Local Stormwater Utilities provide dedicated funds for solving stormwater problems and educating citizens.

Local governments will play a particularly important role in watershed management. Using the watershed goals established by the water management districts, local governments will need to develop stormwater master plans that also are based on their adopted comprehensive plan. The stormwater master plan will provide a blueprint for the upgrading of the existing stormwater infrastructure to reduce flooding caused by existing and future land uses and to reduce the stormwater pollutant load discharged to receiving waters as required by the watershed goals. By implementing a **stormwater utility**, a local government will have a **dedicated source of funds** to build the required stormwater infrastructure. Those funds will also allow a community to implement a comprehensive stormwater management program that includes public education and periodic inspection of stormwater systems to assure they are maintained properly.

Development of any comprehensive watershed management program, whether on a statewide or local basis requires maximum cooperation, and a **team approach** between all participating agencies, governments, and private business. Communities are beginning to shift from the current piecemeal to the comprehensive approach. Ultimately the future of Florida's water resources will depend on the extent to which this leadership is followed.

The local government comprehensive plans are a prime opportunity to develop and implement workable Watershed Management Plans. Much of the information needed for a watershed plan will be developed during the comprehensive planning process—watersheds and soils will be mapped, a future land use plan will be developed, an analysis of stormwater systems will be completed, resource management goals will be established, and a capital improvements plan will be developed. By integrating the land use plan, infrastructure plan, and the capital improvements plan into a watershed management plan, communities will provide a foundation for solving many of their stormwater and land and water resource problems in a cost-effective manner.

Stormwater system creates babbling brook.

CHAPTER FOUR

PRINCIPLES OF STORMWATER MANAGEMENT

The following general principles will help achieve the multiple objectives of stormwater management.

1. **It is much more efficient and cost-effective to prevent problems than to correct them later.** Sound land use planning, based on good site planning principles, is essential as the first, and perhaps the most important step in managing stormwater. All new development plans such as subdivisions, shopping centers, industrial parks, and office centers and redevelopment plans should include a comprehensive stormwater management system.

2. **Every piece of land is part of a larger watershed.** A stormwater management system for each development project should be based on, and support a plan for the entire drainage basin.

3. **Optimum design of the stormwater management system should mimic (and use) the features and functions of the natural stormwater system which is largely capital, energy, and maintenance cost free.** Most sites contain natural features which contribute to the management of stormwater under the existing conditions. Depending upon the site, features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. "Natural" engineering techniques should be used as much as possible to preserve and enhance the natural features and processes of a site to maximize the economic and environmental benefits. Natural engineering is particularly effective when combined with open spaces and recreational use of the site, or in developments that use cluster techniques. Design should seek to improve the effectiveness of natural systems, rather than to negate, replace, or ignore them.

4. **The volume, rate, timing and pollutant load of stormwater after development should closely approximate the conditions which occurred before development.** Two overall concepts must be considered: To the greatest extent possible, the perviousness of the site should be maintained, and the rate of runoff should be slowed. Stormwater management systems should use **Best Management Practices** (**BMP**s) that maintain vegetative and porous land cover and which include on-site storage. These systems will promote infiltration, filtering, and slowing of the runoff.

5. **Maximize-on-site storage of stormwater.** Provision for storage can reduce peak runoff rates; aid in ground water recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion and sedimentation; and provide water for other beneficial uses. Where practical, the "blue-green" approach to development which includes lakes and open space should be used. It inherently provides storage, environmental protection and enhancement of community amenities.

6. **Stormwater runoff should never be discharged directly to surface or ground waters.** Runoff should be routed over a longer distance, through grassed swales, wetlands, vegetated buffers and other areas designed to increase overland "sheet" flow. These systems increase infiltration and evaporation, allow suspended solids to settle, and help remove pollutants **before** they are introduced to Florida's waters.

7. **Stormwater management systems, especially those that emphasize the use of vegetation, should be planned, constructed and stabilized in advance of the facilities that will discharge into them.** This principle is frequently ignored, causing unnecessary off-site effects, extra maintenance, reworking of grades, revegetation of slopes and grassed swales, and extra expense to the developer. The stormwater management system, including erosion and sedimentation controls, should be constructed and stabilized at the start of site disturbance and construction.

8. **The stormwater management system must be designed beginning with the outlet or point of outflow from the project.** The downstream conveyance system should be evaluated to ensure that it has the capacity to accept the design discharge without adverse downstream effects. It may be necessary to stabilize the downstream conveyance system, especially near the stormwater system outlet. Another common problem is a restricted outlet, which causes stormwater to back up and exceed the storage capacity of the collection and treatment system, resulting in temporary upstream flooding. This may lead to hydraulic failure of the system, causing resuspension of the pollutants or expensive repairs to damaged structures or property. In such circumstances it is advisable to use more than one outlet or to increase the on-site storage volume.

9. **Whenever possible, construct the components of the stormwater management system on the contours that follow the natural topography.** This will minimize erosion and stabilization problems caused by excessive water velocity. It also will slow the runoff, allowing for greater infiltration and filtering.

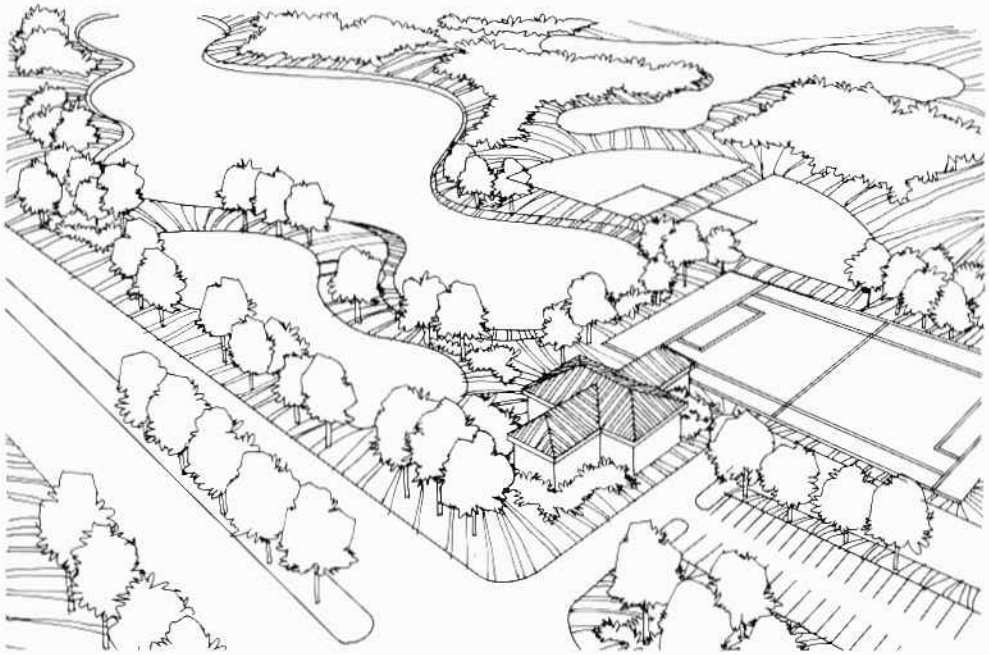
10. **Stormwater is a component of the total water resource. It should not be discarded casually but should be used to replenish those resources.** Stormwater represents a potential resource that is out of place. Its location determines whether it is a liability or an asset. With the water quantity and quality problems that face Florida, we must consider stormwater as an asset. Treated stormwater has many beneficial uses. It may be used for irrigation (farms, lawns, parks, golf courses), recreational lakes, ground water recharge, industrial cooling and process water, and other nonpotable domestic uses.

