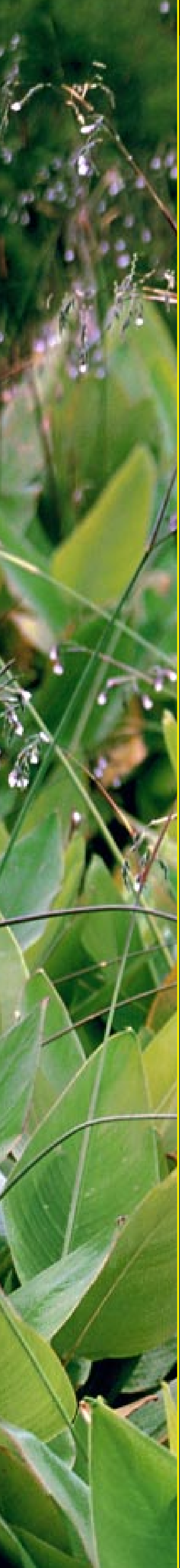


STORMWATER

Best Management Practices

EVERGLADES STORMWATER PROGRAM

South Florida's urbanization began with the building of the Flagler East Coast Railroad in the 1890s. Since then, the population growth rate has mushroomed. As an area urbanizes, natural land is converted to uses that support human activities. Buildings, homes, streets, and parking lots seemingly rise overnight.

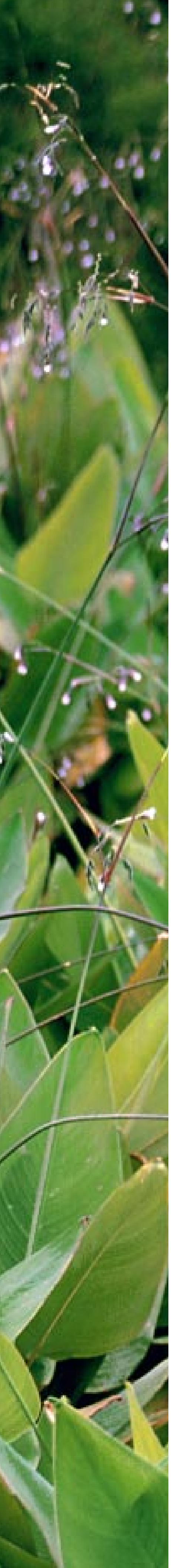
Along with urban sprawl comes a disturbance of the natural water flow. After storms, water runoff becomes accelerated as much of the land has been made impervious by man-made structures. The amount of rain that normally would infiltrate into the ground is reduced. The increased volume of water can overload drainage systems, and the accelerated speed of the runoff created by the rain causes soil and sediment erosion.

Today, greater emphasis is being placed on developing comprehensive Stormwater Management Plans to mitigate the adverse effects of increased runoff. These plans provide for:

- Surface drainage and flood protection
- Erosion and sediment control
- Aesthetic enhancement and recreational opportunities
- Reuse of water resources
- Reduction of pollutants

Best Management Practices, or BMPs, help address the water quality impacts of stormwater runoff by preventing, treating and/or controlling the amount of pollution in urban runoff. Identifying and implementing best practices to suit a specific watershed is an overriding goal in managing stormwater.

While no one Best Management Practice can be the cure-all for a particular plan, a system of practices can pull together as the cars in a train. Henry Flagler's train has evolved into what may be thought of as the BMP treatment train…a linked system for effectively transporting runoff from the urbanized areas of south Florida.



Stormwater Best Management Practices

BMPs help control the volume and speed of runoff before it enters receiving waters and promote the seepage of rainwater into groundwater storage areas. The two general types of BMPs that can be used in combination to manage urban runoff are structural and non-structural.

