Lemon Bay

WATERSHED MANAGEMENT PLAN

Sarasota County

Southwest Florida Water Management District

Janicki Environmental, Inc.

JONES EDMUNDS
ENGINEERS | ARCHITECTS | SCIENTISTS

Chapter 7

Stormwater Management Facility Maintenance

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

7.0 STORMWATER MANAGEMENT FACILITY MAINTENANCE

7.1 INTRODUCTION

Comprehensive, regular maintenance of stormwater management systems is essential to ensure the efficient function of existing stormwater conveyances and for new stormwater facilities to function within their original design parameters following construction. Maintenance is also required for preventing water quality degradation, controlling exotic plant species, preserving aesthetics, and maintaining public safety.

The Stormwater Environmental Utility (SEU) was established in 1989 "to provide a dedicated source of funding for the operation, maintenance, planning, and improvement of the public stormwater system." The SEU developed a *Strategic Maintenance Plan* adopted in 1999 that established level-of-service (LOS) goals for maintenance activities for the Field Services Group (fka Drainage Operations). The plan identifies maintenance practices and classifies practices into *Routine*, *Extraordinary*, and *Support* activities in which the staff engages for maintenance repairs, improvement, management, and operation of the public stormwater system.

Reorganization within the County grouped facilities maintenance into a single entity now called Field Services. The recently created divisions within Field Services are Water Systems and Road Right-of-Way Systems. Figure 7-1 shows the organizational groups within Field Services. Each group provides inspection and maintenance for their respective areas of responsibility. Funding for stormwater maintenance is derived from the Stormwater Environmental Utility Service Assessment.

Jones Edmunds analyzed current maintenance policies and procedures as part of the Roberts Bay North and Lemon Bay Watershed Management Plans (WMPs) including:

- Evaluating current maintenance practices.
- Identifying additional improvements to stormwater maintenance practices.
- Analyzing best management practices (BMPs) for nutrient reduction efficiency and estimating removal costs.
- Analyzing vegetative growth for flood conveyance impairment.

Identifying maintenance practices to improve water quality without compromising flood control allows maintenance to contribute to meeting the County's environmental goals.

The evaluation found that water quality should receive added considerations in maintenance practices; thus, this section of the WMP focuses on identifying maintenance practices for water quality improvement purposes without compromising the flood control LOS. The practices identified are applicable to all the County's watersheds.

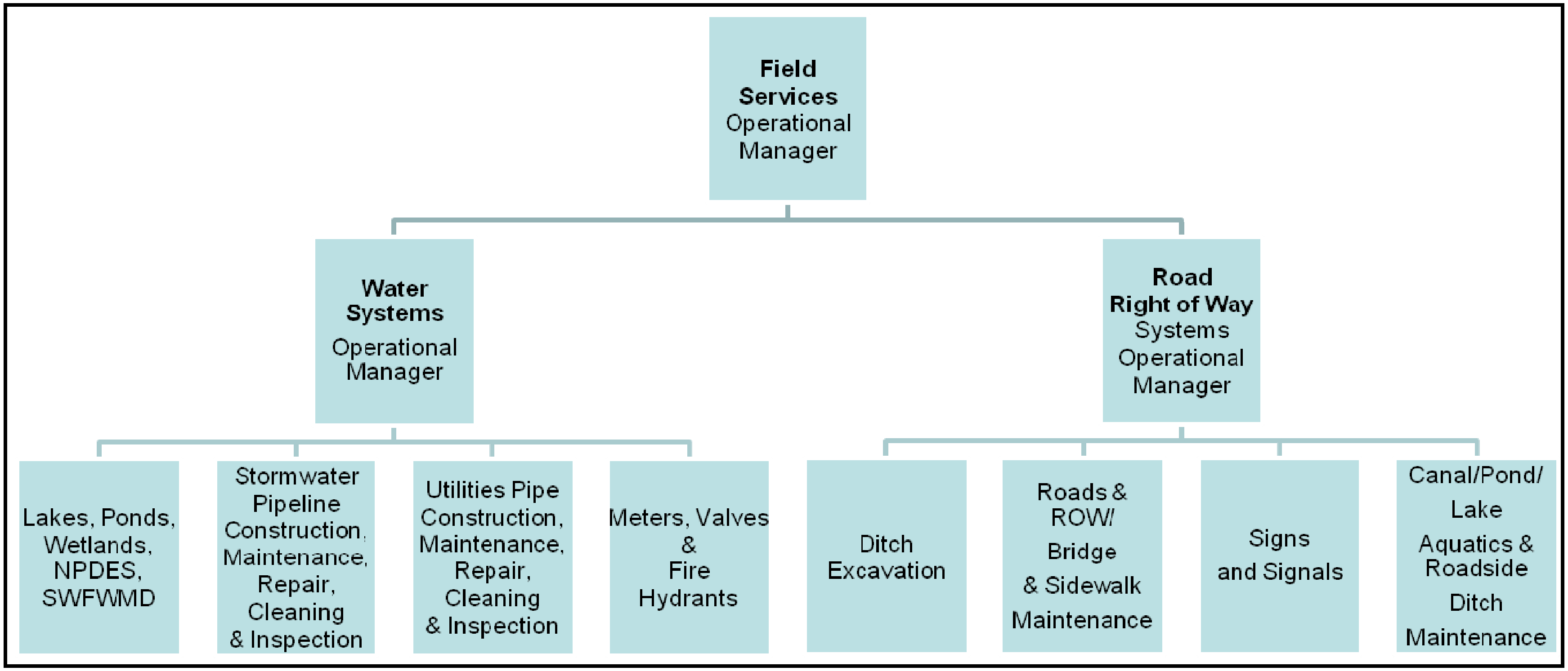

Figure 7-1 Sarasota County Operations and Maintenance Services Organizational Chart

7.2 FACILITIES AND RELATED PROGRAMS

7.2.1 Facilities

The Field Services group is responsible for maintaining a system of canals, lakes, and subdivision retention/detention ponds deeded to the County. Sarasota County has approximately 600 miles of canals, of which 375 miles are maintained by the County. The group also maintains the following types of public stormwater utilities:

- Storm sewers, culverts, pipes, and inlets.
- Water control structures, weirs, and pumps.
- Permitted wetland mitigation sites.
- Roadside ditches.

The *Strategic Maintenance Plan* provides a scoring/scheduling framework to establish priorities for routine system maintenance. The scoring is based on land use, flooding history, and facility type and determines if a facility should be maintained every year, every 2 years, or every 3 years. The total maintenance effort required is calculated; if maintenance demand exceeds the working capacity of the staff, priorities are re-evaluated to balance the demand on the staff to meet their working capacity.

A system inspection schedule is not explicitly outlined in the *Strategic Maintenance Plan* but is referenced as routine inspection programs and internally generated inspection reports.

7.2.2 Related Programs

7.2.2.1 FEMA CRS Program

The Federal Emergency Management Agency (FEMA) offers an incentive program for communities participating in the Community Rating System (CRS) program. Participation is voluntary, and the County chooses to participate to provide lower flood insurance premiums to its residents. The purpose of the program is to recognize and encourage community floodplain management activities that exceed the minimum requirements of the National Flood Insurance Program (NFIP). Premium discounts are provided for the entire County based on a rating system tied to creditable activities within the following categories:

- Public Information.
- Mapping and Regulations.
- Flood Damage Reductions.
- Flood Preparedness.

Within the County's CRS program *Activity 540, Drainage System Maintenance*, is the responsibility of the County's Field Services group, which participates in the following activities:

- Inspecting the stormwater management system.
- Responding to Customer Service Requests.
- Monitoring recurrent problem areas.
- Documenting above activities.

7.2.2.2 NPDES and County MS4 Permit

Sarasota County is a Municipal Separate Storm Sewer System (MS4) operator and holds a National Pollutant Discharge Elimination System (NPDES) permit (Number FLS000004) from the Florida Department of Environmental Protection (FDEP). To maintain the permit, the County has developed a stormwater management program that includes BMPs with measurable goals to effectively implement eight minimum control measures outlined in the 2006 Comprehensive Plan:

1. Maintenance of Structural Controls: Inspect and maintain structural controls. Maintain an internal record keeping system.

2. Development Planning: Adopt stormwater treatment ordinances requirement treatment of the first one inch of runoff. Complete Basin Master Plans. Implement Land Development Practices to reduce impervious surfaces.

3. Roadway Maintenance: Control litter along roads. Sweep Streets. Maintain catch basins, grates and roadside ditches. Properly dispose of wastes. Use Best Management Practices (BMPs) to reduce polluted runoff from road repairs, equipment yards and maintenance shops.

4. Municipal Facilities: Use BMPs to reduce polluted discharges from solid waste transfer lift stations, maintenance and storage yards for waste transportation fleets, and sludge sites.

5. Pesticides, Herbicides, and Fertilizers: Encourage the public to reduce use of pesticides, herbicides, and fertilizers. Train and certify employees handling pesticides, herbicides, and fertilizers. Minimize the use and properly store and mix pesticides, herbicides and fertilizers.

6. Illicit Discharges and Improper Disposal: Inspections, Ordinances, and Enforcement: List non-stormwater discharges allowed into MS4. Inspect and prohibit illicit connections and illegal dumping into the MS4. Use Sarasota

County's Hazardous Materials Emergency Plan to mitigate potential pollutant discharges to surface waters. Support and promote oil recycling, collection of household hazardous wastes. Support and promote marking of storm sewer inlets that discharge into surface waters.