11. **Whenever practical, multiple-use temporary storage basins should be an integral component of the stormwater management system.** All too often, storage facilities planned as part of the system are conventional, unimaginative ponds which are aesthetically unpleasing. Recreational areas (ballfields, tennis courts, volleyball courts), greenbelts, neighborhood parks, and even parking facilities provide excellent settings for temporary storage of stormwater. Such areas are not usually used during periods of high rainfall, and the ponding of stormwater for short periods does not seriously affect their primary uses.

12. **Storage areas should be designed with curving shorelines.** Curving shorelines increase the length of the shore and create development opportunities if a blue-green concept of permanent lakes is being used. The increased shoreline also provides more space for the growth of littoral vegetation to provide more pollutant filtering and a more diversified aquatic habitat.

13. **Vegetated buffer strips should be retained in their natural state and should be created along the banks of all water bodies.** Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a floodplain during periods of high water. They also provide a strip along a shoreline which can accept sheet flow from developed areas and help to minimize the adverse effects of untreated stormwater.

RETENTION AREA AS RECREATION FIELD



14. **THE STORMWATER MANAGEMENT SYSTEM MUST BE MAINTAINED.** Failure to provide proper maintenance reduces the pollutant removal efficiency of the system and reduces the system's hydraulic capacity. Lack of maintenance, especially to vegetative systems which may require re-vegetating, can increase the pollutant load of stormwater discharges. The key to effective maintenance is the clear assignment of responsibilities to an established agency such as a local government or an organization such as a homeowners association, and regular inspections to determine maintenance needs. **Stormwater system designers should make their systems as simple, natural and, maintenance free as possible.**

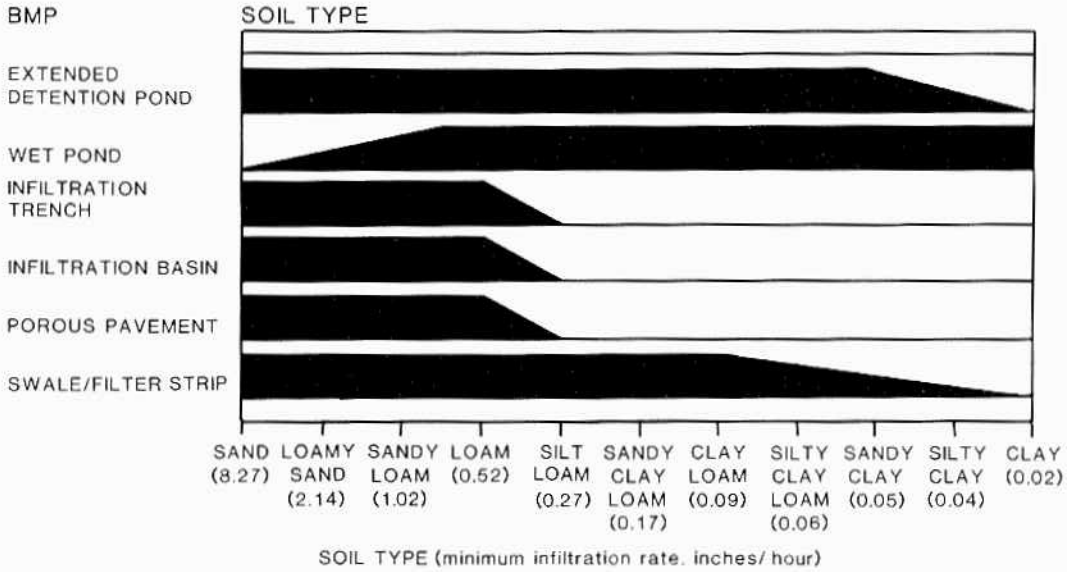
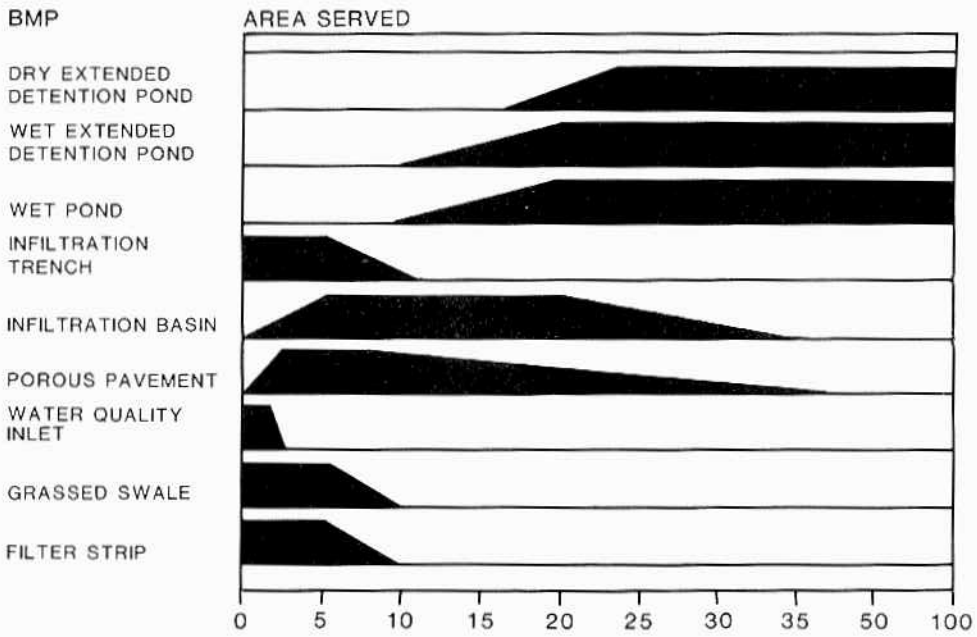


Figure 7:
BMPs FOR DIFFERENT SOIL TYPES



LEGEND:

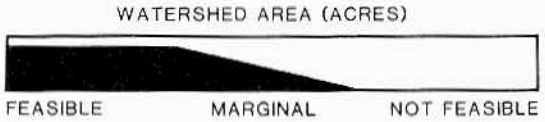


Figure 8:
BMPs FOR DIFFERENT WATERSHED SIZES

CHAPTER FIVE

STORMWATER MANAGEMENT PRACTICES

The control measures discussed in this chapter are intended to serve as basic models and perhaps to stir the imagination of all who are involved with land development—landowners, developers, contractors, engineers, architects, landscape architects, and the government officials who develop and implement stormwater management programs. The suggested approach is to minimize the adverse effects of stormwater through a coordinated system of source controls. Source controls emphasize prevention and reduction of nonpoint pollution and excess stormwater flow before it reaches a collection system or receiving waters.

Source control is the central theme of the various stormwater management methods or **Best Management Practices (BMPs)**. The term Best Management Practice refers to that practice which is used for a given set of conditions to achieve satisfactory water quality and quantity enhancement at a minimum cost. Chapter 6 of the Florida Development Manual: A Guide to Sound Land and Water Management (DER, 1988) contains an extensive discussion of the use, design, construction and operation of a wide variety of stormwater management and erosion and sediment control BMPs.