Non-Structural BMPs include prevention practices designed to improve water quality by reducing the accumulation and generation of potential pollutants at or near their source. They do not require construction of a facility, but instead provide for the development of pollution control programs that include, but are not limited to prevention, education, and regulation. These programs may consist of the following elements:

- Planning and regulatory tools
- Conservation, recycling, and source controls
- Maintenance and operational procedures
- Educational and outreach programs

Structural BMPs involve building an engineered "facility" to treat water at either the point of generation or point of discharge to either the storm sewer system or to receiving waters. Most require some level of routine maintenance. Structural BMPs can be categorized as follows:

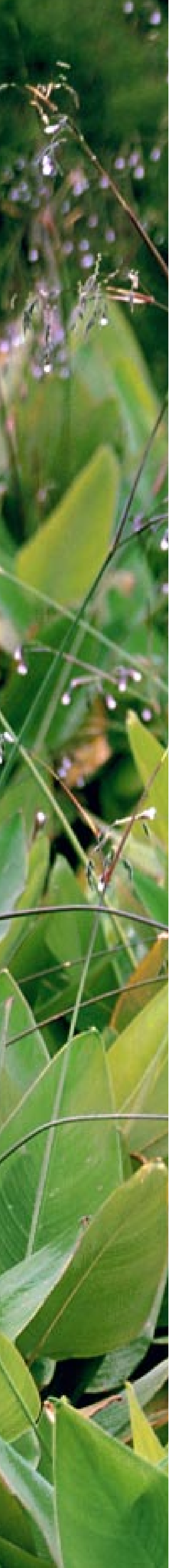
- Retention systems
- Detention systems
- Other systems

The S-9 pumping station, located in Broward County, is the primary discharge structure for the C-11 West Basin, one of the urban tributary basins discharging stormwater runoff into the Everglades Protection Area.

Non-Structural and Structural BMPs

are used in conjunction to create an effective stormwater management plan.

The first strategy of a management plan should be to prevent and reduce pollutants using non-structural BMPs. Structural BMPs are a secondary measure meant to remove additional pollutants from a watershed.



Pollutants Commonly Found in Stormwater Runoff

Pollutants in stormwater runoff are generated from nine major sources: street pavement, motor vehicles, atmospheric deposition, vegetation, erosion, litter, chemicals, construction and agricultural activities, and wastewater.

Each pollutant has a specific adverse impact on the health of our waterways and environment. Common pollutants and their impacts are summarized as follows:

Sediments

These constitute the largest mass of pollutant and consist of solid materials originating from crumbling rocks, eroded soil, or organic material from the land. Sediments clog waterways, smother bottom dwelling organisms, increase turbidity, and degrade aesthetic value.

Nutrients

Nitrogen and phosphorus are generated from landscape runoff (fertilizers, detergents, plant debris), atmospheric deposition, animal wastes and defective septic systems. In excess, these nutrients increase biological productivity and may cause uncontrolled growth of algae and undesirable aquatic weeds.

Heavy Metals

Lead, cadmium, chromium, copper, and zinc originate from motor vehicle operation, direct fallout, industrial facilities, and degradation of highway materials. They disrupt fish and shellfish reproduction and accumulate in fish tissue, thereby posing a threat to humans.

Oxygen Demanding Substances

These substances include decaying organic matter. They consume oxygen in the water and create an oxygen deficit that can kill fish and other aquatic life forms.

Petroleum Hydrocarbons

Petroleum hydrocarbons are generated from leaking storage tanks, vehicle emissions, and improper disposal of waste oil. They can collect in bottom sediments of water bodies where they may harm bottom dwelling organisms.

Pathogens

The primary sources of pathogens such as coliform bacteria and viruses are animal wastes, defective septic systems, illicit sewage connections, and boats and marinas. Contamination prevents swimming in water bodies, drinking from certain water sources, and harvesting fish.

Toxic Materials

Manufactured compounds such as pesticides, solvents, and household and industrial chemicals have been found in at least 10 percent of urban runoff samples.

Other Impacts

Changes in water temperature can also have an impact on water quality. Water holds less oxygen as it becomes warmer resulting in less oxygen available for aquatic organisms. This increases the metabolism, respiration, and oxygen demand of fish and other aquatic life.

Everyday activities provide many opportunities for water conservation and water quality improvement.

Quantifying Pollutants in Stormwater Runoff

Water pollutants can be quantified in terms of concentration or load. Concentration is the amount of pollutant per unit volume of water sampled at a particular time. This may vary considerably with each storm and from site to site. The accepted practice is to determine a single value by analyzing a series of samples taken at points throughout the runoff event and combining them in proportion to the flow rate at the time of sampling. The value is known as the event-mean concentration, or EMC, and is usually expressed as mg/L. It provides a method for comparing different storm events and relating one site with another.