7. Industrial and High Risk Runoff: Prioritize an inventory of all high-risk facilities discharging into the MS4, including outfall and receiving water. Inspect facilities. Monitor high-risk facilities.

8. Construction Site Planning and Inspection and Enforcement: Regulate erosion control through requirement of Erosion Control plans for earth moving activities. Document BMP installation, maintenance and effectiveness. Train inspectors. Use an inspection checklist. Require compliance with stormwater ordinance and local permits. Conduct an annual NPDES workshop for design professionals, land developers, inspectors and contractors.

From the 2000 *Stormwater Environmental Utility Strategic Plan*, the Stormwater Environmental Utility is responsible for several elements of the permit: basin master planning, capital improvement program, stormwater management system inspection, inspection/maintenance of the public drainage system, proper disposal of sediments and other materials, and proper storage and use of herbicides. Field Services provides critical support for four of the measures within the SEU areas of responsibility: Maintenance of Structural Controls; Roadway Maintenance; Pesticides, Herbicides, and Fertilizers; and Illicit Discharge Detection and Improper Disposal. Field Services works with the rest of the County staff to meet the overall goal of the NPDES permit, which is to reduce or prevent impairment of the local waterbodies.

7.3 WATER QUALITY MAINTENANCE PRACTICES AND CONSIDERATIONS

Current stormwater maintenance activities are directed primarily at maintaining the stormwater conveyance function as well as the safety and aesthetic features of the system. The water quality improvement features of the stormwater management facilities should receive equal emphasis. In some cases, this increased focus on water quality can be successful with minor changes to existing routine practices.

Modification of routine maintenance practices may reduce the pollutant load to County waterways. Below is a discussion of several pollutant sources and their impacts to the pollutant load followed by BMP removal efficiencies of these pollutants and a cost/benefit analysis for the removal of pollutants of concern.

7.3.1 Current Practices

Field Services performs activities classified as routine, extraordinary, and support maintenance practices. Generally, routine practices are performed as scheduled or programmed, although recurrent problems are addressed on a relatively consistent schedule and could be called preventive maintenance. As-needed routine maintenance includes:

- Erosion repair.
- Bank stabilization.
- Structure and pipe repair.
- Herbicide spraying.
- Hand clearing.
- Channel dredging for drainage purposes.
- Lake, pond, and mitigation area maintenance and monitoring.
- Vegetative mowing.
- Mechanical system servicing.

Extraordinary maintenance is usually unexpected and generally a response an emergency. The *Stormwater Environmental Utility Strategic Plan* (2000) notes that it is possible to schedule some extraordinary maintenance when deterioration has been observed and documented.

Jones Edmunds held several meetings and conference calls with Field Services to determine the policies and procedures implemented in the field. The topics covered in the meetings with respect to maintenance practices included the following:

- Removing excess vegetation.
- Applying herbicides or growth inhibitors.
- Altering flowpaths.
- Installing check dams or weirs.
- Sodding and seeding.
- Mowing practices.

During meetings with the County, the maintenance staff expressed concern regarding the amount of vegetation in several of the channels and the impact increased vegetation has on flood capacity. Staff regularly denudes the channel banks to restore flood capacity and requested guidance as to a minimal level of vegetation that could remain and not impact flood conveyance or control. This guidance is discussed later in this chapter.

7.3.2 Field Observations of Maintenance Practices

Maintenance practices that could be improved have been noted by County staff as well as during field visits by Jones Edmunds. During the initial meeting with County staff, several examples of undesirable maintenance practices were discussed and photographs shown:

- Woodmere Creek appeared to have had vegetation cut mechanically. The channel and slopes were then denuded, either mechanically or with herbicides. Possibly as a result, there was an approximately 14-inch deep buildup of silt and muck in the channel. Dead vegetation was washed downstream, partially clogging the conveyance. Water quality sampling showed an increase in turbidity and total nitrogen soon after vegetation removal, although this could have been a coincidence.

- Philippi Creek—Channel “Main B” appeared to have fill placed at the bottom of the channel slopes, possibly to remediate slope erosion. The slopes had no vegetation, and there was no vegetation in the channel bottom. A turbidity curtain had been placed in the channel during fill placement but did not appear to be effective. As a result, flowing water was very turbid, a thick layer of muck was observed in the bottom of the channel, and silt had built up in the downstream structures.

- Photographs of Cow Pen Slough showed thick vegetation build-up below the south weir. The County regularly sprays the vegetation but does not remove the decaying plant material from the watercourse.

The negative impacts of these practices on water quality are increased nutrients, increased turbidity, and decreased benthic habitat value.

Sediment management and natural systems tasks in the WMP included site visits and field investigations, during which Jones Edmunds noted current maintenance practices. The following are some examples of maintenance activities observed in the watersheds.

On October 22, 2008 in the Forked Creek subwatershed, on the south side of Overbrook Rd east of Fairview Drive Bridge, we observed improper mowing practices in a drainage swale that drains directly into Forked Creek. The drainage swale had been mowed within the last several days. Dry grass clippings were lying on the side slopes of the swale as well as on a drop inlet directly connected to the creek (Photograph 1). Grass clipping debris was in the bottom of the drop box.

Photograph 1 Grass Clippings Lining Drainage Swale

On October 23, 2008 in the Alligator Creek subwatershed we identified two sites—upstream of the US 41 bridge and the creek adjacent to Dorchester Drive—where maintenance practices were inconsistent with the County's goal of BMPs in the waterways. Herbicides were applied to in-stream vegetation and vegetation on the banks. The location upstream of the US 41 bridge contained approximately 2,000 square feet of water lettuce that had been sprayed and left in the waterway. The rotting vegetation blocked the flow of water and emitted a foul odor (Photograph 2). Additionally, herbicides had been sprayed on vegetation outside of the flowpath, and the vegetation was left to decompose and fall into the waterway. Adjacent to Dorchester Drive, water lettuce was sprayed and left in the waterway and vegetation outside the waterway was sprayed and left to decompose into the waterway.

Photograph 2 Decomposing Water Lettuce Blocking the Flowpath

On October 23, 2008, Jones Edmunds staff visited another site in the Alligator Creek subwatershed at the east end of East Baffin Road. The drainage swales had been completely denuded by an excavator and had not been reseeded (Photograph 3). Sediment was able to flow freely from the downstream end of drainage swales into the tributary of Alligator Creek (Photograph 4).

Photograph 3 Excavated Roadside Drainage Swale

Photograph 4 Erosion at Outfall Pipe

7.3.3 Considerations for Vegetation Removal

Excess vegetation in channels and ditches impacts the flood control capacity of the waterway, so the excess vegetation must be removed to maintain the conveyance capacity of the channel for public safety. However, the current practices of excess vegetation removal by the maintenance staff may result in significant pollutant loading that could potentially be prevented in lieu of other potentially more expensive pollutant reduction measures.

Aquatic and terrestrial vegetation remove nutrients from runoff. When these plants decay, nutrients are released back into the water and environment. Terrestrial vegetation contributes to bank stabilization; removal of the plant and root systems reduces soil moisture capacity and cohesiveness, leading to erosion and excess sedimentation. Both types of vegetation also provide habitat value.

7.3.3.1 Water Quality

A number of attempts have been made to quantify the nutrient (nitrogen and phosphorus) content of wetland plants. Kadlec and Knight (1996) evaluated the ranges of mineral composition of typical plants used in wetland treatment systems. They reported the average nitrogen content to be 2.26% with a range of 1.46 to 3.95% of the dry weight and the average phosphorus to be 0.25% with a range of 0.08 to 0.63% of the dry weight of plant material. Mitsch and Gosselink (1993) report an optimal N:P ratio of wetland plants to be 8:1, concluding nitrogen and phosphorus uptakes by the plant are not independent of each other. They also reported more nitrogen and phosphorus is retained in above-ground plants, with a nitrogen range of 3 g/m^2 to 29 g/m^2. Several studies in Brevard County have quantified the leaching of nutrients into stormwater when the organic constituents are submerged to help facilitate the selection of BMPs. The nutrient leaching cited in these studies was used to estimate the cost per pound of removal of Total Kjeldahl Nitrogen (TKN) and total phosphorus (TP) for several maintenance practices.

One study from Brevard County (Strynchuk et al., 2004) focused on the leaching of nutrients from grass clippings and leaf litter if the solids are trapped in a wet environment BMP. The peak of the leaching process of TKN and P from the organic solid debris into the stormwater system occurs during the first day of submergence. An approximately 11% decrease in the TKN and 54% decrease in the P from the original solids mass corresponds to a 44% increase of TKN and a 746% increase of P in the liquid control volume during that time. The implication from this study is that landscape debris entering the system within hours of cutting or falling will increase the nutrient load in the water. Increased nutrient loads can stimulate excessive algae growth, decrease water clarity, and account for habitat loss. While the study focused on leaf litter and grass clippings, applying herbicides to aquatic plants within the flowpath will have the same outcome and contribute organic nutrients and debris to the system when vegetation is left to decay in the waterway.

