Watershed Management in Hillsborough County

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Nestled on the eastern shores of Tampa Bay, Hillsborough County covers about 900 square miles of land and 25 square miles of inland water area. Municipalities, including the city of Tampa, account for about 140 square miles. Organized in 1934 as Florida's 19th county, Hillsborough County has enjoyed growth and a population increase synonymous with that experienced by the rest of Florida.

Despite the rapid growth rate, about 60% of the county remains either undeveloped or in agricultural use. The remaining 40% consists of urbanized land clustered in three principal regions: the Northwest (including the communities of Carrollwood, Town N' Country, Citrus Park, and Lutz), the East (including Brandon and vicinities), and South County (including Apollo Beach, Gibsonton, Sun City, Ruskin, and vicinities). The majority of the undeveloped land remains in the southern and eastern parts of the county.

A network of three main interstates (I-275, I-75, and I-4), two limited access expressways (Veterans and Lee Roy Selmon), and a number of main arteries, such as Hillsborough Avenue, Dale Mabry Highway, and Gunn Highway, connect the urbanized regions. Regional water and wastewater treatment plants also service the urbanized areas in these regions.

Stormwater management, like other public services, was decentralized, with a "maintenance unit" in each of the main regions directly responding to any drainage inquiries.

During the El Niño rains of 1997-1998, large areas in Hillsborough County, especially in the Northwest, experienced street and structural flooding for an extended period of time. With over 50 inches of rain falling in a 4-month period (following a wet rainy season), El Niño proved to be the ultimate test for the effectiveness of the county's stormwater infrastructure.

Given the magnitude of the problems, a more centralized approach for dealing with the flooding was needed to ensure efficiency in utilizing available resources. A flood response center was set up at the Emergency Operations Center to field all calls. County forces, mobilized from different departments, worked in shifts around the clock to relieve flooding throughout the county.

Flooding that resulted in complaints consisted of localized flooding that could be resolved with proper maintenance or that was caused by undersized drainage systems, closed basins, or lack of outfalls, and regional flooding caused by undersized conveyance systems.

More than three hundred stormwater neighborhood projects were generated, and the need to accelerate stormwater master planning for the entire county was recognized. Regional master plans would be managed as a group, thereby standardizing methodologies countywide. They would also allow for solutions to be implemented for regional problems while more effectively solving the localized problems.

Through discussions with personnel in various county departments and state agencies, it was quickly recognized that the plans could and should do more than solve flood problems created in yesteryears. With $96 million approved by the county commissioners for an accelerated 5-year stormwater program, the objectives of the new plans came to fruition:

1. The plans will be "Watershed Management Plans" embracing the latest concepts of watershed planning outlined by EPA.
2. The plans will cover all 17 watersheds in the county, covering its entire 900 square miles. Accordingly, some watersheds that were studied a decade or so ago will be re-studied using current technology, while other watersheds will be studied for the first time.
3. The plans will comply with the requirements of the county's NPDES permit, as well as the Tampa Bay Estuary Program agreement.
4. The plans will address four areas of concern in each watershed: flood control, water quality, natural systems, and water supply.
5. The plans will examine the adequacy of existing regulations and land use policies, and any resulting recommendations will have regulatory significance.
6. The plans will have specific regional and local recommendations dealing with issues that are specific to the watershed without being too complex or cumbersome to follow.
7. Finally, the most important aspect of the plans is the emphasis on public input. The watershed plans will solicit input from the public and other citizen groups in each of the watersheds at three different stages: when data for existing conditions is collected, the beginning of alternative analysis, and at the recommendation stage. In addition to continuous opportunity for input during the process, these three events will be professionally facilitated to ensure a chance for everyone to voice opinions, concerns, or recommendations. Such facilitated meetings will also build on efforts by other county agencies working with citizen groups to link land use and water management.

In 1998 the county completed studies for six watersheds (Brooker Creek, Double Branch Creek, Rocky/Brushy Creek, Sweetwater Creek, Lower Sweetwater Creek in the northwest part of the county, and Pemberton/Baker Creek in eastern Hillsborough County). Currently nine more watershed plans are being initiated. Plans for the East Lake watershed and Delaney/Archie Creek watershed are being done in-house by county staff, and are scheduled to be completed in fiscal years 1999 and 2000, respectively. Consultants are doing the other seven studies at an estimated cost of $8 million. These include the Hillsborough River and Tampa Bypass Canal watersheds, the Alafia River, the Little Manatee River, Bullfrog Creek, Cypress Creek, and Curiosity Creek. All of the plans are scheduled to be completed no later than the end of fiscal year 2001. ■

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Pollutant Removal Efficiencies for Typical Stormwater Management Systems in Florida

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A substantial amount of research over the past several decades has demonstrated that some commonly used stormwater management techniques are much more efficient in removing and retaining pollutant loadings than others. Nevertheless, many stormwater management facilities are selected or designed based on the ability of a system to function hydraulically rather than on pollutant removal effectiveness. A literature review, which quantifies pollutant removal efficiencies associated with common stormwater management systems, was performed. The results may be useful in modifying existing stormwater management regulations to emphasize the use of techniques that are most effective in terms of removing and retaining stormwater pollutants.

Each reviewed study was evaluated for adequacy of its database, with special attention being paid to factors such as length of study, number of runoff events monitored, monitoring methodology, as well as completeness and accuracy of work. It was preferred that selected studies contain at least a three-month period of data collection, representing a wide range of rainfall and antecedent dry weather conditions. Studies with less than four monitored storm events were not included.