To achieve the desired objectives of flood and water quality protection, erosion control, and improved aesthetics and recreation, a stormwater management system must be an integral part of site planning for every project. Although the basic principles of stormwater management remain the same, each project presents slightly different problems. The many variations in climate, soils, topography, geology, and the planned land use require site-specific design. Each site has its natural attributes that influence the type and configuration of the stormwater management system. For example, sandy soils suggest the use of infiltration practices such as retention areas integrated into a development's open space and landscaping, while natural low areas and isolated wetlands offer opportunities for detention and wetland treatment. *Figure 7* summarizes a number of BMP types according to their feasibility for different soil types. Likewise, the size of the watershed dictates appropriateness of BMPs, as illustrated in *Figure 8*.

Best Management Practices can be classified into two broad categories - Nonstructural and Structural. Nonstructural controls are those which are intended to improve stormwater quality by reducing the generation and accumulation of potential stormwater pollutants at or near their sources. Nonstructural controls are the first line of defense and include practices such as land use planning and management, wetlands and floodplain protection, public education, fertilizer and pesticide application control, solid waste collection and disposal, street cleaning and "good housekeeping" techniques on construction sites. They are prevention oriented and very cost-effective. Structural controls are those which are used to control the stormwater volume and peak discharge rate, as well as reducing the magnitude of pollutants in the discharge water through physical containment or flow restrictions designed to allow settling, filtration, percolation, chemical treatment or biological uptake. These practices typically are land intensive, require proper long term maintenance and can be costly, especially in already urbanized areas.

A. BMP Treatment Train

A stormwater management system might be considered as a **BMP treatment train** in which the individual BMPs are the cars. Generally, the more BMPs that are incorporated into the system, the better the performance of the treatment train. Although the different BMPs will be discussed individually, they often work together as part of a total system.

As noted, the careful design of stormwater management systems should be an integral part of development planning. Stormwater management is not–or should not be–an afterthought, and there are many opportunities to integrate stormwater controls into the open space and landscape elements of development. Creative and imaginative design can produce stormwater management systems that not only function properly but also are aesthetic amenities, reduce maintenance, offer recreational opportunities, wildlife habitat, irrigation, and fire protection. All too often, inadequate or improper design and construction of stormwater systems have produced unsightly and unsafe facilities that do not perform well and which quickly become maintenance problems. Public acceptance of such projects is understandably poor, and the entire concept of stormwater management suffers as a result. **BMPs should not be big muddy ponds.**

B. On-Line Versus Off-Line BMPs

On-line BMPs temporarily store runoff before they discharge to surface waters. These systems capture all of the runoff from a design storm. They primarily provide flood control benefits. Water quality benefits are secondary.

Off-line BMPs divert the first flush of polluted stormwater for treatment and isolate it from the remaining stormwater, which is managed for flood control. Off-line retention is the most effective water quality protection BMP, since the diverted first flush is not discharged to surface waters but is stored-to be gradually removed by infiltration, evaporation and evapotranspiration.

Figure 9 is a schematic of an off-line treatment system in which a **smart weir** directs the first flush of stormwater into the infiltration area until it is filled. The remaining runoff is routed to the detention facility for flood control.

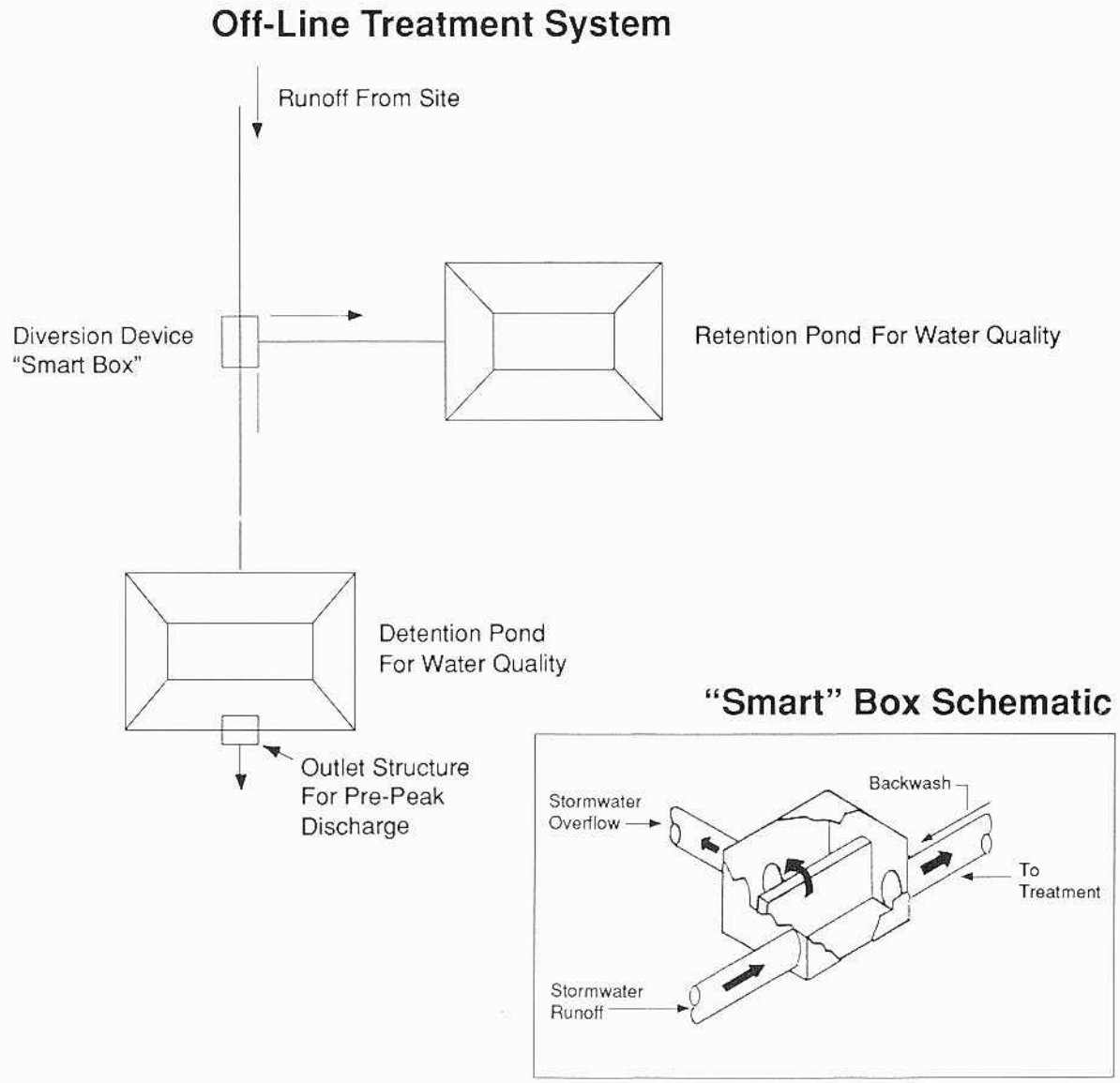
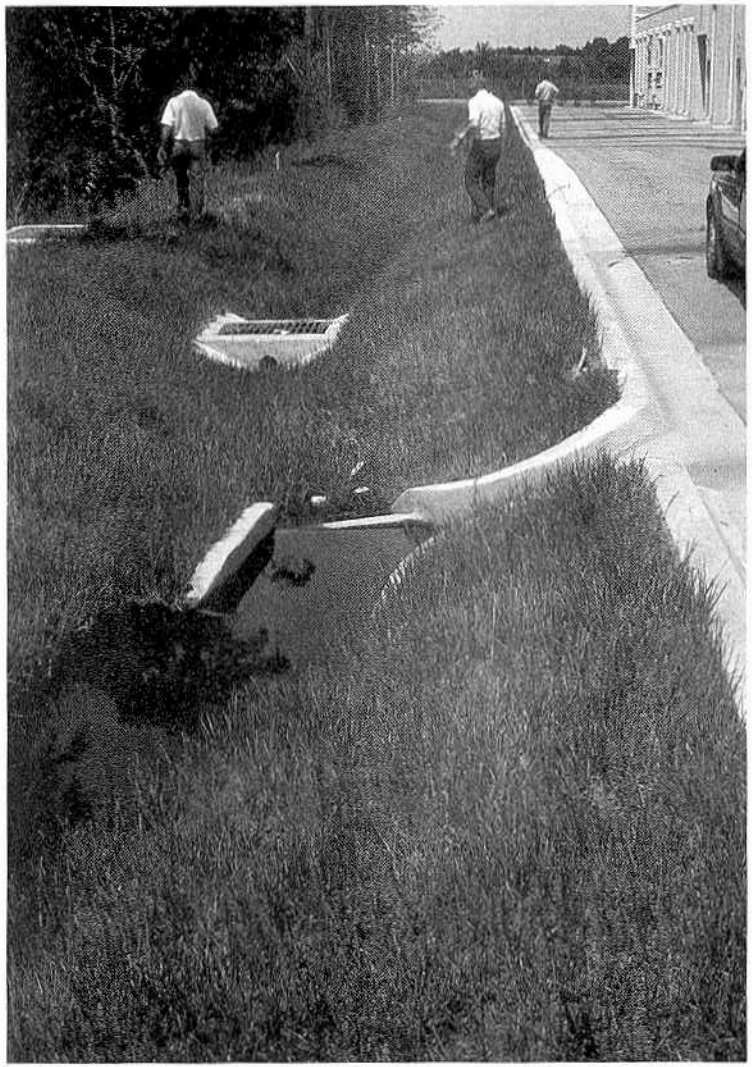


