: 28.5 acres	**Water Quality Impairment:** Within Halifax River TMDL limits
Estimated Treatment Area: 28.5 acres	**TN Load Removal (lbs/yr):** 193
Predominant Land Use: High Density Residential	**TP Load Removal (lbs/yr):** 43
Estimated Conceptual Capital Cost: $479,000	**TSS Removal (lb/yr):** 7,132
Estimated Annual O&M Cost: $7,900	**Cu Removal (lb/yr):** 3.8
TN Cost-Effectiveness ($/lb/yr TN removed): $238	**Required O&M:** Inlet, pipe, and outfall blockage and cleanout
TP Cost-Effectiveness ($/lb/yr TP removed): $1,070	**Age/Condition of Existing Infrastructure:** Fair

Final Project Rank: 1
Final Project Prioritization: High

Figure 2. Example Project Summary for Proposed Project Number 10, Roberta Road

crowns, baffle boxes, and/or biosorption activated media (BAM). An example of a proposed project is provided in Figure 2.

Conclusion

The objective of this study was to evaluate impairment sources, O&M practices, and potential BMP options to reduce pollutant loads to the Halifax River. The results of the evaluation led to a recommended improvement plan.

To assist the County with program implementation and sequencing, a prioritized list was developed for the proposed conceptual BMP alternatives based on information compiled and evaluated as a result of this study. The condition of the existing infrastructure is a major component when prioritizing the individual projects. This criterion was incorporated into the prioritization framework in an effort to tie into the County's existing O&M program. Routine pipe and roadway upgrades were recognized as opportunities to implement exfiltration; however, other critical criteria were factored into the overall ranking for the recommended BMPs, as listed previously. The recommended improvement plan, along with the O&M recommendations, will lead to County compliance with TMDL and future basin management action plans (BMAP).

The adopted TMDL for nutrients is isolated to the North Peninsula study area only. The proposed BMPs in this study area are estimated to remove 1,175 and 229 lb/yr of TN and TP, respectively. The implementation of the recommended BMPs amounts to an estimated 11 and 12 percent reduction in TN and TP from the study areas. Therefore, it appears that implementation of the recommended BMPs in the North Peninsula study area would be on order with the reduction required by the TMDL (i.e., 9 percent reduction for TN).

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