A second study in Brevard County (England, 2008) measured the decrease in nutrient content from the drying process in fertilized and unfertilized grass clippings. After 30 days of drying, the reduction in TKN from the samples ranged from 58 to 96%. The drying process resulted in a 23 to 49% reduction in TP. The implication for maintenance is that removing vegetation to a location outside of the channel that allows for drying has a nutrient-load-reduction benefit compared to leaving the material in the channel.

7.3.3.2 Flood Control Capacities

Denuding channel banks is regularly practiced to maintain the flood capacity of the drainage channel. The increased roughness and drag associated with the density and dimensions of plant growth may inhibit the conveyance capacity of the channel, but the removal of all vegetation leads to increased bank instability and erosion and ultimately the sediment is transported and deposited downstream, with potentially adverse impacts. Maintenance crews regularly practice complete removal (denuding) when clearing roadside ditches and swales. Resodding or seeding is completed within 14 days of the excavation. This practice is consistent with the Florida Erosion and Sediment Control Manual direction that “Disturbed areas which are to be stabilized with permanent vegetation must be sodded or planted within 15 days after final grade is reached unless temporary stabilization is applied.”

Maintenance practices may be altered to mow or trim vegetation to a level that will have minimal impact on the conveyance capacity of the channel and prevent destabilization and erosion of the channel banks. Note that when mowing or trimming, grass and vegetative clippings need to be removed from the channel banks to avoid decomposing in the waterway and increasing the nutrient load to the water and bottom sediments.

Vegetation increases the roughness of channels; therefore, increased vegetation results in increased flood stages. Yet because of the many beneficial aspects of increased vegetation such as erosion control and water quality improvement, vegetation in swales and channels is desirable.

Relative vegetation effects on flood stage were calculated by setting Manning's equation equal for the different roughness conditions and solving for depth. Typical roughness values were taken from the FDOT Drainage Manual (FDOT, 1986). The graphs illustrate the relative effect of vegetation on flood stage for a typical swale (Figure 7-2) and a typical channel (Figure 7-3) and show that in two equivalent channels, one maintained and the other vegetated, flood stages for the same flow will be higher in the vegetated channel. These increases range from significant to modest. For example, in Figure 7-3 if water is flowing at a 4-foot depth in a maintained channel, this same flow would increase by over 3 feet (above 7 feet deep) in a heavily vegetated channel but would expect only modest increases (around 0.6 feet) in a "low" vegetated channel.

Short-standing vegetation has minimal impact to channel conveyance capacity.

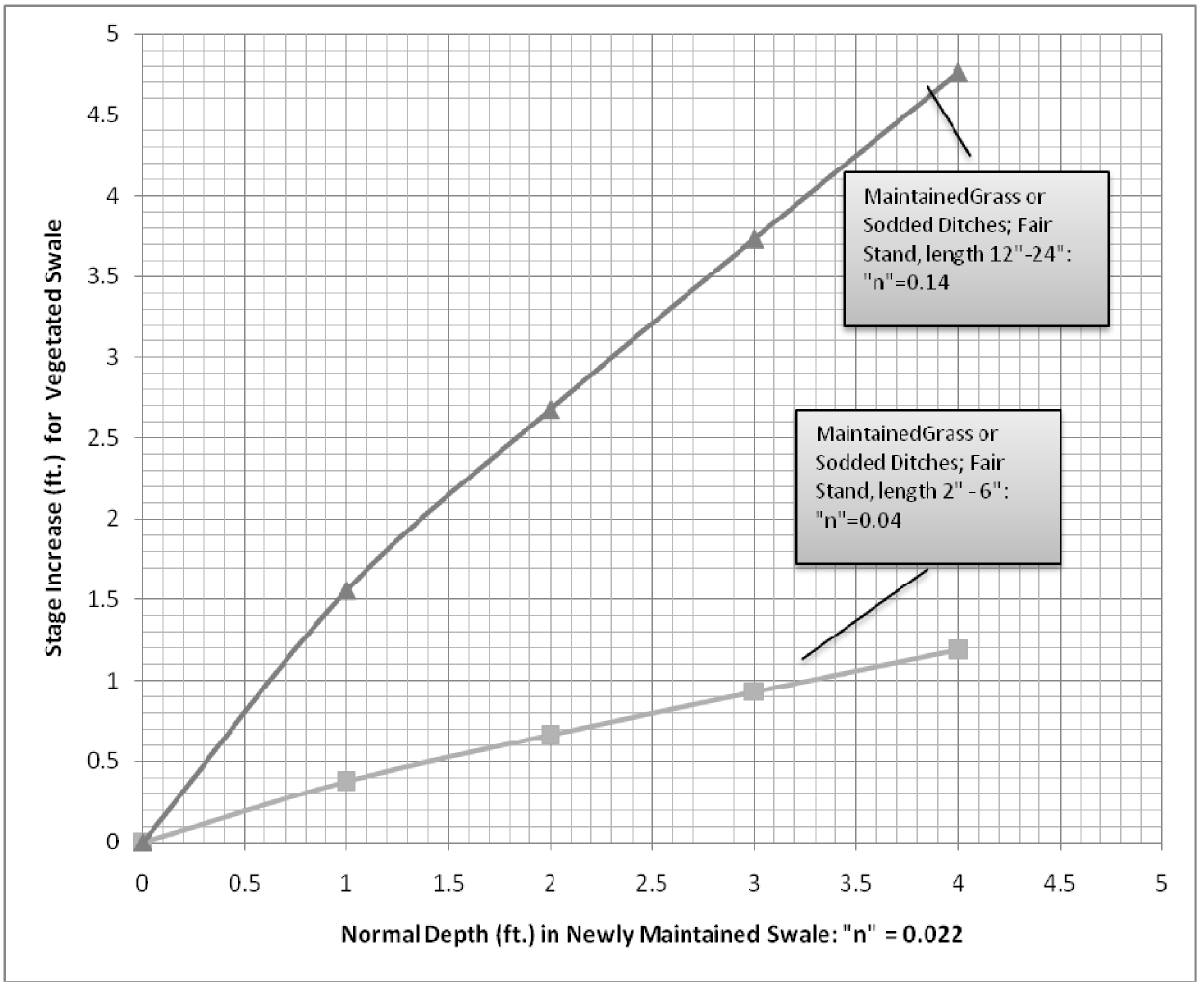

Figure 7-2 Stage Increase for Typical Swale

Source: Jones Edmunds & Associates, Inc. (2009); FDOT Drainage Manual, Volume 2, 1986

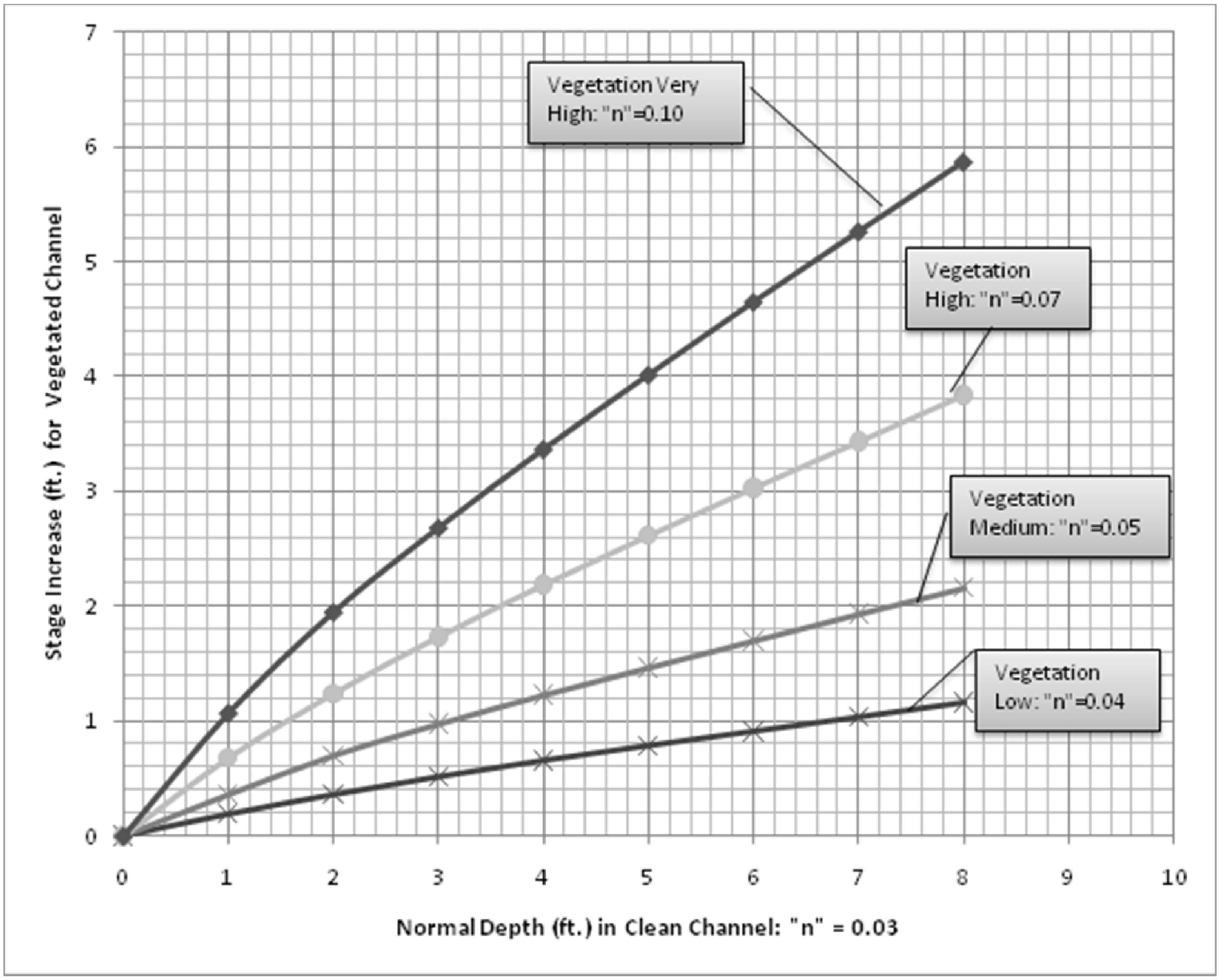

Figure 7-3 Stage Increase for Typical Channel

Source: Jones Edmunds & Associates, Inc. (2009); FDOT Drainage Manual, Volume 2, 1986

The approximate stage increases shown on these graphs are a rough approximation intended to provide basic, relative information. To determine the actual effect of vegetation on flood stage, hydraulic modeling would be needed to incorporate roughness changes. The model will not be limited by the simplifying assumptions used to develop these graphs—namely steady, normal flow.