Figure 9: **SCHEMATIC OF "DUAL-POND" OFF-LINE TREATMENT SYSTEM**



Off-line systems can be designed so that they are integrated with the site's landscaping thus providing an amenity instead of a potential detraction.

C. The Importance of Vegetation

Vegetation provides several benefits in managing stormwater *(Figure 10)*. It absorbs the energy of falling rain, preventing erosion, and maintains the soil's capacity to absorb water, promoting infiltration. It slows the velocity of runoff, reducing peak discharge rate.

Vegetation is especially important in reducing erosion and sedimentation during construction. By phasing and limiting the removal of vegetation, and by decreasing the area that is cleared and limiting the time bare land is exposed to rainfall, sedimentation at construction sites can be reduced by up to 90%. If large areas of land must be cleared at once, those areas upon which construction will not occur within 7 days should be mulched and seeded to provide immediate temporary cover. Special consideration should be given to the maintenance of vegetative cover on areas of high erosion potential, such as erodible soils, steep or long slopes, stormwater conveyances, and the banks of streams.

Stormwater BMPs which use vegetative cover include overland sheet flow, grassed swales and channels, infiltration areas, and grassed discharge or flow areas for roof drainage. All are particularly suited to residential, transportation and recreational developments, but also can be used in commercial and industrial sites.