Load is the mass of pollutant delivered to a receiving water body during a period of time. It provides further insight to the values obtained from concentration based data. Loading rates help provide an understanding of the pollutant attenuation capabilities of stormwater management practices. Load is expressed on an annual basis as kg/year or tons/year.

Feasibility Screening for BMP Selection

Selecting a Best Management Practice is a complex process and is most effective when implemented as part of a comprehensive stormwater management program. Management practices should provide for the following: 1) prevention or reduction of the amount of pollutants entering surface or groundwaters and 2) regulation of the total amount of runoff from rainfall.

Construction of facilities and implementation of practices according to approved plans and applicable permits are essential in the management process. Institutional ordinances and programs must be in place to provide the fiscal resources, review and approve plans, inspect operation, and enforce regulations. A comprehensive program should include a combination of components that are properly selected, designed, implemented, inspected, and regularly maintained. BMP options should be evaluated through feasibility screening for the following factors:

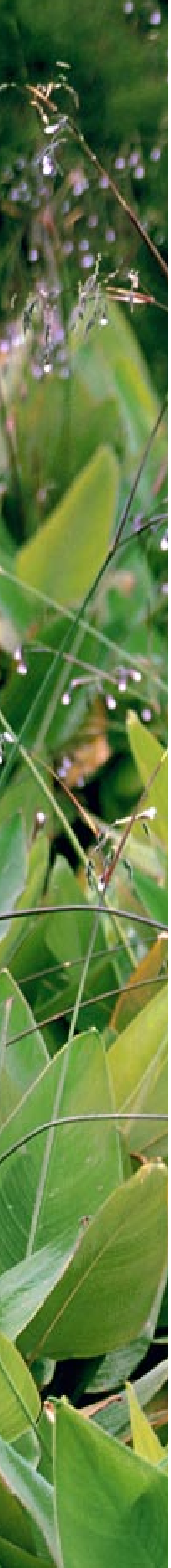
- Physical and technical limitations
- Pollutant reduction capabilities
- Cost considerations
- Supplemental benefits/side effects
- Public acceptance

The area to be managed should be assessed according to the size of the region contributing to stormwater runoff, area required for the BMP option, land and soil characteristics, and intended land use. Rainfall characteristics such as average frequency, duration, and intensity must also be reviewed. These will directly affect the volume of water that needs to be detained, infiltrated, or reused; the time needed to recover the treatment volume; and the process used to capture, filter, or assimilate pollutants. Increasing water residence time and promoting low turbulence help achieve stormwater treatment objectives by allowing for effective settling of sedimentation.

Pollutant type and load will need to be determined, since some BMP methods are more effective than others for removing particular types of pollutant. Treatment goals must be established to determine a minimum treatment performance standard. These standards are usually best achieved through the use of combined BMP practices as part of an overall management plan.

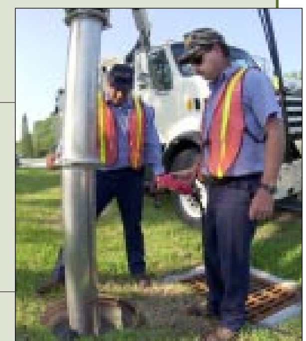
Any proposed BMP should be constructible in a selected location with reasonable effort and expense. Costs to be considered are capital costs for design and construction; permit fees; expenses involved in operation, inspection and maintenance; and unit costs for pollutant removal.

The more publicly accepted the BMP, the better chance it has for success. Structural BMPs require a long-term commitment; therefore, the owner/operator must be comfortable with project requirements before construction begins. Non-structural BMPs need active community support, and participation can be encouraged by defining problems clearly and outlining measures to solve them. Prevention is more cost effective and efficient than treatment of runoff.