Only stormwater management facilities constructed within Florida according to applicable stormwater regulations were included in the evaluation. Pollutant removal efficiencies were obtained and summarized for the following types of stormwater management facilities: (1) dry retention (on-line); (2) wet detention (on-line); (3) off-line retention/ detention; (4) wet detention; (5) wet detention with filtration; (6) dry detention; and (7) dry detention with filtration.

The terms "detention" and "retention" are often used interchangeably by engineers, even those who have been designing stormwater management facilities for many years. For purposes of this discussion, "detention" refers to the collection and temporary storage of stormwater, generally for a period of time ranging from 24 to 72 hours, in such a manner as to provide for treatment through physical, biological or chemical processes with subsequent gradual release of stormwater to downstream receiving waters, while "retention" means on-site storage of stormwater with subsequent disposal by infiltration into the ground or evaporation in such a manner as to prevent direct discharge of stormwater runoff into receiving waters.

A summary of literature references and estimated pollutant removal efficiencies was prepared for each type of stormwater system evaluated. The results of these evaluations are summarized in the following sections.

Dry Retention Systems (On-Line)

In spite of the fact that on-line dry retention systems are used extensively throughout Florida, relatively little research has been conducted to evaluate their pollutant removal. Only two references, both of which were conducted as part of the Orlando Areawide 208 Assessment during the late 1970s, were identified. A summary is given in Table 1.

The first study, published in 1978 by the East Central Florida Regional Planning Council (ECFRPC), was conducted on a commercial watershed in Orlando. Concentration-based removal efficiencies for the dry retention system reported in this study ranged from approximately 61% for total phosphorus to more than 90% for species of nitrogen. Information on the amount of retention storage available within the system is not presented.

The second study, conducted by Wanielista (1978), was also part of the Orlando Areawide 208 Assessment. It presents calculated estimates for the efficiency of retention systems based upon simulations of yearly rainfall/runoff events. Removal efficiencies are presented as a function of retention volume with increasing removal efficiencies associated with increasing runoff volumes retained. This simulation assumes that the retention pond drains completely between rain events so that the design retention volume is available for the next storm event. Removal efficiencies of approximately 80% are associated with retention of 0.25 inches of runoff, 90% for 0.50 inches, and 95% for 0.75 inches. Even though the removal estimates are only calculated and are not based upon actual field measurements, they are used extensively throughout Florida.

It is obvious that removal efficiencies achieved in retention systems are regulated to a large degree by the amount of runoff volume retained. In general, the annual pollutant removal effectiveness of a retention system should increase as the retention volume increases. However, since dry retention systems do not always recover the entire pollution abatement volume before the next storm event, the actual observed pollutant removal efficiencies for dry retention systems are probably somewhat less than the values presented by Wanielista. Based on experience by ERD in evaluating stormwater management systems, recommended removal efficiencies for on-line dry

Table 1. Treatment Efficiencies For Dry Retention Systems Based On Selected Research Studies In Florida

Study Site/ Land Use	Type Of Efficiencies Reported	Mean Removal Efficiencies (%)									
		NOx	TKN	Total N	Ortho -P	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Orlando/ Commercial[1]	Concentration	-92	-91	-91	—	-61	-85	-92	—	—	—
Orlando/ Urban[2]	Calculated										
	a. 0.25" ret.	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80
	b. 0.50" ret.	-90	-90	-90	-90	-90	-90	-90	-90	-90	-90
	c. 0.75" ret.	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95
	d. 1.00" ret.	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
	e. 1.25" ret.	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9

1. ECFRPC (1978)
2. Wanielista (1978)

Table 2. Recommended Removal Efficiencies for On-line Dry Retention Facilities

Treatment Volume inches	Percent Removal oF TP, TN, TSS Total Cu, Pb and Zn (%)
0.25	-60
0.50	-80
0.75	-90
1.00	-95
1.25	-98

retention facilities are summarized in Table 2.

Wet Retention Systems (On-Line)

Similar to dry retention systems, relatively little research has been conducted within Florida on treatment efficiencies for wet retention systems. Only two such studies were identified during the literature search. A summary of removal efficiencies achieved in the two investigations is given in Table 3.

Table 3. Treatment Efficiencies for Wet Retention Systems Based on Selected Research Studies in Florida

Study Site/ Land Use	Type Of Efficiencies Reported	Mean Removal Efficiencies (%) NOx	TKN	Total N	Ortho -P	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Orlando/ Residential[1]	Mass	-93	-45	-62	+20	-29	-76	-20	-23	-51	-59
Orlando/ Commercial[1]	Mass	-95	+16	-19	-44	-73	-93	-60	-25	-49	-77
Mean Values		**-94**	**-15**	**-41**	**-12**	**-51**	**-85**	**-40**	**-24**	**-50**	**-68**

1. Harper (1998)

Both of the studies identified in the literature search were conducted in the Orlando area by Harper (1988) as part of a two-year study for DEP. One site represented residential land use and one site commercial land use. Both wet retention systems were designed to provide a pollutant abatement volume of 0.50 inches of runoff over the watershed area. Neither was observed to drain completely between storm events, with a permanent pool depth of approximately 6 to 24 inches. With the exceptions of NOx, TSS, and the measured heavy metals, considerable variability was observed in the treatment performance for the two systems. Measured treatment efficiencies ranged from approximately 10 to15% for orthophosphorus and TKN; 40 to 50% for total nitrogen, total phosphorus, and BOD; and more than 85% for TSS and NOx.