Since it is clear that different maintenance practices will have varying levels of impact on flood levels, it may be important to understand two other data elements. The first element is the actual design roughness for each channel reach. If higher roughness values were used, then it may be possible to be less aggressive with vegetation removal and still provide desired levels of service for flood protection. Unfortunately, the design calculations for many of the channels and swales are not available due to the age of the system. Additionally, the channel geometries may no longer be representative of the original design conditions due to erosion, sedimentation, or other changes. The second element is how much the roughness (i.e., the maintenance practice) could deviate from the original design condition or the condition currently used in the County's models without creating a reduction in the desired flood protection LOS. This element of data would require extensive analysis and likely result in reach-specific maintenance requirements.

7.4 BEST MANAGEMENT PRACTICES

In stormwater management, BMPs refer to controls and techniques used to mitigate impacts from stormwater runoff due to land development. Stormwater BMPs, structural and non-structural, are intended to improve stormwater runoff quality and many provide hydrologic restoration benefits as well. Source control, a subset of non-structural BMPs, addresses pollution prevention through "good housekeeping" practices. These non-structural BMPs are designed to improve stormwater runoff quality, and a select few of them provide hydrologic restoration benefits.

Some structural BMPs function in part to attenuate flow and provide a specified level of flood protection. They also function to reduce stormwater pollution. Structural BMPs are generally stormwater ponds (wet and dry), constructed wetlands, grassed swales or ditches, bioretention systems, filtration systems, and sediment removal devices. The ability of a structural BMP to remove constituents of concern partially depends on maintenance.

Non-structural BMPs are a combination of practices that focus on preservation of natural systems and pollution reduction. Low-impact-development (LID) practices such as disconnecting stormwater drains, protecting buffers, and reducing impervious areas as well as public education are part of the suite of non-structural BMPs that do not require traditional stormwater maintenance. Source control is a subset of non-structural BMPs that requires maintenance effort. Source control BMPs discussed here are street sweeping, storm drain cleanout, herbicides, fertilizer management, and harvesters.

In 2003 the U.S. Environmental Protection Agency (EPA) identified approximately 130 individual BMPs associated with NPDES regulation categories and requirements. Examples of BMP options are provided in Table 7-1.

Table 7-1 EPA's NPDES BMP Options

Structural BMPs	Non-Structural BMPs	Source Control
Dry detention ponds	Buffer zones	Parking lot and street cleaning
Wet ponds	Conservation easements	Storm drain system cleanout
Infiltration basins	LID Practices	Herbicide management
Porous pavement	Public Education	Fertilizer management
Bioretention	BMP inspection and maintenance	Harvesters
Stormwater wetlands	Source Control	
Grassed swales		
Sediment Removal Devices		

Source: EPA: The Use of Best Management Practices in Urban Watersheds (2005)

7.4.1 Structural BMPs

7.4.1.1 Wet Pond

Wet ponds are popular BMPs in the urban Florida landscape. They provide flood protection, erosion control, and pollutant removal for stormwater runoff in developed areas. A network of drainage devices, typically swales and culverts, direct runoff from a developed area to a drainage basin. A control structure regulates the release of water downstream into receiving waters through orifices, notches, and grates.

Urbanization and the associated increase in impervious area cause an increase in peak runoff. By attenuating runoff and controlling the discharge of the stormwater, flooding and erosion risks downstream can be reduced. The vegetation in littoral zones and on the banks improves water quality.

Maintenance of these ponds consists of as-needed mowing, structure inspection and clean-out, and aquatic plant control.

7.4.1.2 Dry Pond

Dry ponds are designed to capture and treat stormwater runoff by allowing water to infiltrate through soil media into the shallow groundwater aquifer (SWFWMD, 2008). Grass usually covers the side slopes and bottom of the pond. Under normal circumstances, these ponds do not discharge to a downstream stormwater conveyance system.

Maintenance of these ponds consists of as-needed mowing and litter and debris removal as well as excess sediment removal.

7.4.1.3 Infiltration Systems

For the purposes of this discussion, infiltration systems are dry, constructed ponds with underdrain systems to allow runoff to discharge to a downstream stormwater conveyance system. The underdrain system has sand or soil media that act as a filter. Replacement of the media is necessary to maintain the design function of the pond.

Maintenance of these ponds consists of as-needed mowing, litter and debris removal, and replacement of the sand filter.

7.4.1.4 Permeable Pavement

The use of permeable pavement is generally considered part of a suite of LID practices to reduce non-point source stormwater runoff but is treated as a structural BMP herein because it requires maintenance. Permeable pavement allows some infiltration of stormwater through voids in the paving material or "gapped" installation where traditional paving materials do not have the capacity for any percolation or infiltration of runoff.

Newer products such as porous asphalt, pervious concrete, etc. minimize runoff from small storms and allow some stormwater to infiltrate into the soil media below, reducing runoff and pollutant loads to receiving waters. The paving material is underlain with an aggregate sub-base and geotextile. Water is stored in the voids in the aggregate and will eventually evaporate or infiltrate. Using care is necessary when choosing sites for porous pavement, and maintenance is required three to four times per year.

Pervious pavement systems must be maintained by removing clogging material from the surface to maintain optimum surface infiltration rates. Vacuuming systems on vehicles are often used for large pervious pavement areas where the vehicles' movement is not limited. The surface must not be pressure washed to remove clogging material since pressure washing can force clogging material deeper into the pervious pavement system where it is more difficult to extract, thus permanently reducing infiltration rates. Alternative methods (such as industrial vacuum cleaners) for removing clogging material from less-accessible installations, such as walking, cycling, and cart paths or driveways, may be permissible as long as surface infiltration rates are improved and are greater than the threshold 1.5 inches per hour. Follow-up infiltration rate measurements, to ensure that the infiltration rate exceeds 1.5 inches per hour, are required. Any surface shifting or cracking should be promptly repaired. Filter material removed during vacuum sweeping should be replenished with material that meets the specifications of the original filter material. Please see the Sarasota County Low-Impact Development Manual for additional information.

7.4.1.5 Bioretention

Bioretention areas are shallow depressions used as structural stormwater controls to capture, treat, and infiltrate stormwater runoff and are part of a suite of LID practices. Within the bioretention area, nutrient adsorption media, soils, mulch, and planted vegetation facilitate treatment and remove pollutants from the runoff. Multiple bioretention areas are often distributed throughout a larger catchment, providing numerous treatment and water storage areas. Although any one treatment area may be small, the cumulative effect can be significant. This distributed approach also better mimics predevelopment hydrologic conditions by promoting stormwater infiltration, thereby reducing runoff and recharging groundwater.

To facilitate maintenance of the underdrain system, capped and sealed inspection and cleanout ports that extend to the surface of the ground should be provided at the beginning and end of each run of pipe and at every 50 feet or every bend greater than 45 degrees, whichever is shorter.

The following maintenance procedures are recommended:

- Prune and weed to maintain appearance and keep any structures clear as needed.
- Maintain/mow the pretreatment vegetative filter or swale at least twice during the growing season and remove clippings from the flow path.
- Replace mulch where needed when erosion is evident.
- Remove trash and debris as needed.
- Replace mulch over the entire area every 2 to 3 years.
- Remove sediment from inflow system and outflow system as needed.
- Stabilize any upstream erosion as needed.
- Remove and replace any dead or severely damaged vegetation.

7.4.1.6 Constructed Stormwater Wetlands

Constructed stormwater wetlands are designed primarily for pollutant removal, erosion control, and flood protection but also provide wildlife habitat and aesthetic value. Generally, stormwater influent is stored in shallow pools that allow the settling of particulates, biological uptake by plants, and filtration by the soil media. The shallow pools and small channels associated with constructed wetlands create a suitable environment for submerged and emergent vegetation. As with natural wetlands, the constructed wetland must be able to maintain a permanent pool in the dry season but tend to have less biodiversity. Constructed wetlands are designed to effectively remove sediment, nitrogen, phosphorus, and heavy metals from runoff.