NON-STRUCTURAL BMP OPTIONS

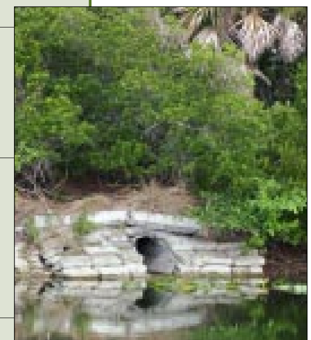
P = Planning and Regulatory Tools
C = Conservation, Recycling and Source Control
M = Maintenance and Operational Procedures
E = Educational and Outreach Programs



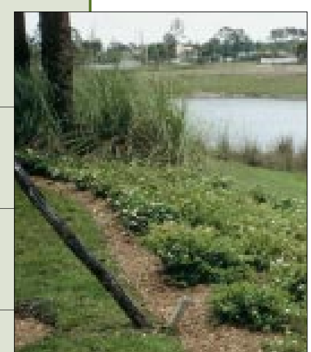
Option	Description/Components
Ordinances and Regulatory Programs **(P)**	• Defined objectives/purposes • Definitions • Permitting requirements • Variances • Performance/design standards • Enforcement policies
Low Impact Development **(P)**	• Use of small, cost-effective, multi-functional landscape features • Source control concept • Include hydrologic functions such as filtration, frequency and volume of discharges, groundwater recharge
Conservation Plan **(C)**	• Appropriate lawn irrigation • Xeriscape landscape component • Low volume plumbing fixtures • Conservation oriented rate structures by utilities • Leak detection programs • Public education for conservation
Using Reclaimed Water **(C)**	• Treating and disinfecting wastewater and using it for a new beneficial use such as irrigation, groundwater recharge, manufacturing processes, wetlands, fire protection, dust control
Source Control Measures **(C)**	• Address management, storage and/or disposal practices of contaminants such as erosion and sediment, animal, yard and solid waste, toxic materials, fertilizers, pesticides, herbicides and household products
Turfgrass Management **(M)**	• Irrigation practices • Mowing practices • Fertilization practices • Targeted pest management • Aerification and/or dethatching • Composting
Street Cleaning **(M)**	• Removal of accumulated deposition of solids
Catch Basin Cleaning **(M)**	• Removal of accumulated sediment and trash from catch basins
Road Maintenance **(M)**	• Repair of road surfaces to minimize roadway debris and potholes
Canal/Ditch Maintenance **(M)**	• Removal of excessive vegetation or built up sediments at bottom of canals • Routine maintenance of degraded or blocked flow ways
Modification of Structural **(M)** Operations	• Diversion from critical habitat areas • Increased detention times • Water storage for future use • Groundwater recharge options
Storm Drain Stenciling **(E)**	• Labeling storm drains to prevent dumping
Hazardous Waste Education Campaign **(E)**	• Informing the public how to meet hazardous waste regulations
School Programs **(E)**	• Producing displays and exhibits or making presentations to all levels of school children
Erosion Control Campaign **(E)**	• Distribution of seedlings for erosion control • Training sessions for construction personnel in private and public sectors
Volunteer Opportunities **(E)**	• Creating opportunities for community involvement such as water quality monitoring
Neighborhood Projects **(E)**	• Select and promote neighborhood projects and conduct award ceremonies