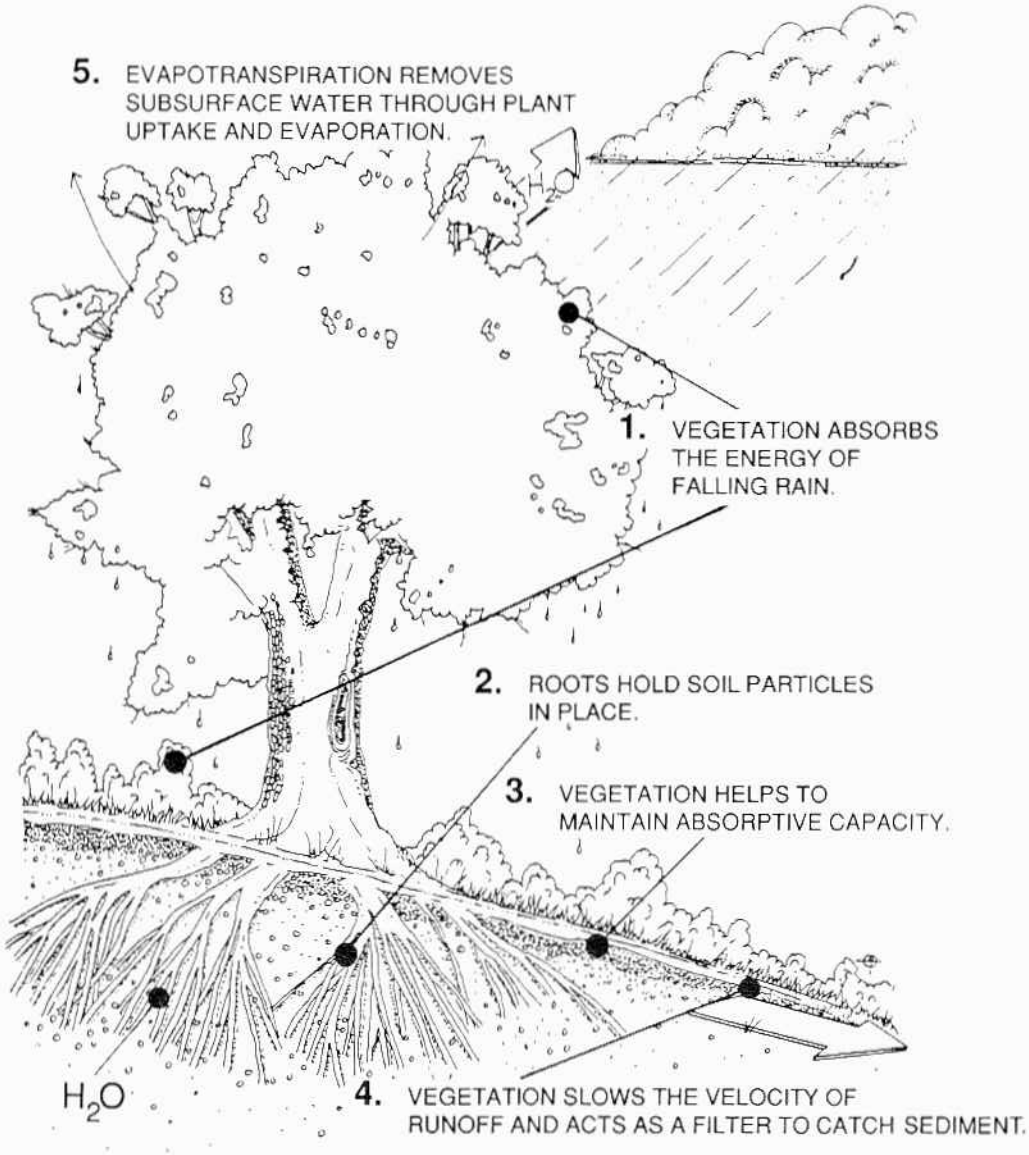


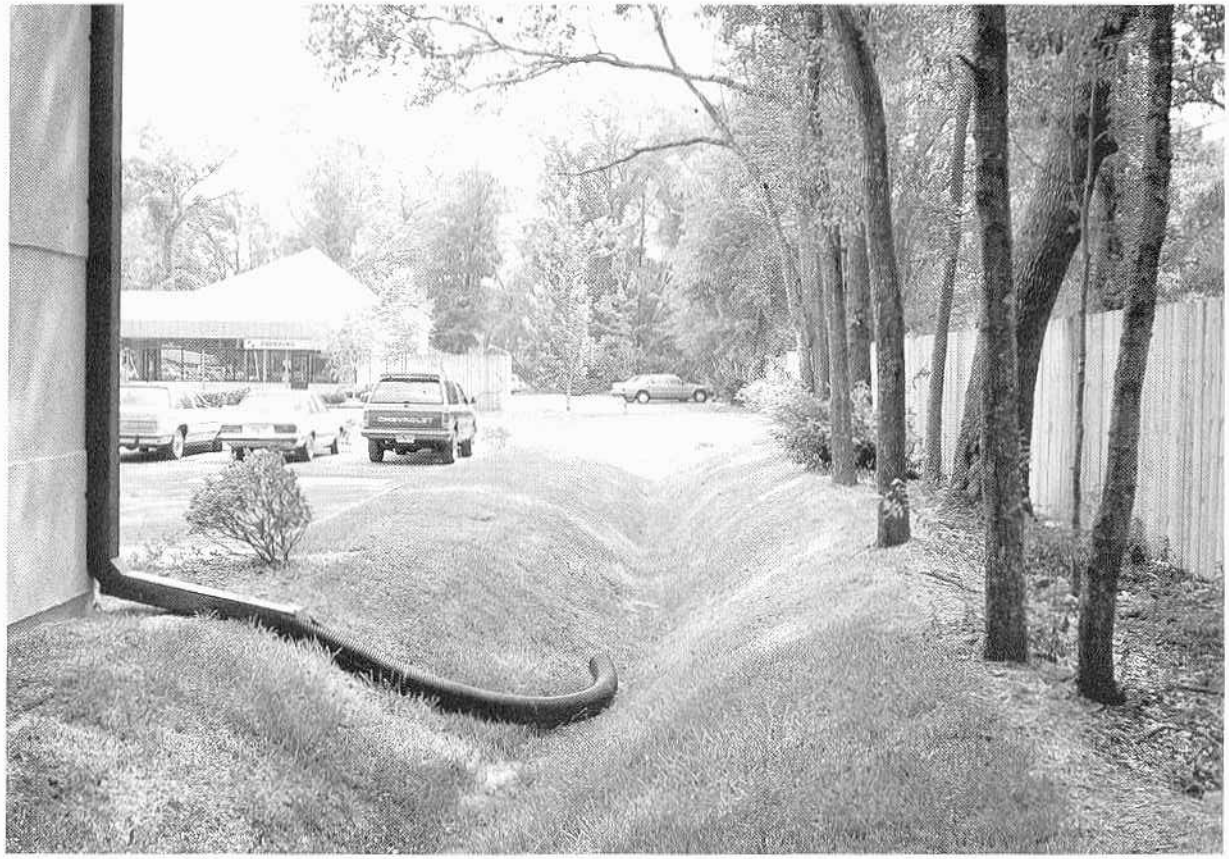
Figure 10: **EROSION CONTROL BY VEGETATION COVER**

The amount and nature of topsoil and vegetation are important factors that affect infiltration of stormwater. A thick layer of topsoil with dense sod provides excellent natural infiltration. Any area under development that is to be revegetated should be covered by an adequate layer of topsoil. The original topsoil at the site should be removed and stockpiled for reuse to provide a minimum of four inches over areas that have a porous sub-soil. In areas of heavy clay, six to eight inches of topsoil will provide proper plant growth and create absorbent soil.

D. Infiltration (Retention) Practices

In an undeveloped area, infiltration is a natural part of the hydrologic cycle. A certain part of precipitation is absorbed into the ground, replenishing the ground water and feeding trees and other plants. **Retention BMPs retain stormwater on-site, allowing it to infiltrate into the ground or to evaporate.** These practices reduce the volume of stormwater, and are the most effective for reducing stormwater pollution since, typically, the first flush is not discharged to surface waters. By reducing the volume of stormwater, infiltration also helps reduce the effects of stormwater on estuaries which are vulnerable to too much fresh water.

The amount of infiltration depends primarily on the soil. Successful use of infiltration requires appropriate site conditions to assure that the stormwater will infiltrate within 24 to 72 hours. Coarse-grained sandy soils have excellent infiltration capacity. As soils begin to contain higher amounts of fine-grained clays and silts, their infiltration capacity diminishes. To protect ground water from contamination, the seasonal high water table and bedrock should be at least three feet beneath the bottom of the retention practice. In areas where limerock is near the surface and sinkholes are common, special precautions must be taken to protect the ground water.



Infiltration Practice: Directing roof runoff to grassed areas.

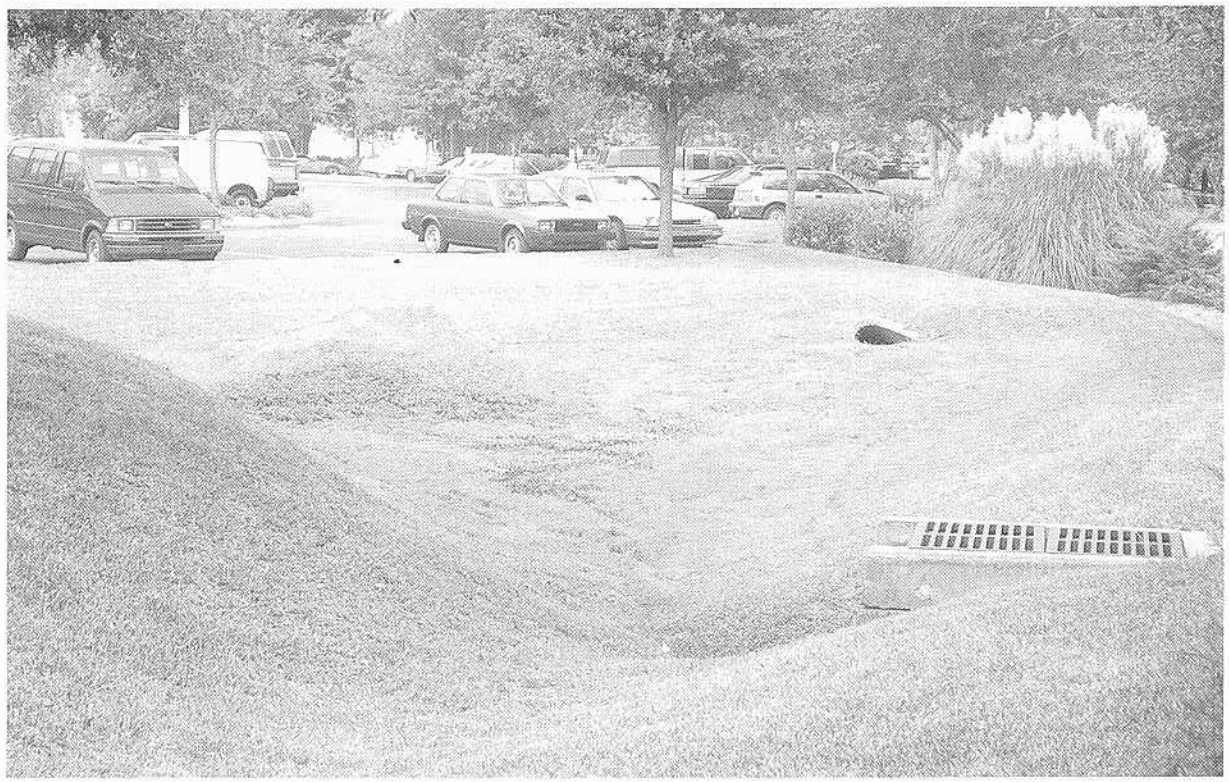
In areas with appropriate site conditions, off-line infiltration BMPs should be used where possible. Typical retention BMPs include grassed swales (often with check dams), retention basins, infiltration areas, and infiltration trenches. With imaginative design and proper installation, retention practices can effectively meet the challenges of aesthetics, safety, maintenance and effectiveness. However, as with any portion of a development project, good solutions do not happen by themselves. They must be carefully planned as part of the entire development.