7.4.1.7 Grassed Swales

Grassed swales are linear, vegetated, open-channel BMPs used for stormwater treatment and conveyance and are often associated with roadway drainage. The design allows the water to be absorbed quickly. Swales will normally hold water after storm events but are generally dry features.

7.4.1.8 Sediment Removal Devices

Sediment removal devices (CDS Units, baffle boxes, water quality inlets) are designed to retain coarse-grained sediment from an urban landscape with fine-grained sediment usually passing through. The removal efficiency of the unit depends on many factors, including the size of the sump and the amount of sediment and debris collected in the sump. As the sump fills, the efficiency of sediment removal starts to decrease; sediment captured in the sump will start to become re-suspended in the water column as the sump is filled and collected debris will be flushed downstream. With ongoing semi-annual cleaning, maintenance staff can gauge which units need more frequent cleanout to maintain higher water quality removal efficiencies.

7.4.2 Non-Structural BMPs

7.4.2.1 Maintenance Buffer Zones

Buffer zones along watercourses provide important benefits, including water quality improvement, flood protection, bank stabilization, and habitat protection. While most research has focused on forested buffers, similar benefits may be realized in an urban setting. A buffer in an urban area is typically an area of vegetation consisting of trees, shrubs, and grass designed to:

- Trap sediment and remove pollutants.
- Protect stream banks from erosion by providing hearty root systems to increase the cohesiveness of the soil matrix and reduce the velocity of overland flow.

Buffers facilitate pollutant removal through plant uptake of nutrients and removal of surface runoff particulates. Recommended minimum buffer widths for specific watershed objectives listed in the Chesapeake Bay Riparian Handbook are shown in Table 7-2.

Table 7-2 Minimum Buffer Widths

Objective	Buffer Width (ft)
Bank stabilization	< 25
Water temperature	15-25
Nitrogen removal	35-90
Sediment removal	50-100
Flood mitigation	50-200
Wildlife habitat	> 100

7.4.2.2 Conservation Easements

"A conservation easement is a voluntary, legally binding agreement between a landowner and a government agency or non-government conservation organization that keeps land in natural habitat, agricultural and/or open space uses. The agreement is customized to meet the landowner's and conservation entity's objectives and, in most cases, is perpetual." (http://edis.ifas.ufl.edu/fr149, 2010). The easement agreements limit the amount of development on a property, are usually perpetual, and provide a tax benefit to the landowner. Each conservation easement agreement is unique and should be handled on a case-by-case basis.

7.4.2.3 BMP Inspection and Maintenance

Once designed and constructed, structural BMPs will function appropriately for a time but inspection and maintenance is a necessary part of successfully managing a stormwater system. Deferred maintenance and declining infrastructure can lead to increased costs and flooding risks as well as ecological degradation of the system downstream.

Regularly scheduled maintenance practices help to ensure the proper functioning of flood control facilities. These maintenance practices also affect the amount of sediment, debris, and pollutants reaching County waterways. Included in these activities are cleaning out baffle boxes; removing excess vegetation and sediment from swales and roadside ditches; replacing damaged infrastructure; and maintaining control structures, weirs, and pumps.

In the County's MS4 Permit, the stormwater management program requirements are to reduce the discharge of pollutants to the maximum extent practical. Table 7-3 lists the inspection and maintenance frequency required by the permit.

Table 7-3 MS4 Permit: Inspection and Maintenance Schedule for Structural Controls and Roadways

Structural Control	Required Frequency of Inspection	2008 Permit Requirements for Maintenance Activities
Stormwater Treatment Ponds - Wet	1.5 - 2 years	As Needed
Stormwater Treatment Ponds - Dry	1.5 - 2 years	As Needed
Stormwater Treatment Ponds - Dry w/Infiltration	1.5 - 2 years	2 x/year
Exfiltration Trench	2 x/year	2 x/year
Stormwater Pump Stations	2 x/year	As Needed
Canals (miles)	1 x/year	As Needed
Channel control structures	4 x/year	As Needed
Pollution control boxes	4 x/year (2008) 1 x/year (2009)	As Needed
Grassed Swales (miles)	1 x/year	As Needed
Inlets/catch basins/grates	1 x/year	As Needed

Wet and dry pond maintenance activities include mowing, removing debris and litter, removing accumulated sediment, stabilizing eroded banks, fertilizing, applying herbicides, and cleaning out infrastructure. These activities occur multiple times per year as needed. Wet ponds require aquatic plant management and harvesting as needed. Infiltration ponds and exfiltration trenches require additional maintenance of sand filtration systems. The annual or biannual complete removal and replacement of the geotextile, filter sand, and gravel are normally recommended. Bar screens in a stormwater pump station need to be cleared and sediments and debris removed frequently for the system to operate as designed. Canals, channels, and swales all require mowing, debris removal, and sediment removal. Stormwater structures require debris and sediment removal and structural repairs to remain in good working condition.

Drainage area conditions at a specific BMP may dictate more frequent maintenance (i.e., heavy vehicular traffic, construction, invasive-exotic vegetation). Excess debris, sediment, and vegetation may impede the flood protection capabilities of a system as well as hinder the pollutant removal functions. In developing a proactive maintenance plan, maintenance crews need to make note of large amounts of debris, sediment, or vegetation to mark these structures or areas for more frequent maintenance.

Current stormwater system maintenance is primarily a flood control function; however, routine BMP maintenance can improve the overall efficiency and removal rate of pollutants. For water quality considerations sediment and debris cleanout may need to be more frequent than maintenance for flood protection. Table 7-4 shows the recommended frequency of cleanout for sediment and debris removal in common structural BMPs to maintain the design water quality improvement levels.

Table 7-4 Recommended BMP Cleanout Frequency for Water Quality Improvement

BMP Type	Annual Frequency of Cleanout
Wet Detention Pond	1
Dry Retention Pond	1-2
Infiltration System	2
Permeable Pavement	3-4
Bioretention	1
Stormwater Wetlands	1
Grassed Swales	1
Stormwater Structures	2-18

7.4.3 Source Control

7.4.3.1 Street Sweeping

New technology incorporated into street sweepers has brought about a re-evaluation of the benefits and effectiveness of street sweeping. Vacuum-assisted and regenerative-air sweepers are now able to pick up fine-grained sediments that carry a large portion of the pollutant load. Two distinctive but not mutually exclusive removal rates are cited in the literature: the removal of sediment load and the removal of nutrients associated with the sediment load due to stormwater runoff.

The amount of sediment removed by street sweeping depends on several factors. The intensity of a rainfall event, the length of time between sweeping events, particle size, land use, and the location of the impervious surface (up-gradient or down-gradient) all contribute to determining the amount of sediment available for sweeping, the efficiency of removal, and the quantity of sediment removed from the potential sediment load to stormwater runoff. The frequency of sweeping in wet and dry seasons impacts the overall removal rates, and the U.S. Geological Survey (Breault et al., 2005) reports that only a small fraction of the total load is removed unless intensive sweeping programs are implemented. Total sediment load reduction by street sweeping is cited in the literature as 15 to 90% of the potential sediment load to the stormwater system.

The Federal Highway Administration (www.fhwa.dot.gov/environment) reports vacuum-assisted sweeper removal efficiencies of 74% for total phosphorus, 77% for total nitrogen, and 93% for total solids. The expected reduction of pollutants from street sweeping varies with the frequency of sweeping. Comparing monthly to weekly frequencies of sweeping, researchers found reductions in total solids ranging from 42 to 60%, in total phosphorus ranging from 15 to 30%, and in total nitrogen ranging from 20 to 45%. A report assessing maintenance practices in Florida issued through the University of Florida cites the average total nitrogen (TN) at approximately 500 mg/kg and TP at approximately 300 mg/kg in sediment samples removed through street sweeping.

7.4.3.2 Drain Clean-out

A small number of monitoring studies evaluate the pollutant reduction resulting from storm drain or catch basin cleanouts and the optimal frequencies for cleanouts at a catchment scale. These studies indicate catchment cleanouts can reduce pollutants by 5 to 25% depending on catchment conditions, cleaning frequency, and type of pollutant. The pollutant-removal capability of catch basins is fundamentally constrained by the design that retains coarse-grained sediments but pass finer grained sediment that typically contains higher concentrations of nutrients and metals (Law et al., 2008).

7.4.3.3 Herbicides

The tropical climate in Sarasota County provides an ideal setting for aquatic invasive/exotic plant species to flourish. The undesirable vegetation, if left unchecked, may eradicate native plant species, cause public health risks, and impede flood conveyance.

Using herbicides to manage aquatic plant growth has been a common practice in the United States since the late 1800s. Occasionally the use of these chemicals has resulted in human health and environmental problems. Herbicides are now regulated by the EPA and FDEP with only 11 herbicides approved for use in plant management in Florida waters.

Maintenance staff is responsible for choosing the herbicide and application method appropriate to the aquatic vegetation. Education and training are essential to balancing the environmental risk with the chemicals and the potential degradation of an ecosystem when the invasive plants prosper.

7.4.3.4 Fertilizer Management

Nitrogen and phosphorus are common nutrients found in fertilizer. The misuse of fertilizer products may create undesirable environmental and recreational conditions. Excess nutrients accelerate algae growth particularly when coupled with the tropical temperatures in Sarasota County, leading to red tide blooms, impaired flood conveyance, public health risks, and eutrophication of aquatic systems.