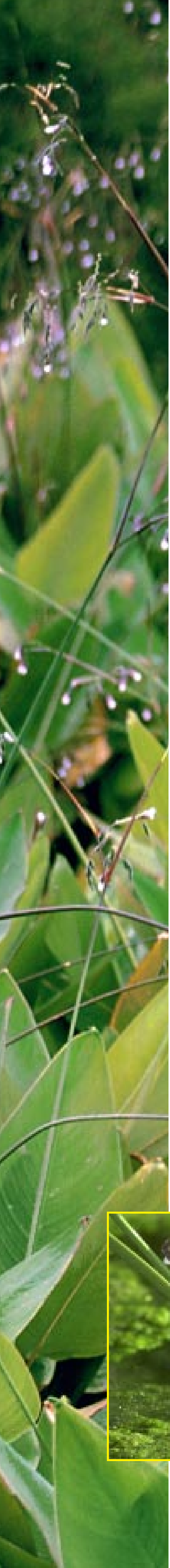
STRUCTURAL BMP OPTIONS

R = Retention
D = Detention
O = Other



Option	Description/Components
Dry Retention Basin **(R)**	• Storage impoundment • Should drain within 72 hours • Runoff pretreated to remove course sediment • May flow through sediment trap or vegetated filter strip
Exfiltration Trench **(R)**	• Shallow, excavated ditch backfilled with stone • Runoff infiltrates subsoil, then groundwater • Pretreatment of runoff generally necessary • Suited for areas of less than 5 to 10 acres • Most effective when used in combination with other BMPs
Concrete Grid Pavements **(R)**	• Porous layer diverts runoff into reservoir. • Filtrates into underlying soil • Reduces runoff and traps vehicle-generated pollutants • High failure rates without upkeep
Vegetated Filter Strip **(R)**	• Land with vegetative cover • Effective for overland sheet flow • Sloping areas distribute runoff uniformly. • Pesticides, fertilizers should be avoided.
Grassed Swale **(R)**	• Shallow, vegetated, man-made ditch • Located above water table to allow runoff to infiltrate groundwater • Provides pretreatment before discharge of runoff to treatment systems • Mow at least twice annually to height of 3 to 4 inches.
Sand Filter **(R)**	• Self-contained bed of sand • Particulate filtered out from first flush of runoff • Filtered water collected in pipes and returned to water body
Dry Detention Pond **(D)**	• Pond to detain runoff for up to 24 hours to allow for pollutant settling • Normally dry between storm events • Minimum 1 foot required from control elevation to bottom of pond
Wet Detention Pond **(D)**	• Permanent pool to store and release water at a controlled rate • May include forebay to trap and remove sediment • May establish wetland fringe around pond perimeter
Constructed Wetland **(D)**	• Simulates water quality functions of natural system • Does not replicate all ecological functions of wetland • Located where impact to surrounding areas is minimal • May include forebay, microtopography, and pondscaping
Water Quality Inlet **(O)**	• Settling by gravity to remove pollutants • Designed to trap floatable trash and debris * Requires extensive maintenance * Recommended for small drainage areas • Most effective when used in combination with other BMPs
Sediment Separation **(O)**	• Devices such as sumps, baffle boxes capture sediments, debris. • Efficient only within specific ranges of volume and discharge rates • Collected sediment transported or pumped to waste facility
Chemical Treatment **(O)**	• Chemical use to coagulate and separate pollutants • Coagulated compounds need disposal and possible dewatering.





Non-Structural BMP Options

Non-structural options consist of establishing practices that serve as pollutant control measures and setting policies that promote changes in human behavior to reduce activities that create pollution. These options can be used to complement structural BMPs in developing areas but may be the only alternative in existing urbanized locations.

To ensure the proper operation of a BMP system, periodic maintenance and upkeep of system components is necessary. Maintenance activities may include proper management of turfgrass, street cleaning and road maintenance, canal and ditch maintenance, and catch basin cleaning.

Regulatory measures should be developed to address such issues as hazardous materials codes, land development and use regulations, water shortage and conservation policies, and controls on types of flow allowed to drain into sanitary municipal storm sewer systems. Local governments are responsible for establishing these programs, and they must comply with state and federal mandates.

Plans for implementing non-structural BMPs in existing developed areas should incorporate the following actions:

- Identification of priority pollutant reduction opportunities
- Protection of natural areas that help control runoff
- Ecological restoration to clean up degraded water bodies

Citizens should be educated about the relationship they have with the watershed in their area and how their actions can affect the health of local waterways. The public can help prioritize clean-up strategies and volunteer to help with water restoration and protection activities.

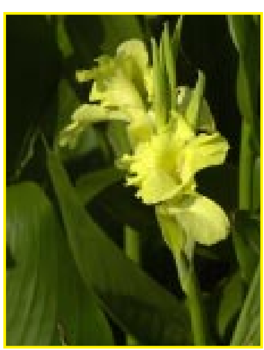
Structural BMP Options

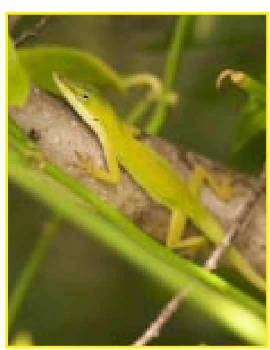
Structural mechanisms for controlling stormwater runoff in developing areas fall into three categories: 1) retention systems, 2) detention systems, and 3) other systems.