Off-line infiltration can be easily incorporated into landscaped and open space areas such as natural or excavated grassed depressions, recreational areas, and even landscaped parking lot islands. Some retention practices can be designed as landscaped rock gardens or picturesque creek beds. Lawns, especially on waterfront property, can be designed to store runoff for a short time. Since retention areas frequently are designed to remain dry when not in use, they can often provide multiple uses—stormwater management during wet weather and recreational, open spaces or parking during dry weather.

Dry Retention Basins or Areas

Nearly every land use in a developing area can effectively and economically incorporate on-site, off-line retention into its design. If site conditions will not allow total infiltration of the first flush, then parts of the first flush can be infiltrated as pretreatment before the stormwater enters a wet detention or wetland treatment system for final treatment.

On a small scale, lawns, parking lot islands, and small landscaped areas all can be used to store stormwater and allow it to infiltrate. Such areas are especially appropriate as elements of a **BMP treatment train** where raised storm sewer inlets are placed in the retention area allowing some treatment before excess stormwater is routed to a detention facility.



On a larger scale, retention areas can be designed into the open spaces of an entire development or park system. Orlando has been very creative in using this concept to modify older stormwater systems and reduce the pollutant loading to the city's downtown lakes. Proper design of these retention systems can insure successful, useful and attractive results. During dry periods, large retention areas can serve as parks or community recreation areas.

Side slopes of infiltration areas should be gentle enough to mow and should be properly shaped to blend with the surrounding topography. When intended for recreational use, side slopes can provide an amphitheater for spectator seating on grassy banks. Banks can also serve to contain balls in the playing area, avoiding the need for a fence.

Proposed spreader swale at Al Coith Park (Orlando).

Good vegetative cover and proper drying are extremely important in the design and development of multiple-use retention and recreation facilities. The basin floor must be properly graded (two percent slope—more on poorly drained soils) to provide adequate surface drainage and yet must allow appropriate recreational use and avoid low spots that might remain wet. In some situations, underdrains may be needed to promote infiltration and to help eliminate standing water. By eliminating the possibility of standing water, problems of weeds, algae and mosquitos can be avoided and the multiple uses of the stormwater system can be realized.

The natural characteristics of the site must be respected and used properly. In many situations, the appropriate appearance of BMPs will be crisp and clear with a certain quality of sophistication. In other instances, especially in parks or residential developments, retention areas can be effectively created in naturalized or wooded areas, further reducing maintenance.

With sensitive placement, imaginative design, careful construction and appropriate landscaping, stormwater retention facilities can effectively protect property and water quality and still be an aesthetically satisfying part of the community environment.

Grassed Swales

Swales, or grassed waterways, are one of the oldest stormwater BMPs, and have been used along streets and highways for years. A swale is:

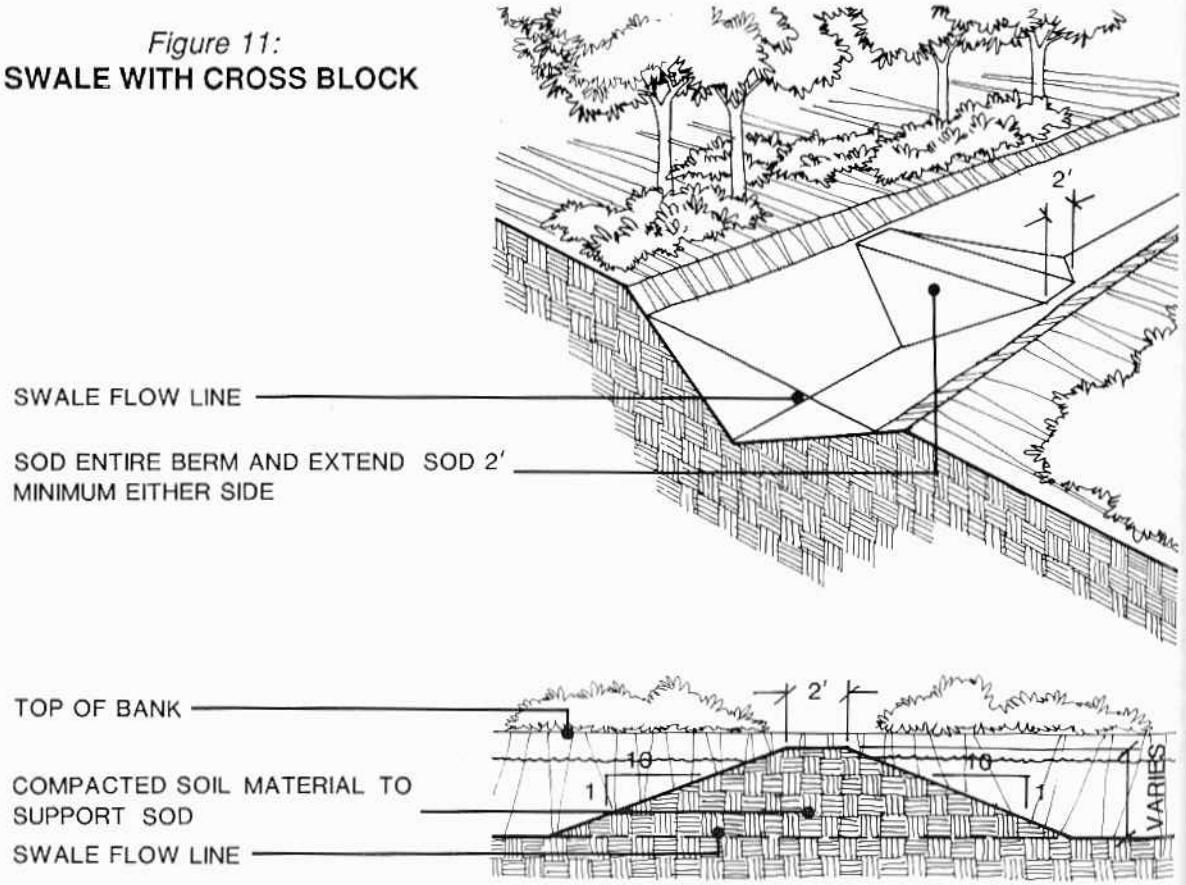
1. a shallow trench which has side slopes flatter than three feet horizontal to one foot vertical;
2. contains areas of standing or flowing water only after a rainfall;
3. planted with or has vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake;
4. designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce the stormwater pollutant load.

Traditionally, swales are used primarily for stormwater conveyance, and are considered an on-line practice. As with other retention practices, the effectiveness of pollutant removal depends on the volume of stormwater than can be infiltrated through the filtering vegetation and into the soil.