Sarasota County adopted Ordinance Number 2007-062 governing fertilizer and landscape management. Specific sections of the ordinance address:

- Application.
- Nutrient content.
- Impervious surface.
- Buffer zones.
- Grass clippings.
- Training and licensing.
- Enforcement.

The Ordinance requires the use of BMPs to minimize the negative and cumulative impacts of fertilizer misuse on the County's natural systems and waterways, citing these as critical to the environmental, recreational, cultural, and economic well-being of Sarasota County residents and the health of the public.

7.4.3.5 Harvesters

Aquatic vegetation plays an integral role in marine systems, but often non-native, invasive plants are found in the waters of Sarasota County. Hydrilla, water lettuce, and water hyacinth are undesirable types of vegetation commonly found in County waterways. These species tend to block out sunlight necessary to maintain a healthy benthic environment by creating a canopy on the water surface and hindering oxygen circulation by keeping the water stagnant. Additionally, non-native plants often impede recreational water use, increase flooding risks, and eradicate native species.

Mechanical harvesters offer an alternative to herbicides in controlling aquatic vegetation. Harvesting is perceived by the public as being environmentally neutral and does not suffer the negative public perception that herbicides do. Harvesters are large machines that cut and collect aquatic plants. Cut plants are removed from the water by a conveyor belt system and stored on the harvester until disposal. Harvested weeds may have a beneficial reuse as compost. Harvesters can cut and collect several acres per day depending on weed type, plant density, and storage capacity of the equipment. Harvesting speeds for typical machines range from 0.5 to 1.5 acres per hour.

Photograph 5: Aquatic Weed Harvester

Transportation and disposal of the vegetation biomass after harvesting is an important financial consideration in harvester use. A large degree of variation is found in the biomass of the "crop"; water hyacinth can weigh 200 to 300 tons per acre and hydrilla can weigh 10 tons or less per acre (Gettys et al., 2009). With the removal of the biomass, all of the nutrients that would contribute to the system during plant decomposition are now removed.

Routine mechanical maintenance of the harvester is necessary monthly, with some done quarterly. Cleaning the machine thoroughly when it is being moved from one waterbody to another ensures undesirable plants and microbes will not infest another waterbody. Table 7-5 lists some of the advantages and disadvantages to using harvesters.

Table 7-5 Advantages and Disadvantages of Aquatic Harvesting

Advantages	Disadvantages
Opens waterway conveyance immediately	Repetitive maintenance practice
Removes nitrogen and phosphorus from the system	Machinery is difficult to maneuver
Removes organic material and reduces the amount of particulates in the conveyance if harvested before the end of the life cycle of the plant	Small fish and turtles may be caught and harvested in plant material
Targets specific areas	Capital expenditure and maintenance costs are significant
Oxygen remains in the water when decomposing plant material is removed	Machines generally clear only several acres per day
	Disposal of vegetation may be costly
	Short-term increase in turbidity

Plant Management in Florida Waters, a website created and maintained by the University of Florida's Institute of Food and Agricultural Sciences, concludes that even with the disadvantages associated with harvesters, the machines are suitable for many Florida waterways. Evaluation of plant species, disposal of wastes, uses, and physical characteristics of the waterbody play an important role in choosing to use a harvester.

7.4.4 BMP Efficiencies

BMPs and maintenance practices impact the removal of solids, heavy metals, nutrients, and organics found in stormwater systems. The three primary constituents found in runoff and evaluated for removal efficiencies in this WMP are suspended solids, nitrogen, and phosphorus.

Suspended solids are primarily a function of land use; an increase in the amount of impervious area found in urban development is associated with an increase in suspended solids in stormwater runoff. If suspended solids remain suspended, the particulates reduce water clarity and limit the amount of sunlight reaching marine life; suspended solids that settle in a stream system adversely impact benthic habitats and the flood control capacity of the system.

Nitrogen and phosphorus are nutrients found in soils naturally; increased erosion usually associated with urban development adds not just solids to the stream system but nutrients as well. Fertilizer contributes to the nutrient load in runoff when lawns are unable to assimilate the amount of fertilizer applied. Excess nutrients combined with the tropical temperatures in Sarasota County can lead to excessive algae growth impacting not only the recreational aspects of the waterways but also creating an oxygen deficit impacting the marine life and aquatic habitats.

BMPs function to limit pollutants from reaching primary conveyance systems (i.e., channels, streams, canals, ditches) and eventually the bays of Sarasota County. There is considerable variability in the effectiveness of BMPs to achieve pollutant removal. Rainfall variability makes efficiencies hard to predict, but the regular inspection and maintenance of BMPs and consistent maintenance practices can facilitate better functioning of a stormwater system for flood control and water quality improvements.

Regular inspection and maintenance of can facilitate better functioning of a stormwater system for flood control and water quality improvements.

In June 2007, the FDEP issued a report titled *Evaluation of Current Stormwater Design Criteria within the State of Florida.* Summarized in the text are the performance efficiencies of stormwater management retention and detention system ponds to remove pollutant loads found in stormwater runoff from studies specific to Florida. In stormwater ponds, removal efficiency is related to the retention volume, residence time, littoral zone size, scheduled maintenance, and mowing frequency. Removal efficiencies in infiltration and bioretention systems are affected by the number of storms where first flush occurs and the frequency of media replacement. Table 7-6 cites the range of removal efficiencies of total suspended solids loads associated with stormwater runoff by BMP from these Florida studies.

Table 7-6 TSS Removal Efficiencies in Common BMPs		
BMP Type	# of Studies	Efficiency Range
Dry Retention Pond	2	80-99%
Wet Detention Pond	10	55-94%
Dry Retention with Filtration	2	77-98%
Offline Systems	2	89-95%

A literature search revealed a great deal of variability in the range of removal efficiencies of structural and source control BMPs. The geographic location, climate, degree of urbanization, and study limitations all impact the variance found in removal efficiencies. Table 7-7 shows the range of removal efficiencies within individual studies as well as across technical documentation from public and private sources.

Table 7-7 Range of Removal Efficiencies (%) of Structural and Source Control BMPs

Study	Year	Dry Retention			Wet Detention			Dry Retention w Filtration			Offline Systems/ Constructed Wetlands			Porous Pavement			Grassed Swales			Bioretention			Other Filtration			Buffer Zones			Street Sweeping			Catch Basin/Baffle Box		
		TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Evaluation of Current Stormwater Design Criteria within the State of Florida	2007	80-99	61-99	80-99	55-94	20-91	4-63	77-98	0-92	0-80	89-95	76-92	30-85	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
The Cost and Effectiveness of Stormwater Management Practices	2005	—	15-45	—	—	30-65	—	—	50-80	—	—	15-45	—	—	30-65	—	—	15-45	—	—	—	—	—	30 - 80	—	—	—	—	—	—	—	—	—	—
Technical Memorandum: The Runoff Reduction Method	2008	—	—	—	—	50-75	30-40	—	25	15	—	50-75	25-55	—	25	25	—	15	20	—	20-40	40-60	—	60 - 65	30-45	50-85	—	—	—	—	—	—	—	—
Urban Pollutant Loads and General BMP Cost Analysis	2005	50	30	—	90	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Effective Use of BMPs in Stormwater Management	2005	61	19	21	58-78	48-62	21-43	75	60-70	55-60	36-96	21-89	19-48	82-95	65	80-85	7-69	14-37	14-55	80	65-87	49	—	—	—	—	—	—	37-50	9-28	—	10-25	—	—
Permeable Pavement Summary Fact Sheet	2005	—	—	—	—	—	—	—	—	—	—	62	88	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 7-7 Range of Removal Efficiencies (%) of Structural and Source Control BMPs

Study	Year	Dry Retention			Wet Detention			Dry Retention w Filtration			Offline Systems/ Constructed Wetlands			Porous Pavement			Grassed Swales			Bioretention			Other Filtration			Buffer Zones			Street Sweeping			Catch Basin/Baffle Box		
		TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Stormwater Pollutant Removal Criteria	2004	40-60	20	20	50-90	50	30	—	—	—	90	50	30	0-80	60	50	—	—	—	90	60	30	60-80	30-50	30-35	—	30	30	—	—	—	—	—	—
Stormwater Management Program for Nutrient Control	2004	—	—	—	—	40	25	—	—	—	—	35	40	—	—	—	—	20	20	—	35	40	—	45	35	—	—	—	—	—	—	—	—	—
Riparian Forest Buffer Practice and Riparian Grass Buffer Practice	2007	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45-65	65-85	—	—	—	—	—	—
Final Report of the Statewide Task Force on Riparian Forest Buffers	2000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	37-99	6-97	7-95	—	—	—	—	—	—
Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping	2008	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18-72	10-30	15-45	39-75	3-6	14-27
Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts	2002	62	46	—	62	46	—	78	56	—	—	—	—	—	—	—	—	—	—	45	32	—	—	—	—	—	—	—	25-95	5-90	—	—	—	—
Residential Street Dirt	2004	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20-92	—	—	—	—	—

Table 7-7 Range of Removal Efficiencies (%) of Structural and Source Control BMPs

Study	Year	Dry Retention			Wet Detention			Dry Retention w Filtration			Offline Systems/ Constructed Wetlands			Porous Pavement			Grassed Swales			Bioretention			Other Filtration			Buffer Zones			Street Sweeping			Catch Basin/Baffle Box		
		TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Accumulation Rates and Chemical Composition and Removal Efficiencies																																		
New Developments in Street Sweeper Technology Article 121	2002	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45-65	30-55	—	—	—	—
Stormwater Best Management Practices in an Ultra Urban Setting: Selection and Monitoring	2006	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	55-93	40-74	42-77	—	—	—

Complete references provided in Appendix F.