In general, treatment efficiencies for wet retention systems are substantially lower for many parameters than removal efficiencies estimated for dry retention systems, probably because of several factors. First, wet retention systems typically regain the pollution abatement volume by infiltration of the runoff into the groundwater at a slower rate than dry retention systems because of the differences in effective percolation area. As a result, subsequent storm events may occur prior to evacuation of the required treatment volume, thereby reducing the overall efficiency of the system. Second, particulate forms of nitrogen and phosphorus that settle upon the pond bottom can resolubilize in the wet environment into the water column of the pond. Material that was trapped into the sediments at one time may then be transported from the pond with the next storm event that exceeds the available pollution abatement volume. However, this phenomenon of resolubilization can be minimized by increasing the permanent pool depth to approximately 6 feet or greater to isolate settled sediment material.

A summary of mean removal efficiencies for the two wet retention systems is given in at the bottom of Table 3. On an average annual basis, wet retention systems provide approximately 40% removal of total nitrogen, 50% of total phosphorus, 85% removal of TSS, and 40% removal of BOD. Removal efficiencies for heavy metals average 25% of total copper, 50% of total lead, and 68% of total zinc.

Off-Line Retention/Detention — (Dual Pond)

Off-line retention/detention systems, often called dual pond systems, are commonly used within Orlando and other urban areas. Thet provide an off-line retention pond with a pollution abatement volume generally equivalent to 0.50 inches of runoff over the contributing watershed area. After the retention pond reaches the design storage level, a diversion weir then diverts the remaining stormwater runoff into a separate detention pond for flood control purposes.

Off-line retention/detention systems provide pollutant removal mechanisms in both the retention system as well as the detention portions of the pond. The initial first-flush pollutants are diverted into the retention facility. Stormwater runoff entering the separate detention pond is generally cleaner than the stormwater runoff that enters the off-line retention ponds. Removal processes such as settling, adsorption,, and precipitation reactions can also occur within the detention facility during the drawdown period.

A summary of treatment efficiencies for off-line retention/detention systems based on studies conducted within Florida is given in Table 4.

Table 4. Treatment Efficiencies for Off-line Retention/detention Systems (dual Pond) Based on Selected Research Studies in Florida

Study Site/ Land Use	Type Of Efficiencies Reported	Mean Removal Efficiencies (%) NOx	TKN	Total N	Ortho -P	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Orlando/ Residential[1]	Mass	-88	-83	-85	-96	-92	-95	-90	-85	-71	-91
Orlando/ Commercial[1]	Mass	-95	—	-30	-61	-76	-89	-64	-47	-80	-81
Mean Values		**-92**	**-83**	**-58**	**-79**	**-84**	**-92**	**-77**	**-66**	**-76**	**-86**

1. Harper (1998)

Only two studies providing pollutant removal efficiencies for off-line retention/detention systems were identified in Florida. Both were conducted by Harper (1988) in the Orlando area on residential and commercial watersheds. Each system was constructed according to city of Orlando regulations that were applicable at the time of construction and provided a permanent pollution abatement volume of 0.50 inches over the contributing watershed area within the retention pond portion of the system.

Excellent removal efficiencies were achieved in the study reported by Harper (1988) in the Orlando residential watershed. Measured removal efficiencies for total nitrogen, total phosphorus, TSS, BOD, total copper, and total zinc were equal to 85% or greater. Removal efficiencies measured in the commercial watershed studied are somewhat lower than those reported in the residential watershed. Removal efficiencies for total nitrogen, total phosphorus, TSS, and BOD measured in this study were 30%, 76%, 89%, and 64%, respectively. Removal efficiencies for the measured heavy metals ranged from 47% for copper to 81% for zinc.

Mean values for the two studies are reported at the bottom of Table 4. On an average basis, off-line retention/detention facilities provide good removal efficiencies for total nitrogen, total phosphorus, TSS, BOD, and heavy metals. Annual removal efficiencies for this type of system can be expected to be approximately 55-65% for total nitrogen and total copper; 75-85% for total phosphorus and total lead; and 80-90% for TSS, BOD, and total zinc.

Wet Detention Systems

Of the stormwater management facilities investigated during this research, probably the most amount of research within Florida has been conducted on wet detention systems. Unfortunately, much of it was conducted on wet detention systems that were not constructed according to current regulations regarding mean detention time, pond configuration, and depth. Many of the available studies do not present information regarding the pollution abatement volume or residence time within the system.

A summary of treatment efficiencies for wet detention systems based on selected research studies in Florida is given in Table 5.

Table 5. Treatment Efficiencies for Wet Detention Systems Based on Selected Research Studies in Florida

Study Site/ Land Use	Type Of Efficiencies Reported	Mean Removal Efficiencies (%) NOx	TKN	Total N	Ortho -P	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Brevard Co./ Commercial[1]	Concentration	—	-76	—	—	-69	-94	—	—	-96	—
Boca Raton/ Residential[2]	Concentration	-93	+31	-12	-93	-55	-68	—	—	—	—
	Mass	-87	0	-15	-82	-60	-64	—	—	—	—
Maitland/ Highway[3]	Concentration	-85	-22	-35	-94	-81	—	—	-56	-88	-92
EPCOT/ Highway[3]	Concentration	-79	-35	-44	-92	-62	—	—	0	0	-88
Orlando/ Urban[4]	Concentration	—	-15	—	-57	-38	-66	—	—	-40	—
Orlando/ Residential[5]	Mass	-95	-90	—	—	-91	-82	-90	-90	-90	-96
DeBary/ Comm.-Resident.[6]	Mass										
	a. t_d = 7 days	-50	—	-20	-40	-60	-85	-50	-40	-60	-85
	b. t_d = 14 days	-70	—	-30	-60	-70	-85	-60	-50	-85	-95
Tampa/Light Commercial[7]	Mass	-65	-49	—	-67	-65	-55	—	—	—	-51
Mean Values		**-80**	**-37**	**-26**	**-73**	**-65**	**-75**	**-67**	**-59**	**-77**	**-85**

1. PBS&J (1982) 3. Yousef, et al. (1986) 5. Harper (1988) 7. Rushton and Dye (1993)
2. Cullum (1984) 4. Martin and Miller (1987) 6. Harper and Herr (1993)

Measured removal efficiencies for NOx, orthophosphorus, total phosphorus, TSS, and heavy metals are relatively consistent between the studies presented within the table. In contrast, a high degree of variability in measured removal efficiencies is present for TKN and total nitrogen. Removal efficiencies for total nitrogen range from -12% to 44% for the studies presented. Wet detention systems provide mean removal efficiencies of 60% or greater for NOx, orthophosphorus, total phosphorus, TSS, and copper. Removal efficiencies for orthophosphorus, TSS, lead, and zinc approach or exceed 75%.