Used alone, swales must percolate 80% of the runoff from a three-inch rainfall within 72 hours to provide proper water quality benefits. However, this is often impossible because of soil or slope, and the greatest utility of a swale is as a pretreatment conveyance system to reduce pollutants before the stormwater enters a retention and detention basin, or a wetland. **Swales should be seen as an important <u>component</u> of a BMP treatment train.**

One way to improve the effectiveness of pollutant removal and the infiltration capability of a swale is to place small check dams along the swale, or to use raised driveway culverts to cause stormwater to pond, slowing the runoff and holding it-allowing some to soak into the ground and be filtered by vegetation. On high speed highways, safety must be considered, and a maximum water depth of about 1.5 feet and flow line slopes on the check dams of 1 vertical/20 horizontal are recommended. Along residential streets and lower speed highways, steeper flow line berm slopes (1:6) are acceptable. *Figure 11* is an example of a swale with a cross block.

Figure 11:
SWALE WITH CROSS BLOCK



The feasibility of swales depends on land use and site characteristics. Considerations such as on-street parking, and small lots with numerous driveway culverts may be a limiting factor. On the other hand, parkways, boulevards, collector streets and streets in large-lot subdivisions may all benefit from using swales.

Maintenance requirements for swales will not be significantly greater than those for a normal lawn. However, public education is essential, especially for residents who live in developments served by swales. Residents need to be informed about the benefits provided by their swale so they take pride in maintaining it and do not fill it in. Residents need to know that leaves, limbs and other vegetation, along with debris and oil should not be disposed of in the swale. If this occurs, the pollutants in these materials will be delivered to downstream waters and a benefit of the swale would be lost.

Many local governments require curb and gutter systems and prohibit swales. Such policies should be reviewed to determine why they were established and if they can be modified to help reduce stormwater management costs and water quality degradation. If curb and gutter systems are used, curb cuts should be used wherever grassed areas are adjacent to the road to allow some infiltration and treatment of the stormwater. An effective treatment train can be formed by using a curb cut in association with a raised storm sewer inlet which ultimately conveys the runoff to a retention or detention system.

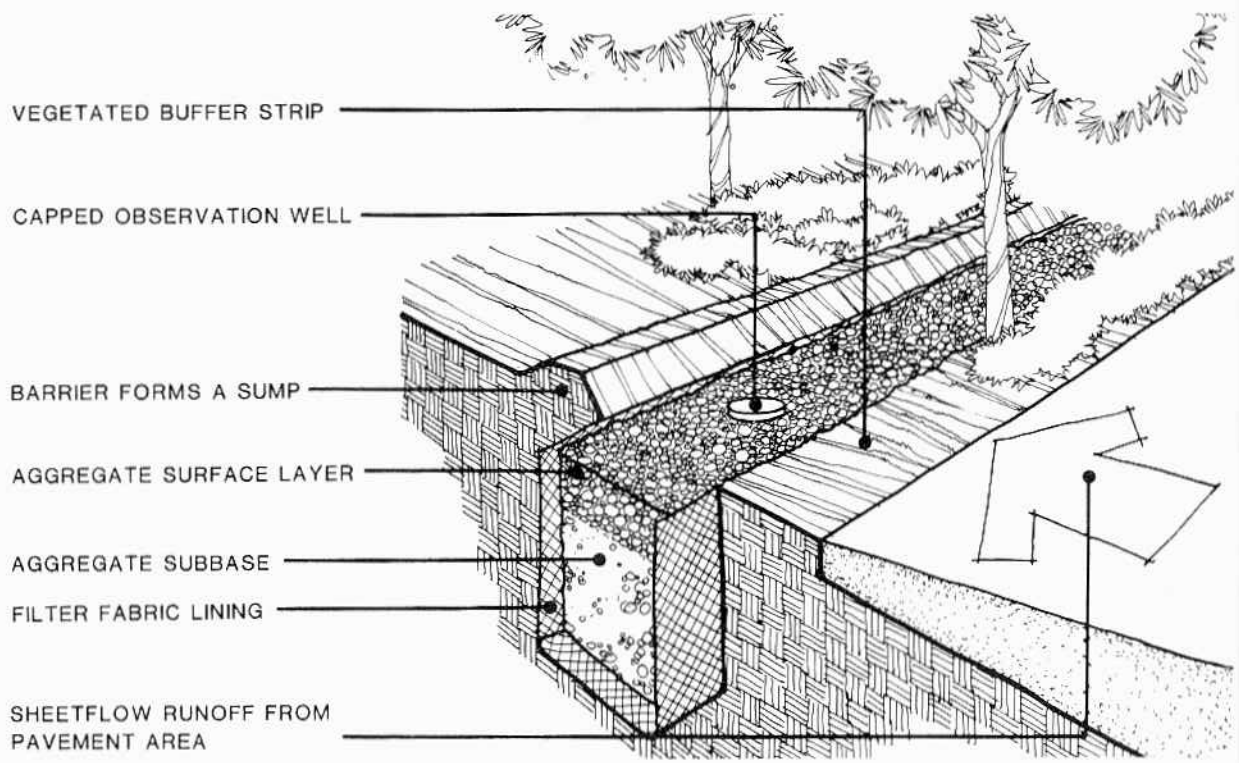
Infiltration Trenches

In many urban areas, land costs are so prohibitive that infiltration basins are not feasible. In such cases an off-line **infiltration trench** can be the primary component of the treatment train. This BMP consists of a long, narrow excavation ranging from 3 to 12 feet in depth (depending on stormwater volume, soil and water table conditions) which is backfilled with stone aggregate, allowing for the temporary storage of the first flush stormwater in the voids between the aggregate material. Stored runoff then infiltrates into the surrounding soil.

To prevent ground water contamination, trench bottoms should be at least four feet above the seasonal high water table. Another important consideration for infiltration trenches is to use the treatment train concept to maximize water quality benefits, reduce maintenance requirements, and prevent the physical clogging of these systems by sediment, leaves and other materials. Limestone aggregate should not be used since it has a tendency to cement together, thus reducing the void space in which the stormwater is stored.

Infiltration trenches can be located on the surface or below the ground. **Surface trenches** receive sheet flow runoff directly from adjacent areas after it has been filtered by a grass buffer. Surface trenches typically are used in residential areas where smaller loads of sediment and oil can be trapped by grassed filter strips that are at least 20 feet wide. While surface trenches may be more susceptible to sediment accumulations, their accessibility makes them easier to maintain. Surface trenches can be used in highway medians, parking lots and in narrow landscaped areas.

INFILTRATION CHANNEL



Underground trenches can accept runoff from storm sewers and can be applied in many development situations, although discretion must be exercised with their applicability. To prevent clogging, pretreatment is essential. Inlets to underground trenches must include trash racks, catch basins and baffles to reduce sediment, leaves, other debris, and oils and greases. Maintenance or replacement of underground trenches can be very difficult and expensive, especially if they are placed beneath parking areas or pavement.

The most commonly used underground trench is an **exfiltration system** in which runoff is diverted into an oversized perforated pipe placed within an aggregate envelope. The first flush of stormwater is stored in the pipe and exfiltrates out of the holes through the gravel and into the surrounding soil. The City of Orlando has installed many exfiltration systems throughout downtown to reduce stormwater pollution of its lakes. Routine maintenance consists of vacuuming debris from the catch basin inlets and, if needed, using high pressure hoses to wash clogging materials out of the pipe.