7.4.5 Cost/Benefit Analysis

FDEP evaluated 31 projects across the state that were funded by 319 grants for TP and TN removal and costs—17 projects were wet detention ponds, 3 were dry retention ponds, and 11 were other treatment options. The cost per pound of removal of TN annually was approximately $5,000 for the "average" wet detention pond and was approximately $4,000 for the "average" dry retention pond; the cost per pound of removal for TP annually was approximately $17,000 for the "average" wet detention pond and was approximately $21,000 for the "average" dry retention pond.

Jones Edmunds performed a cost/benefit analysis to evaluate the cost of pollutant removal by common BMPs and maintenance practices. For the purposes of this analysis, BMPs are those practices with an associated initial capital cost as well as labor costs, and maintenance practices were labor costs only. The three constituents evaluated are solids, nitrogen, and phosphorus.

7.4.5.1 BMPs

For wet retention, dry detention ponds, and street sweeping, literature values for pollutant removal efficiencies are generally reported as TN and TP. The pollutant constituents in stormwater runoff are generally land development based; therefore, the cost per pound of removal for nutrients in Table 7-8 reflects TN and TP removal.

The equation developed and used to calculate the dollars per pound removal values of BMPs has four variables: annualized BMP cost, estimated pollutant load, constituent of interest percentage of total estimated pollutant load, and BMP efficiency. The following criteria and assumptions were used for the BMP evaluation:

1. Annualized BMP cost
   - ❖ Capital costs for land purchase is included in the pond values. An FDEP 319h grant study provided land costs from around the state; these costs were averaged and divided over the life span of the BMP.
   - ❖ Harvester and street sweeper costs include the capital cost for the equipment divided over the life span of the BMP.
   - ❖ The interest rate for the capital expense was held constant at 6.5% across the lifespan of the BMP.
   - ❖ The lifespan of the BMPs are assumed to be:
     - Wet Ponds—40 years
     - Dry Ponds—40 years
     - Stormwater structure—50 years
     - Street Sweeper—10 years
     - Harvester—15 years

- ❖ All dollars per pound reported include the annual cost of maintenance. The maintenance costs are based on contractual values or labor costs of $15/hour.

2. Estimated load
   - ❖ For wet ponds, dry ponds, and sediment-removal devices, the total load averages in lb/ac/yr from the SIMPLE model were weighted based on area. The weighted average of lb/ac/yr was applied to a reasonable drainage area for the BMP and then used as the estimated load value (pounds) for a BMP.
   - ❖ Street sweeping services for Sarasota County are contracted to a private entity. Information from the 2009 NPDES Annual Report Form for street sweeping was used in the evaluation: total street miles swept was 4,300 (16.5 miles/day on a 5 day work week) and 735 tons of material collected (5,650 lb/day on a 5 day work week).
   - ❖ The estimated load of the harvester is based on the literature values discussed in Section 7.4.3.5.

3. Pollutant % of estimated load
   - ❖ The constituent percent of the average load from the SIMPLE Model results determined the percent of the pollutant within the load. This was applied to wet ponds, dry ponds, sediment removal devices, and street sweeping. The constituent percents are 8.5% TSS, 0.1 % TP, and 0.5% TN.
   - ❖ For the harvester, from Section 7.3.1.1, the TKN is assumed to be 2.26% of the dry weight and the TP is assumed to be 0.25% of the dry weight of plant material (Kadlec and Knight, 1996).

4. BMP efficiency
   - ❖ Table 7-8 shows the removal efficiencies of wet ponds, dry ponds, sediment removal devices, and street sweeping for total suspended solids, total nitrogen, and total phosphorus. Minimum and maximum efficiency values were used to establish a range of costs for constituent removal.
   - ❖ Harvesters do not remove any suspended solids from the system; therefore, the efficiency is 0%; the TKN and TP removal is estimated between 75% and 100%, taking into account some vegetation being left in the water course.

To calculate $/lb removed by pollutant, the following formula was applied:

$$\$/lb = \text{Annualized BMP Cost} \div (\text{Estimated Load (lb)} * \text{Pollutant \% of Estimated Load} * \text{BMP Efficiency})$$

Each BMP has a range of removal efficiency; therefore, the $/lb pollutant removal also has a range of values. In Table 7-8, the lower dollar value represents the maximum possible efficiency of a BMP while the higher dollar value represents the minimum efficiency.

Table 7-8 Annual BMP Cost per Pound of Nutrient Removal[1]

BMP	TSS $/lb	TP $/lb	TN $/lb
Wet Retention Pond	$50 - $100	$3,500 - $15,000	$1,000 - $20,000
Dry Detention Pond	$100 - $150	$6,500 - $10,000	$1,500 - $2,500
Sediment Removal Devices	$2 - $5	$10,000 - $20,000	$500 - $1,000
Street Sweeping	$10 - $30	$200 - $500	$20 - $50
Harvester	$0 - $0	$200 - $600	$30 - $70

1. Transportation and disposal fees for sediment and vegetation are NOT included.

Ponds and sediment removal devices are stationary BMPs with fixed drainage areas; the intent is to not only provide treatment of runoff but for ponds, attenuation, and flood control as well. Once installed, operation and maintenance costs are minimal.

Street sweepers and harvesters are both source-control practices that have the ability to affect large areas of the County. Operation and maintenance costs are generally much higher than that of stationary BMPs. The intent of these mechanical BMPs is to prevent pollutants from reaching the downstream system across a large geographic area, although both do have flood-control components. If a mechanical BMP were purchased and limited to use in a single subbasin, the cost would far outweigh the benefit, but by using the mechanical BMP throughout the County the cost per pound of removal is reduced.

For example, if both BMPs have equal pollutant loads and equal drainage areas (3 acres), the cost per pound of pollutant removal of the street sweeping is approximately 10 times more than the sediment removal device. The reality is the sediment-removal device has a fixed removal cost based on location, but the street sweeper has the ability to increase its service area and decrease the cost. If the street sweeper is used in a larger drainage area (as an example 30 acres instead of 3 acres), the costs per pound of pollutant removal are now equal. By increasing the coverage of the street sweeper even more, the cost per pound of removal is now less than that of the sediment-removal device.

7.4.5.2 Maintenance Practices

Maintenance duties often involve the management of grasses, aquatic plants, and other vegetation that impede the stormwater system. Section 7.3.3.1 presented information on the nutrient content of vegetation; this information was evaluated to establish average values of TKN and TP for grasses, leaves, and aquatic plants.

For the purposes of the evaluation, the benefit is expressed in pounds of nutrient removed. TKN, which is a laboratory measurement of organic nitrogen (N), ammonia (NH_3) and ammonium (NH_4+), was included because it provided a common denominator for a large portion of the data sets that are lacking a measurement of TN.

To evaluate maintenance practices as cost per pound of pollutant removal, a similar equation was developed. To calculate $/lb removed by pollutant, the following formula was applied:

$/lb = Annualized Labor Cost ÷ (Estimated Load (lb) * Pollutant % of Estimated Load * Estimated Maintenance Practice Efficiency)

The general baseline criteria and assumptions used to equate $/lb removal are based on cost information provided by Sarasota County's Maintenance Department. Table 7-9 shows the removal costs for common maintenance practices.

Table 7-9 Maintenance Practices Cost per Pound of Nutrient Removal[1]

Maintenance Activity	TSS $/lb	TP $/lb	TKN $/lb
Herbicide	$0 - $0	$0 - $0	$0 - $0
Hand Clearing	$2 - $20	$30 - $90	$20 - $80
Ditch/Channel Cleanout	$20 - $200	$1,100 - $3,000	$200 - $750
Sediment Removal	$15 - $45	$6,600 - $13,000	$600 - $1,200
Mowing	$2 - $20	$30 - $80	$15 - $70

1. Transportation and disposal fees for sediment and vegetation are NOT included.

7.5 RECOMMENDATIONS

As described in the preceding sections, the stormwater maintenance staff has two important responsibilities: inspection and permit compliance and facility maintenance. Both tasks are vital to maintaining public safety, reducing flood risks, and the improving the health of the aquatic environment. The *Strategic Maintenance Plan* provides a baseline to build and implement a more robust approach to maintenance to meet the County's maintenance needs.

> *Jones Edmunds recommends the following approach to expand and enhance the stormwater maintenance process to include water quality in addition to flood protection as part of the focus:*
>
> - *Implement the 1999 Strategic Maintenance Plan.*
> - *Achieve the inspection and maintenance frequency required in the MS4 Permit.*
> - *Update the Strategic Maintenance Plan.*
> - *Adopt practices listed below when fiscally feasible.*

Updating the *Strategic Maintenance Plan* and adopting several non-structural BMPs and source control practices may provide the best opportunities for increased awareness and implementation of mechanisms to improve the quality of stormwater runoff to the bays and estuaries throughout the County.