In many of the studies the ability of the system to remove total nitrogen is heavily dependent on the fraction of total nitrogen present as organic nitrogen. Organic nitrogen is not readily available through biological or chemical processes, and there are relatively few mechanisms for removal of this species in a wet detention system. In contrast, both NOx and ammonia are readily taken up in biological processes, which accounts for the relatively good removal efficiencies achieved for these species in wet ponds. In systems where organic nitrogen represents a dominant proportion of the total nitrogen in the incoming stormwater flow, removal of total nitrogen can be expected to be relatively poor. If inorganic species of NOx and ammonia represent the dominant nitrogen species found, then removal efficiencies for total nitrogen can be expected to increase.

On an average basis, wet detention systems can be expected to provide a net removal of approximately 20 to 30% of total nitrogen; 60 to 70% of total phosphorus and copper; and 75% or more for total suspended solids, total lead, and total zinc. The report by Harper and Herr (1993) presents separate removal efficiencies for pond detention times of approximately 7 days, along with detention times of 14 days or more. With the exception of TSS, increasing the pond detention time results in a slight improvement in removal efficiencies for the listed parameters. At a detention time of seven days, removal of total nitrogen, total phosphorus, and TSS is estimated to be approximately 20%, 50%, and 85%, respectively. Heavy metal removal is estimated at 40%, 60% and 85% for copper, lead, and zinc, respectively. At a detention time of 14 days, removal of total nitrogen, total phosphorus, and TSS increases slightly to approximately 30%, 70%, and 85%, respectively. Heavy metal removal at a detention time of 14 days increases to 50%, 85%, and 95% for copper, lead, and zinc, respectively.

Wet Detention with Filtration Systems

Wet detention with filtration systems are commonly used throughout Florida. However, prior to 1993, no specific research had been conducted to evaluate their pollutant removal effectiveness. In 1993, a study was performed by Harper and Herr over a 6-month period at a research site in DeBary, Florida. A detailed hydrologic budget was calculated for the pond and filter system combined and separately, and flow-weighted composite samples were collected of stormwater runoff, underdrain outflow, bulk precipitation, and groundwater inputs to allow calculation of a detailed mass balance for the overall system.

A summary of treatment efficiencies measured by Harper and Herr (1993) for wet detention with filtration systems is given in Table 6.

Table 6. Treatment Efficiencies For Wet Detention With Filtration Systems Based On Selected Research Studies In Florida

Study Site/ Land Use	Type Of Efficiencies Reported	Mean Removal Efficiencies (%)									
		NOx	TKN	Total N	Ortho -P	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
DeBary/ Comm.-Resident.[1]	Overall	-27	0	0	-37	-61	-98	-99	-37	-71	-89

1. Harper and Herr (1993)

On an annual mass basis, the wet detention with filtration system was found to remove approximately 60% of the total phosphorus and 98% of the TSS. However, no net removal of total nitrogen was measured at the site. Removal efficiencies for heavy metals were variable, ranging from 37% for total copper to 89% for total zinc.

Harper and Herr (1993) concluded that the majority of removal processes occurred within the open water portions of the pond and not within the filter media. Particles of nitrogen, phosphorus, and heavy metals trapped on the filter media, were found to solubilize over time, resulting in increased concentrations of dissolved species in the underdrain flow compared with concentrations measured in the pond. No long-term effectiveness or affinity of the filter media was observed to retain inputs of nitrogen, phosphorus, and heavy metals.

The poor removal efficiencies for total nitrogen exhibited by the system were found to be related to entrapment of particulate nitrogen on the filter surface with later subsequent decomposition and solubilization of particulate forms into dissolved forms of nitrogen that could then pass through the filter media and into the outflow. The effectiveness of the system would probably have been greater if the filter system had been removed, because the particulate forms of phosphorus and nitrogen would have settled into the bottom sediments where solubilization into the water column would have been of less concern. The study concluded that filter systems remove relatively little pollution present in the stormwater flow on a long-term permanent basis, and the operation of wet detention ponds could probably be enhanced by elimination of the filter system and substitution of an orifice that allowed a slow drawdown over a period of several days.

Dry Detention Systems (Without Filtration)

Although dry detention facilities are used commonly within SFWMD, the literature review did not find any studies conducted within Florida that identified their pollutant removal effectiveness. Dry detention systems remove pollutants primarily through sedimentation processes with a limited amount of biological and chemical activity. Since dry detention facilities are designed to regain the pollution abatement volume within a period of several days, opportunities for biological activity is severely limited.

Removal of suspended solids in these systems between the inflow and outflow is relatively good. Removal of particulate forms of nitrogen, phosphorus, and heavy metals may also occur due to sedimentation during travel through the pond. However, few removal mechanisms are available for dissolved forms of nutrients, heavy metals, or other parameters, other than losses due to infiltration into the pond bottom.