Orlando Streetscape Project Exfiltration Trench

E. Detention Practices

Unfortunately, variations in soil, water table and geologic conditions throughout Florida preclude the exclusive use of infiltration practices in many locations. These locales often have slowly percolating soils, high water tables, and flat terrain typical of the "flatwoods" area of Florida. In such areas, permanently wet detention systems and wetland treatment systems are likely to be the preferred BMPs. The concept of the stormwater treatment train is especially applicable to detention systems. The use of swales, landscape infiltration areas, and perimeter swale/berms for pretreatment will greatly improve the pollutant removal effectiveness, aesthetics and longevity of a detention system.

Detention systems are storage areas that maintain a planned permanent level of water even after stormwater discharge has ceased. These permanent lakes and ponds, if properly planned and constructed, provide multiple benefits including improved property values. They provide "lakefront" property, possibilities for recreation and wildlife habitat, water for irrigation and fire protection, and even a source of fill. Detention systems also provide flood protection and very good removal of stormwater pollutants.

Figure 12 illustrates the basic components of a wet detention system that is used for flood control and water quality enhancement. Essentially, a wet detention "lake" consists of a permanent water pool, an overlying zone in which the design runoff volume temporarily increases the depth while it is stored and released at the allowed peak discharge rate and a shallow littoral zone in which wetland plants biologically remove dissolved stormwater pollutants such as metals and nutrients. During storms, runoff replaces "treated" waters which were detained within the permanent pool after the previous storm. Wet detention lakes are often used in series, with swale interconnections.

Technical design criteria for detention systems have been established by the Department of Environmental Regulation and the water management districts. These criteria address general concerns that are important to safe, efficient operation of such systems including: evaluation of runoff hydrographs for storms of various size and frequency; determination of level of flood protection, rate of stormwater release; design requirements to maximize pollutant removal; provisions for maintenance; and provisions for emergency overflow to protect adjacent and downstream properties.

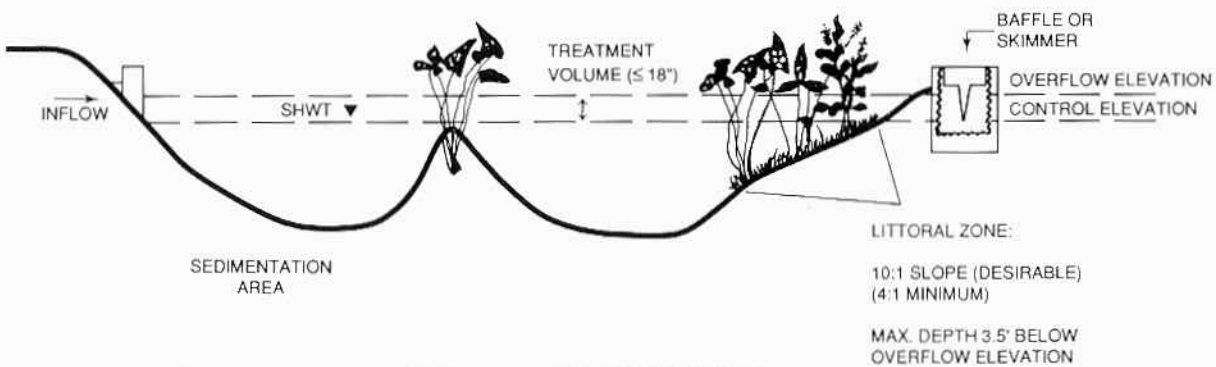


Figure 12: **TYPICAL WET DETENTION COMPONENTS**

Once the technical requirements have been established, they must be translated into physical reality through competent design and construction. The same set of technical requirements can be met through a traditional engineering solutions or through creative design with full appreciation for aesthetic, maintenance, safety and multiple use considerations.

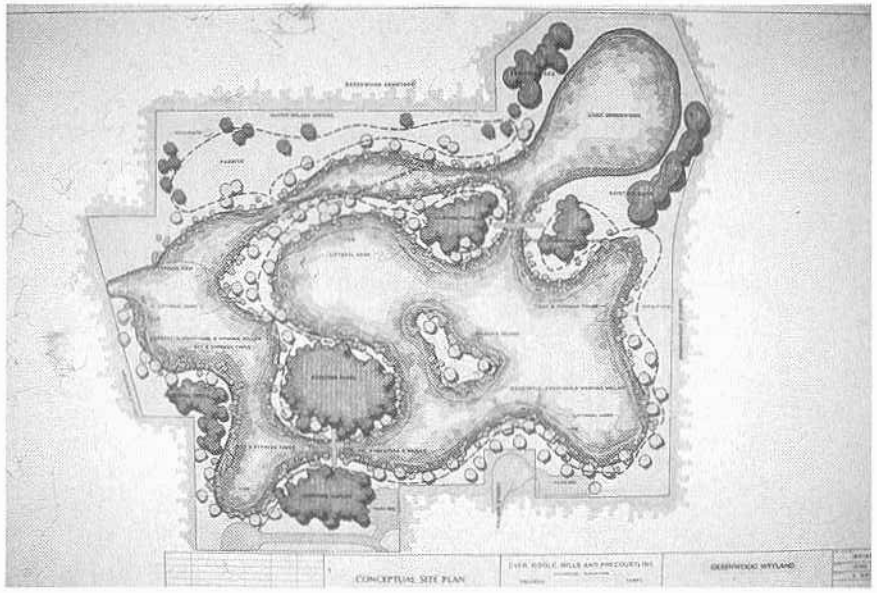
The solution shown at right illustrates several important elements in the design of detention systems. The permanent water pool is bordered by a stone edge capped by a concrete coping to give a refined appearance that blends with its landscaped surroundings. The first level of stormwater control is provided within the borders of stone and concrete coping. For storage capacity required by more intense storms, the lawn area surrounding the permanent pond is carefully graded to contain additional runoff. The final level of control is provided by an emergency overflow swale designed to convey stormwater from a very large, infrequent storm, more severe than the design storm, safely away from improvements susceptible to damage.

The entire appearance of this example is aesthetically pleasing, provides recreational opportunities and has been skillfully integrated into the overall landscape design of this urban setting. Because of the rock and concrete edging, bank erosion and maintenance are not problems, and the overflow area of the facility is simply maintained as lawn.

Detention systems can be designed to fit almost any new development. Depending on the nature of the land use, the detention lakes can be refined and sophisticated or natural and somewhat wild. As illustrated by the examples presented in this section , the problems of safety and maintenance as well as the considerations of aesthetic quality and multiple use can be effectively controlled through sound planning and careful design.

Regional detention systems can be established to provide stormwater management for several projects within a watershed. In addition, regional facilities can provide for water quality enhancement and flood protection for existing stormwater problems and, if located and designed as part of an overall stormwater master plan, they can also address stormwater management needs associated with future development. Regional facilities also offer many advantages such as economy of scale for construction and operation costs and greater overall effectiveness.

In addition to their stormwater management benefits, regional detention systems also can provide much needed recreational and open space benefits in the urban environment. As part of its Southeast Lakes Watershed Project, the City of Orlando constructed a very creative detention system called the Lake Greenwood Urban Wetland. Besides being an innovative stormwater treatment train, the system also provides an attractive urban wetland and recreational area.



Lake Greenwood Urban Wetland
(Conceptual Views)