> *With the County's water quality goals in mind, Jones Edmunds recommends the following modifications, additions, or removal of maintenance practices to progress toward meeting those goals.*

7.5.1 Inspection and Permit Compliance

7.5.1.1 NPDES Inspection

A system inspection schedule is not explicitly outlined in the *Strategic Maintenance Plan* but is referenced as routine inspection programs and internally generated inspection reports. The current NPDES permit requires inspecting all stormwater facilities ranging from quarterly to every 2 years.

> *The inspection schedule in this program should be adopted by reference into the Strategic Maintenance Plan.*

7.5.1.2 Asset Management

Maximo is an asset-management system implemented by the County that tracks inspections and maintenance work orders. Additionally, the spatial component of the stormwater system is being inventoried and mapped by the GIS department. Functionality between the two systems is somewhat difficult. Implementing a work flow process for maintenance, tracking inspections, assisting in resource allocation for CIP projects, and providing good customer service to residents will be achieved when the two systems are integrated.

7.5.1.3 FEMA Community Rating System

The County participates in a Community Rating System (CRS) through FEMA to reduce hazard damages.

> *Incorporating the documentation for required annual inspections and debris removal into the Maximo system would help track long-term issues that may require a CIP or help identify smaller local-scale projects that may improve drainage and water quality.*

7.5.2 Facility Maintenance and BMPs

7.5.2.1 Facilities: Scheduling

The *Strategic Maintenance Plan* details for maintenance of drainage canals, structures, ponds, and lakes based on a 1-, 2-, or 3-year cycle.

> *Revising the matrix for maintenance and decreasing the maximum cycle to 2 years will help reduce flooding concerns and decrease the organic debris and nutrients in the system.*
>
> *For the most effective removal of nutrients, baffle boxes should be cleaned at least monthly during the wet season and quarterly during the dry season to remove sediment and vegetation.*

7.5.2.2 Facilities: Denuding Conveyance Features

As a regular maintenance practice, County staff excavates and denudes roadside swales and other conveyance features to eliminate vegetation and remove possible sediment accumulation. The current practice for County maintenance crews is to seed or sod the denuded swales within 2 weeks after the excavation. This practice leaves the channel vulnerable to erosion until ground cover is reestablished.

Jones Edmunds recommends replacing the practice of denuding with mowing/removal practices that keep vegetation and root systems in place to reduce sediment load. To reduce nutrient leaching and sediment loading, grass clippings need to be removed from the swale. In cases where denuding is necessary to ensure public safety or reduce flooding risks, the practice should be limited to the dry season to minimize the chance for erosion to occur. Additionally, where denuding is necessary, we recommend placing sod within 2 days.

7.5.2.3 Non-Structural BMPs: Buffer Zones

Buffer zones provide aesthetic value as well as functional value to uplands adjacent to the watercourse.

Jones Edmunds recommends implementing buffer zones on County-owned uplands to:

- *Minimize maintenance.*
- *Reduce pollutant loads found in urbanized overland flow.*

A general practice by County staff and homeowners is mowing beyond the top of bank within the stream banks or to the waterline. Grass clippings and vegetation debris are often left within the banks or adjacent to the watercourse. As discussed in Section 7.3.3.1, removing the organic debris is a source control for minimizing additional nitrogen and phosphorus entering the waterway. Researchers found a benefit to landowners in reduced mowing and maintenance costs when these areas are managed as vegetated buffers rather than turf grasses (University of South Carolina, 2000).

A "no-mow buffer" reduces the probability that organic debris will reach the waterway. Jones Edmunds recommends adding buffer zones to major waterways to prevent landscape debris from blowing into the surface water system. Additionally, public education on the benefits of buffer zones for private property along the watercourse will result in increased awareness of water quality issues.

General maintenance guidelines for the buffer zone include leaving native vegetation and leaf litter undisturbed, restricting pesticide and herbicide use, and removing non-native vegetation.

7.5.2.4 Non-Structural BMPs: Low-Impact-Development

LID is a stormwater management approach that uses a suite of hydrologic controls (structural and non-structural) distributed throughout the site and integrated as a treatment train (i.e., in series) to replicate the natural hydrologic functioning of the predevelopment landscape.

Jones Edmunds recommends that when a drainage project is sent to a staff engineer for design and permitting considerations, the project should be evaluated and if feasible incorporate LID design standards.

7.5.2.5 Source Control: Street Sweeping

In 1983 the EPA reported that street sweeping was not effective in reducing pollutant loads in stormwater runoff. Recent innovations in technology have improved the abilities of street sweepers to more effectively pick up fine-grain sediments that tend to carry a large part of the pollutant load in runoff. The new technology incorporates an air-filtrated vacuum sweeper with a mechanical sweeper to remove particles adhering to the pavement. For industrial and densely-populated areas where space for additional stormwater BMPs is not available, street sweeping removes sediment and pollutants before either reaches the stormwater system.

Although there are challenges to funding the program,

Jones Edmunds recommends weekly street sweeping in the wet season to maximize removal of sediment and pollutants between rain events and bi-monthly street sweeping during the dry season.

Initially, the program should focus on neighborhoods, communities, and industrial areas that do not have stormwater BMPs. In areas with limited stormwater BMPs, adding street sweeping can be part of a treatment train approach to improving water quality. Building partnerships with other stakeholders for funding street sweeping in highly urbanized areas with large traffic corridors would benefit the County's waterways.

7.5.2.6 Source Control: Herbicides

A normal practice by the County maintenance staff is to use herbicides within a watercourse or on adjacent banks.

To facilitate achieving TMDL levels set within Sarasota County and improving water quality in impaired water bodies, the practice of herbiciding and leaving decaying vegetation in the watercourse should be replaced with vegetation removal.

Vegetation removal by mechanical harvesting, bagged mowing, or hand clearing provides more effective removal of nutrients from the system. Removing exotic-invasive species during routine maintenance creates a more natural system. However, the removal process must not destabilize the stream banks. This activity would be best suited to maintenance performed during the dry season. Ideally, soil amendment using compost materials and re-introducing native species will decrease maintenance requirements.

The release of nitrogen and phosphorus from vegetation to the water is highest during the 24 hours following cutting/falling/treating than the cumulative effect of all the subsequent time the plant matter stays in the waterway. The removal mechanism of the vegetation is site specific. For example, in Photo 2 Alligator Creek of Section 7.3.2 mechanical harvesting would be the preferred mechanism because of the depth of water in the creek, whereas the preferred mechanism in Photo 1 showing a roadside swale in Forked Creek would be bagged mowing.

7.5.2.7 Source Control: Fertilizer Management

The County fertilizer ordinance states: "In no case shall grass clippings, vegetative material, and/or vegetative debris either intentionally or accidentally be washed, swept, or blown off into stormwater drains, ditches, conveyances, water bodies, or roadways." This statement is not explicit in the Sarasota County Stormwater Maintenance: Canal and Drainage System Maintenance Bid Contract.

Jones Edmunds recommends adding this statement as a working condition to all outside vendor bid contracts involving stormwater system maintenance and referencing the fertilizer ordinance as guidance when updating the Strategic Maintenance Plan.

Many County residents take pride in their homes and landscaping.

As the wet season approaches, informing residents through stepped-up public education and awareness to reduce or eliminate fertilizer application during this critical time will help reduce nutrients from reaching the waterways.

Continued training and licensing of landscape professionals and consistent code enforcement are explicit in the County ordinance and should continue.

The grass and vegetative clippings retained from maintenance could be composted for other beneficial uses as long as pesticides and herbicides have not been applied.

7.5.2.8 Source Control: Harvesters

Applying herbicide to aquatic vegetation and leaving the decaying organic debris in place are detrimental to the County's efforts to improve water quality. With the vast channel system throughout the County, removal of the decaying vegetation is somewhat prohibitive with a limited maintenance staff. Aquatic harvesters mechanize the process and reduce the time required for maintenance crews to perform this task. Eliminating herbicides in the waterways also eliminates the chemicals in herbicides from entering the environment and provides composting material to use in soil amendment for bank stabilization. Harvesters also can remove organic debris associated with algae blooms, water lettuce, and hydrilla that impact the aesthetics and health of County waterways.

> *Jones Edmunds recommends adding an aquatic harvester to the suite of maintenance practices to help the County achieve its water quality goals.*

7.5.3 Other

7.5.3.1 Composting Pilot Study

> *Jones Edmunds recommends a pilot study on the beneficial reuse of grass clipping and vegetation debris.*

Maintenance staff and contracted vendors will bag grass clippings during the mowing specifically along waterways and transport the debris to a designated composting facility. The compost would then be used by maintenance staff on stream banks that need to be stabilized or vegetated. The maintenance staff would transport the compost to the site and amend the compost into the on-site soils. Composting the organic debris offers several benefits:

- Removing products before decay will reduce the potential for nitrogen and phosphorus to enter the waterways.
- Using compost material as a soil amendment on eroding banks will provide structure and moisture capacity to the soil matrix.
- Improving the soil matrix may result in better vegetation root growth and ultimately more stable systems.

Stormwater maintenance has traditionally played an active role in maintaining the flood capacity of the stormwater system throughout the County. By creating an even more robust maintenance program by implementing these recommendations, maintenance activities will play a bigger role in improving the quality of the runoff reaching the estuaries and bays of Sarasota County.