Estimated treatment efficiencies for dry detention systems are presented in Table 7 based on extensive previous research conducted by ERD on stormwater management facilities.

Assuming a detention time of 1 to 3 days within the system, removal of suspended solids can be expected to range from approximately 60 to 80%. In general, approximately half of the total phosphorus measured in runoff is present in a particulate form. Much of the particulate matter can be expected to settle out within the detention facility. However, resolubilization of some settled particulate matter may increase dissolved phosphorus concentrations within the water column, reducing the effective removal efficiency of the system. Therefore, removal of total phosphorus within the system is estimated to be approximately 20 to 40%.

Table 7. Estimated Treatment Efficiencies for Dry Detention Systems

Parameter	Range of Estimated Removal Efficiencies (%)	Recommended Removal Efficiency (%)
Total N	-10 to -20	-15
Total P	-10 to -40	-25
TSS	-60 to -80	-70
BOD	-30 to -50	-40
Total Cu	-20 to -50	-35
Total Pb	-40 to -80	-60
Total Zn	-50 to -90	-70

Particulate forms of total nitrogen generally compose approximately one-third of the total nitrogen measured in stormwater runoff. Much of the particulate matter can be expected to settle out within the pond. However, some resolubilization may occur, reducing the observed treatment effectiveness. Annual removal of total nitrogen within a dry detention system is estimated to be approximately 10 to 20%.

Lead and zinc are typically characterized by significant particulate fractions that account for the majority of the metal species measured in stormwater runoff. As a result, mass removal for these metals should be good. In contrast, copper is primarily in a dissolved form in runoff, and its removal efficiency should be substantially less than for lead or zinc. Annual removal in dry detention ponds is estimated to be 20 to 50% for total copper, 40 to 80% for total lead, and 50 to 90% for total zinc.

Significant decomposition of oxygen-demanding wastes may also occur with a detention time of 1 to 3 days. Some BOD is also present in stormwater as particulate matter that may settle out onto the pond bottom. As a result, treatment efficiency for BOD in a dry detention system is estimated to be approximately 30 to 50%.

Comparison of Treatment Efficiencies for Stormwater Management Systems

A comparison of treatment efficiencies for typical stormwater management systems used in Florida is given in Table 8 based on information obtained in the literature review. In cases where a range of removal efficiencies are presented in technical reports related to a particular stormwater management technique, the mid-point of the range is given in Table 8 for comparison purposes.

The Florida State Water Policy, outlined in Chapter 17-40 of the Florida Administrative Code, establishes a goal of 80% annual reduction of stormwater pollutant loadings by stormwater management systems. Of the stormwater management systems listed in Table 8, only dry retention systems, with 0.5 inches of runoff retained, meet the State Water Policy goal of 80% reduction in annual pollutant loadings to the system. Off-line retention/detention facilities meet the 80% reduction goal for total phosphorus, TSS, BOD, and total zinc, but provide only

Table 8. Comparison Of Treatment Efficiencies For Typical Stormwater Management Systems Used In Florida

TYPE OF SYSTEM	Estimated Removal Efficiencies (%)						
	Total N	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Dry Retention							
a. 0.25-in. retention	-60	-60	-60	-60	-60	-60	-60
b. 0.50-in. retention	-80	-80	-80	-80	-80	-80	-80
c. 0.75-in. retention	-90	-90	-90	-90	-90	-90	-90
d. 1.00-in. retention	-95	-95	-95	-95	-95	-95	-95
e. 1.25-in. retention	-98	-98	-98	-98	-98	-98	-98
Off-Line Retention/ Detention	-60	-85	-90	-80	-65	-75	-85
Wet Retention	-40	-50	-85	-40	-25	-50	-70
Wet Detention	-25	-65	-85	-55	-60	-75	-85
Wet Detention with Filtration	0	-60	-98	-99	-35	-70	-90
Dry Detention	-15	-25	-70	-40	-35	-60	-70
Dry Detention with Filtration	0	0	-75	0	-65	-90	-25
Alum Treatment	-50	-90	-90	-75	-80	-90	-80

a 60 to 75% annual pollutant reduction for total nitrogen, copper, and lead. Wet detention systems can meet the 80% reduction goal for TSS only, with removal efficiencies from 40 to 50% for total nitrogen, total phosphorus, and BOD. Dry detention with filtration systems meet the 80% reduction goal for total lead only, and it provides virtually no pollutant removal for total nitrogen, total phosphorus, or BOD. Based on the available literature, dry detention with filtration systems were found to exhibit a high degree of variability in estimated removal efficiencies. The actual removal efficiencies achieved by dry detention with filtration systems are a function of the relationship between the underdrain system and the seasonal high groundwater table.

Based on the information provided in Table 8, the most effective stormwater management systems in terms of retaining stormwater pollutants appear to be dry retention, off-line retention/detention ponds, wet retention, and wet detention systems. The use of these types of systems should be emphasized to maximize the pollutant removal effectiveness for stormwater management systems.

Based upon the literature review, there is little evidence to indicate that filter systems improve the operational performance of stormwater management systems. In fact, much of the research indicates that filter systems may actually degrade the pollutant removal effectiveness of either a wet detention or dry detention system. In addition, filter systems must be routinely maintained to continue the proper hydraulic performance of the system. In view of the poor pollutant removal effectiveness of filter systems, and the continuing maintenance problems associated with these systems, the use of filter systems with wet detention or dry detention ponds should be discouraged.