Retention systems include dry retention basins, exfiltration trenches, concrete grid pavements, vegetated filter strips, grassed swales, and sand filters. These rely on settling with soil infiltration/filtration to remove potential contaminants. As water passes through filtration media, it can then be routed into other water bodies, evaporated, or percolated into the groundwater. At construction sites, control mechanisms should be installed only after soils have been permanently stabilized to prevent clogging from sediments generated during construction. Restrictions may apply to systems located where groundwater requires protection.

Detention systems such as dry detention ponds, wet detention ponds, and constructed wetlands rely primarily on settling for pollutant control. These BMPs require silt removal along with periodic removal of accumulated trash and debris to prevent clogging of control devices. Constructed wetlands are designed to simulate the water quality improvement functions of natural wetlands. Many of these systems are currently being designed to include vegetated buffers and deep-water areas to provide wildlife habitat and aesthetic enhancements.

Other systems that can be incorporated into BMP practices are water quality inlets, sediment separation procedures, and chemical treatment processes. Water quality inlets in their simplest form are catch basins that allow for pollutant settling. Proper disposal of coarse-grained sediments and hydrocarbons is required, and





clean-out costs may be significant. Sediment separation practices use sumps, baffle boxes, oil/grit separators, and sediment basins to capture trash, sediments, and floating debris. They are efficient only within specific ranges of volume and discharge rates. Chemical processes include coagulation and separation of solids to remove pollutants. Although land requirements are small for chemical treatment practices, operations and maintenance costs can be high.

Opportunities for BMP Implementation

New Development. Before development occurs, land in a watershed is available for a number of pollution prevention and treatment options such as setbacks, buffers, open spaces, and wet ponds or constructed wetlands. Siting requirements and land use ordinances are more easily implemented during this period. Options available during the beginning stages of development generally are not practicable or cost effective after an area is developed.

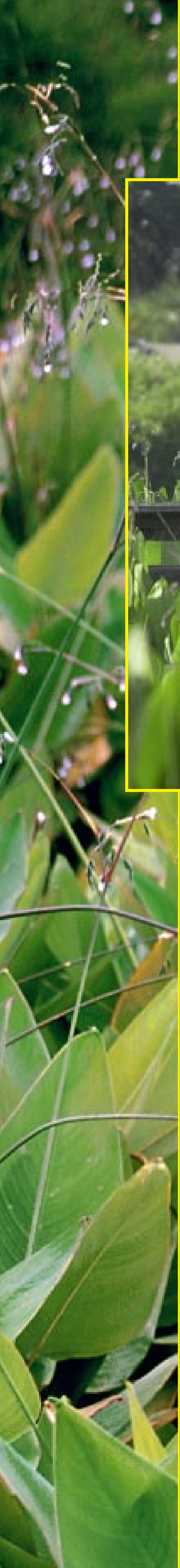
Retrofitting. Retrofitting water management systems in developed areas can be difficult and costly; therefore, targeting existing runoff control projects for better efficiency and economy may be a feasible option. Pollution reduction opportunities should be identified and protective measures that help control runoff into natural areas should be put into place. Then ecological restoration and retrofit activities to clean up water bodies can begin.

Site Construction. During construction phases, BMPs can be implemented to control pollutants resulting from the erosion of disturbed soils. These focus on controlling the amount of soil lost during high winds, rainfall and runoff thereby minimizing subsequent adverse impacts of downstream sedimentation. These practices may consist of seeding and mulching exposed soils, constructing sediment basins, or using bales of hay as runoff barriers.

Conclusion

The population of the 16-county area served by the South Florida Water Management District has increased by approximately 25 percent over the last ten years. This kind of rapid urbanization impacts natural waterflow systems that affect water quality and quantity. Effective water management practices need to be implemented at every level, from homeowners associations and local drainage districts, to cities and counties, and all the way to the regional water management level.

One hundred years ago, south Florida was still a wilderness. Today our highly populated area needs solutions to problems perpetuated by rapid urbanization. The harmful effects of excess stormwater runoff can be reduced through the development of Best Management Practices. The implementation of linked water management systems will provide needed controls to manage runoff and reduce pollution in our waterways.



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