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Lake Munson Stormwater Master Plan Implementation

Theresa B. Heiker

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Leon County's master planning efforts began decades ago. They focused initially on flood prevention and more recently on water quality improvements. As technology increases our knowledge of the systems, we are able to better define our structural and non-structural recommendations to achieve our goals. While increasing development creates additional burdens on natural systems, it also provides the revenue base to implement the retrofit recommendations. Leon County's master planning efforts are best demonstrated in the Lake Munson Basin and Leon County's commitment to the restoration of the lake.

Hydrology

Lake Munson is a 225-acre, cypress-rimmed lake resulting from the historic impoundment of Munson Slough. Topographic data and Spanish exploration records suggest that Munson Slough originally joined the Wakulla River and discharged to the Gulf of Mexico. Various karst features, such as Ames Sink and the Wakulla Springs system, apparently developed to capture the slough. Munson Slough currently ends at Ames Sink after flowing through approximately three miles of the Apalachicola National Forest downstream from Lake Munson.

The hydrology of the Munson system was altered by the construction of "mosquito control ditches" to drain many of the isolated wetlands in the 1940s and 1950s. Natural creeks were extended to provide the outfalls, making it difficult to be certain what the original drainage area may have encompassed. The urban development within Tallahassee also increased the rate and volumes of discharges in the system until the implementation of stormwater rate control regulations.

Ames Sink, as the receiving water for 72 square miles of drainage area, can be overwhelmed by the runoff from either a single high-intensity event (March 2-3, 1991) or a long-duration, high-volume series of events (May through October 1994). There is only an 18-foot fall from the Munson dam and the normal water elevation at Ames Sink three miles south. Consequently, repeat flooding of the slough vicinity becomes a more pressing and difficult issue as the basin continues to develop without volume restrictions.

Water Quality

Lake Munson was ranked the seventh most degraded lake in Florida in 1982. It remains substantially degraded since being listed as the ninth water body in priority in the 1988 NWFWMD Surface Water Improvement and Management Program. Lake Munson historically received flows from the wastewater treatment facilities serving Tallahassee (diverted to spray irrigation in 1984), the Dale Mabry treatment plant (closed), and other package treatment plants. During the early 1940s, a coal gasification plant discharged to the system. Prior to the implementation of water quality standards, the Lake Munson tributaries received discharges from numerous service stations, automobile repair facilities, and an oil recycling facility. These historic uses are believed to be the sources of high levels of petroleum byproducts and nutrients present in the lake sediments.

Challenges

One of the greatest water quality challenges facing the lake is the physical impact of the accumulated sediment load. Bathymetry indicates peat and muck up to ten feet deep in some areas of the lake, leaving an average water depth of only three feet. Drawdowns to consolidate the material are not substantially effective because of the stormwater runoff through the creek system, the irregular sediment loading throughout the lake, and the poor quality of the material itself. The sediment load in the system is considered to be partly responsible for the loss of Lake Henrietta approximately one mile upstream of Lake Munson. The effects of just the past 45 years of sediment transport can be readily identified in the 30-acre delta, which has blossomed in the headwaters to Lake Munson.

The sediment delta was sampled to determine handling requirements during the lake restoration effort. Approximately 10% of the material is manmade floatables, such as Styrofoam cups, lumber, packing crates, white goods, and tires. An additional 5% is vegetative debris such as trees and limbs. The sediments throughout the current project area were tested for Total Petroleum Hydrocarbons (TPH) and the EPA priority pollutant metals. In addition, the two samples with the highest concentrations of "total" metals and TPH were tested for toxicity characterization leaching potential (TCLP) to determine if the constituents in the sediment were leachable and whether the sediments might require special handling and disposal. The sediment does contain petroleum byproducts and pesticides above the detectable limit; however, the TCLP tests verified that the materials do not merit a hazardous classification.

The sediments are extremely high in nutrients, creating a tremendous oxygen load on the water system while supporting a stellar growth in exotic and nuisance species. The extensive growth of hydrilla and other exotic species has rendered the lake virtually inaccessible by motorized boats. Efforts to contain the exotics have included the introduction of grass carp with limited success. Removal of the underlying nutrient-laden sediment layer is considered to be crucial to the success of the aquatic weed control program.

Historic Studies

Fish surveys by the Florida Game and Fresh Water Fish Commission date back to 1954, at which time the lake was considered a good waterfowl hunting area and a cracker fishing lake. Even in 1954 many residents avoided fishing the lake because of algal blooms and wastewater effluent discharges. The decline in the lake led to a 1977 drawdown and supplemental restocking program, but it failed to produce the desired effect. The survey taken in 1986 indicated an overall 75% decrease in fish biomass from the 1976 survey.

Numerous flood studies were commissioned by the city of Tallahassee and Leon County, such as the study completed in 1972 that recommended either a 500-foot bottom depth ditch for the mile upstream of Lake Munson, or the construction of flood-storage in three upstream wetlands, among other things. The area was studied as part of the EPA 208 program.

The Lake Munson Basin was modeled as part of the 1991 City of Tallahassee and Leon County Stormwater Management Plan developed by NWFWMD. Several recommendations included non-structural improvements, such as enforcement of floodplain development restrictions, floodplain and wetland acquisition, and development setbacks for the upstream natural system. Structural improvements included the construction of stormwater treatment facilities in each of the tributary systems, with a focus on the overall basin improvement rather than achieving a current water quality standard with any of the facilities.

The lake itself was studied by NWFWMD under the EPA Clean Lakes Program culminating in the issuance of the Diagnostic Feasibility Report for Lake Munson in August 1992. This report, which provided substantial background for this article, recommended the construction of seven upstream water quality facilities prior to implementation of the in-lake restoration efforts. Of these facilities, two are complete, two are in planning, two are being reevaluated by the city of Tallahassee, and one is part of Leon County's current project.

In addition to the technical studies, the Leon County Board of County Commissioners created a Lake Munson Action Team comprising seven technical staff members from various resource agencies and five private citizens concerned with the lake. The Lake Munson Action Plan prepared by the committee recommended implementation of the 1991 Stormwater Management Plan, increased inspection and maintenance of existing stormwater facilities, in-lake restoration and upstream trash rack construction, and a public awareness and education program. The Plan was presented for public comment and adopted by the board in November 1994. The public comments were supportive of restoration, but skepticism about the implementation remained high.

Implementing the Restoration Plan

The initial project focuses on flood control through the construction of additional floodplain storage at historic Lake Henrietta, decreasing the meander in the slough between Lake Henrietta and Lake Munson, removing the sediment and trash delta in Lake Munson, and providing a "pop-off" to the north arm of Lake Munson for high flows. The removal of the 27-acre delta at the head of Lake Munson decreased water surface elevations in the upstream slough by 1.5 feet. The flood control measures provide an opportunity for concurrent water quality improvements as the 30-acre Lake Henrietta facility is designed for sediment capture and trash removal, and the slough reconstruction provides an opportunity for stabilization of the slopes which currently contribute to the lake's sediment load.

The Lake Henrietta facility substitutes for one of the facilities recommended in the 1991 Stormwater Management plan. The facility will capture up to a 2-year return frequency storm event, but does reduce 100-year flood elevations up to one foot in the downstream slough. The improved maintenance of sediment capture and removal will assist as well in flood reductions. The wetlands adjacent to Lake Henrietta are being restored through a control structure in the slough to increase the hydroperiod, and additional discharge points to the wetlands through the maintenance access will improve the hydration, which was a non-structural recommendation of the WMD.

The slough was analyzed to determine which reaches were subject to scour. The improved slopes, decreased meander, and the use of soil stabilization materials will decrease the erosion and sedimentation currently plaguing the system. The improvements, including the removal of the sediment delta, were so successful in lowering flood elevations that rock dams will be constructed in the slough to maintain the hydroperiod of the adjacent wetlands.

During removal of the sediment delta, the slough base flow will be diverted through an adjacent city borrow pit to the north arm of Lake Munson. Following construction, the ditch will remain to provide for additional discharge of high flows during storm events. This flow will serve to flush the isolated north arm which currently has unexpectedly high nutrient levels.

The construction of the upstream improvements is anticipated to require two years. A bid protest was received following the staff's recommendation to award the contract, and construction will proceed as soon as the issues are resolved. The final step will be the in-lake restoration, which will proceed to design request for proposal following the award of the upstream construction contract. The design will focus on sediment removal for water quality improvement, but will consider wetland and upland habitat requirements as well as public recreation.

Partners of Leon County

The review and adoption of the Lake Munson Action Plan occurred during record flooding throughout Leon County from a series of tropical storms and depressions. The series of studies on the system were used to prepare a flood-mitigation project proposal to utilize federal disaster funds. The $1.96 million in federal Community Development Block Grant funds provided the upfront monies needed to prepare the surveys, design drawings and specifications, soil samples, wetland and upland habitat evaluations, hydrologic and hydraulic models (including groundwater), and other analyses necessary to obtain the local, state, and federal permits required for the project. The funds were also used to acquire some of the necessary project sites and relocate the affected residents.

Additional funds are being provided by the Florida Game and Fresh Water Fish Commission and EPA Section 319 Nonpoint Source Management Grant Program. The Leon County Solid Waste Facility will cost-share in hauling costs of sediments suitable for daily or final cover as the current landfill is closed in the next two years. The city of Tallahassee is currently negotiating to allow Leon County to construct some of the improvements on city property and to accept sediments for use on the adjacent airport, reducing haul costs substantially. The U.S. Forest Service is providing the use of adjacent Apalachicola National Forest property for a material handling site and access to the sediment delta.

Primary funding for the project is through capital improvement bonds issued by Leon County. The county commission recognizes the need to restore and protect the water bodies within its jurisdiction and is committed to a $24 million Lakes Restoration Program, with the Lake Munson Restoration Project as our showcase. ■

The Florida Watershed Restoration Act and TMDL Program

Blake Guillory and Tom Sear

The 1999 legislative session produced a TMDL bill, called the Florida Watershed Restoration Act, that establishes the Total Maximum Daily Load (TMDL) process for the state. This paper presents a summary of the bill that establishes the means and mechanism by which Florida will comply with federal law.

The 1972 Clean Water Act (CWA) established a goal of attaining "swimable and fishable" surface waters throughout the U.S. To this end, the NPDES program for permitting point and non-point sources was developed. The point source permits granted under the NPDES program primarily imposed technology-based effluent limitations (TBEL) on point source dischargers. Because of enforcement of the point source program, water quality improvements have been impressive; however, there are still many surface waters that have not attained their designated uses, some because the non-point sources have not been adequately addressed.

The Clean Water Act [Section 303(d)] requires both EPA and states to identify those water segments that are currently unable to (or are not expected to) meet water quality standards through the use of technology-based effluent limitations. The CWA also requires that these water segments be ranked according to the severity of their water quality problems and use attainment. Water segments that do not meet their water quality limits (WQLs) are typically identified when states develop their Section 305(b) reports to EPA and Congress on the status of quality and use attainment. States are to address these WQLs by establishing TMDLs for those pollutants that impair their designated uses. In the absence of action by the states, EPA is required to establish TMDLs. EPA has established a policy that requires states to establish a schedule for completing TMDLs, with expectations that these schedules not exceed 8 to 15 years.

EPA and a number of states are currently faced with legal actions by environmental groups that contend EPA and the states have failed to meet the requirements of Section 303(d) of the CWA. The legal actions include notices of intent to sue, active lawsuits, and court orders and consent decrees. On April 22, 1998, Earthjustice (formerly the Sierra Club Legal Defense Fund) filed suit in Florida alleging that the state is moving too slowly in developing the TMDLs, and they desire a broader approach to water quality improvements.

Clearly, the establishment of TMDLs can have serious implications for the Florida water industry. With increasing populations comes the necessity for new or expanded wastewater treatment facilities and stormwater management controls that, together with land use changes, may severely impact receiving water quality. In other states where TMDL suits have been brought, the courts have been asked to modify, revoke, reissue, or terminate existing permits as necessary to meet established TMDLs. Further requests have also been made to prohibit any new sources or dischargers into water quality limited segments.

Because of the ramifications of setting TMDLs on existing and new sources of pollutant loading, local stormwater programs must provide input to EPA and DEP at every stage in the TMDL-setting process. Those communities which hesitate until their permits are up for renewal may find it too late to have any influence on the outcome of the process.

Following is a summary of Florida Watershed Restoration Act that establishes the Total Maximum Daily Load (TMDL) process for Florida. All point source and non-point source discharges within the state may be directly affected by this legislation.

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- The bill designates DEP as the lead agency and requires it to perform a complex capacity analysis before calculating and allocating the amount of a pollutant which a water body may receive without violating water quality standards.
- Previous lists of impaired waters cannot be used in any regulatory program in Florida, and any TMDL calculations or allocations established prior to this act must undergo all of the rule adoption procedures identified in the bill.
- Before revising and prioritizing the list of impaired waters, DEP must first adopt by rule a methodology that outlines the analysis that will be used to determine whether a water body is impaired.
- If a water body is determined to be impaired due to narrative or biological criterion, DEP is required to first isolate and identify the pollutant causing the impairment prior to proceeding to develop a TMDL for that pollutant.
- Water bodies on the revised list may be dropped or added as additional information becomes available.
- If impairment is due solely to activities other than point and non-point sources, no TMDL is required.
- If existing programs such as technology-based effluent limits or other pollution control programs including the National Estuary Program or the Everglades restoration are deemed sufficient to achieve water quality compliance no further TMDL compliance will be required.
- A pollution load reduction goal (PLRG) developed by a water management district can be used as a TMDL as long as the PLRG was developed with the same requirements as the TMDL process given in this bill.
- TMDL allocations are to be based on the following eight specific criteria:
  1. Existing treatment levels and management practices;
  2. Differing impacts pollutant sources may have on water quality;
  3. The availability of treatment technologies, management practices, or other pollutant reduction measures;
  4. Environmental, economic, and technological feasibility or achieving allocation;
  5. The cost benefit associated with achieving the allocation;
  6. Reasonable time frames for implementation;
  7. Potential applicability of any moderating provisions such as variances, exemptions, and mixing zones; and
  8. The extent to which nonattainment of water quality standards is caused by pollution outside of Florida, discharges that have ceased, or alterations to water bodies prior to the date of this act.
- By February 1, 2001, DEP must submit a report with draft legislation recommending any addition criteria that should be considered in making TMDL allocations.
- TMDLs for point sources will be implemented through the NPDES permitting process.
- Non-point source allocations will be implemented through incentive based programs such as public works projects, land acquisitions, pollutant trading, and development of best management practices.
- The bill presumes that best management practices provide compliance with state water quality standards and limits

Continues Pe 33

Watershed Restoration from Page 29

DEP's right to institute a proceeding against an owner for contamination where best management practices have been properly implemented.

Conclusions

Proper and thoughtful implementation of a watershed management program that addresses establishment of a TMDL offers a great opportunity for local governments and industry to control their destiny. Affected parties can influence the outcome only if they actively participate in the process of TMDL determination, which is generally used to address violations of chemical standards in rivers and streams. A broader watershed approach creates opportunities to bundle TMDLs, to strike a balance between controls over point sources and non-point sources, and to consider other water-related problems in the watershed. These include wetland loss, sediment contamination, aquatic species habitat degradation, drinking water protection, and health of riparian areas.

At the core of the process to establish specific TMDL limits is good science, which immediately becomes the pressure point whereby arguments for and against rational decisions will be made.

On one side, arguments will be made that there is insufficient data, or that the data is statistically invalid or suspect. The other scientific extreme will argue that there will never be enough data, and that we have to use our best judgement. Both positions are correct.

We are left with a dilemma, the resolution of which rests in the active participation by all those who have an interest in sound governmental decision-making. EPA recognizes this and has coined the phrase "stakeholder involvement" to describe those individuals, industries, and third parties who have a vested interest in the outcome. Like exercising your right as a citizen to vote, becoming an active stakeholder participant is the duty of local stormwater managers.

It is expected that the TMDL process will be long-term. For this reason, the legislature has directed DEP to provide a report describing the evaluation criteria by February 2001, and a summary report on the program's effectiveness by January 1, 2005. At present DEP is beginning to develop the methodology rule for determining whether a water body is impaired. It will then prepare a revised list of impaired waters along with a priority ranking and schedule relating to basin assessment and the calculation and allocation of TMDLs.

DEP is currently identifying technically qualified individuals who have the means and desire to participate in a technical advisory committee that will address TMDL methodologies. Of particular importance is the selection of individuals with proven expertise in the fields of statistics and water quality. Stakeholders and the general public will be able to provide input to methodology development at public workshops that will present interim work products created by the TMDL committee.

Further information regarding the state's TMDL program can be obtained from DEP by contacting Jan Mandrup-Poulsen (850-921-9488), or by visiting the DEP TMDL Web site (www.dep.state.fl.us/water/division/tmdl). ■