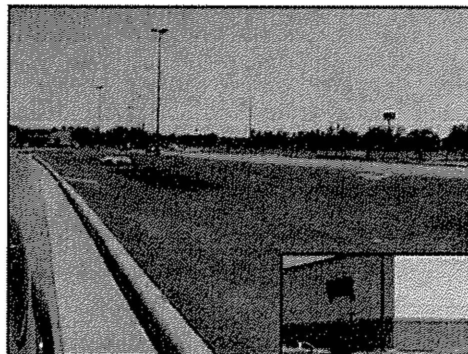
Infiltration Basins

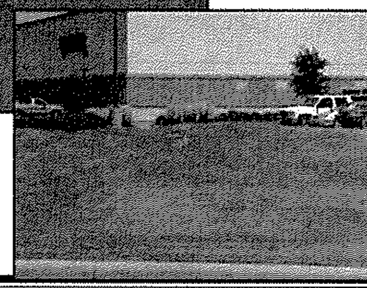
Benefits:

- *Provide reductions of peak flows and reductions in overall runoff volume.*
- *Recharge ground water.*
- *Provide removal of pollutants.*

Limitations:

- *Requires permeable soils to be effective.*
- *Should not be used in areas with high ground water tables.*
- *Studies have shown high rates of failure.*
- *Maintenance requirements are typically high.*
- *Often have poor public perception due to lack of aesthetic appeal.*





Costs:

One study estimates construction costs at $2.00 per ft³ for a 0.25-acre basin (SWRPC, 1991).

Effectiveness:

One study (Schueler, 1987) estimates average removal rates based on land disposal of waste water at:

- *Total suspended solids:* *75%*
- *Nitrogen:*......................................*55-60%*
- *Metals:*...*85-90%*
- *Bacteria*.. *90%*

Discussion:

Infiltration basins utilize a shallow impoundment designed to receive and capture stormwater runoff and allow the water to infiltrate into the groundwater. Infiltration basins require very specific conditions of soils and groundwater tables to be applicable. When properly designed and maintained infiltration basins can provide effective sediment and pollutant removal as well as groundwater recharge. Soils should have a minimum infiltration rate of 0.5 inches per hour with no greater than 20 percent clay content for infiltration practices to be effective. Holding time in infiltration measures should be around 24 hours. Risk of contamination to groundwater is a major limitation to infiltration basins, and design should ensure at least a 2 to 5 feet separation distance between the bottom of the basin and the seasonally high water table. Infiltration basins are recommended for use in treating small drainage areas (<10 acres) and small storms. Failure rates are typically high for infiltration basins due to reduction of soil permeability from sedimentation and from improper design and maintenance.

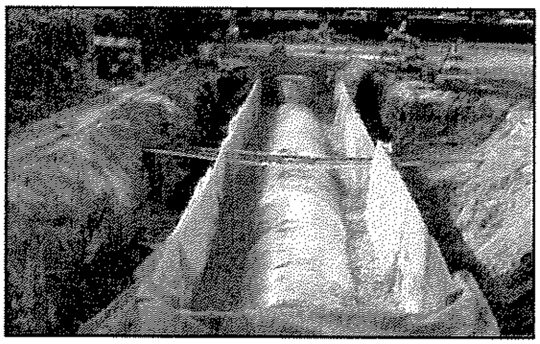
Infiltration Trench

Benefits:

- *Provides groundwater recharge.*
- *Reduces runoff volumes.*
- *Removes pollutants through filtration.*

Limitations:

- *Should not be used in areas with high ground water tables.*
- *Maintenance requirements are typically high.*
- *Studies have demonstrated relatively high failure rates.*
- *Require permeable soils to e effective.*



Discussion:

Infiltration trenches are rock or gravel filled excavations designed to receive stormwater runoff with no outlet. Infiltration trenches have the same specific design restrictions as other infiltration practices: separation from groundwater to prevent groundwater contamination, permeable soils to allow adequate infiltration rates, and low sediment inputs to prevent clogging. Infiltration trenches have a wide range of design variations suitable to various site conditions, and are often used along with other practices to form a stormwater treatment system. Basic design components common to all variations include pretreatment (such as grassed channels) to remove larger particles, treatment areas of large stones to provide storage for anticipated runoff volumes, and conveyance measures to ensure that the trench is not overwhelmed (such as overflow drains). Soils should have a minimum infiltration rate of 0.5 inches per hour, typically with no greater than 20 percent clay content for infiltration practices to be effective. Holding time in infiltration measures should be around 24 hours. Design should ensure at least a 2 to 5 feet separation distance between the bottom of the basin and the seasonally high water table. Infiltration trenches are recommended for sites with drainage areas less than 5 acres. Infiltration trenches have the potential to become clogged rapidly in areas with high inputs of suspended particles. Inspection should be conducted regularly to check for clogging of the system. Monitoring wells are often placed inside the trench to provide a method of checking infiltration rates. Preventative maintenance (such as measures to reduce inputs of suspended particles) is more cost-effective than repairs to a failing system, which may involve replacement of the rock or gravel layer.

Infrastructure Planning

Benefits:

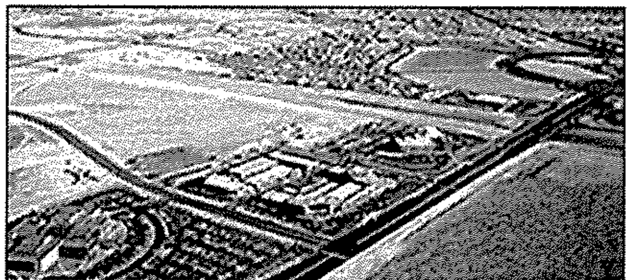
- *Infrastructure planning helps shape future use of an area and helps communities avoid urban sprawl.*

Limitations:

- *Developers must be on board with .planning efforts to ensure success.*

Costs:

- *Costs associated with developing plan may include staff time required to study area, meet with stakeholders. Training developers and others will also be a cost.*



Developers can design streets and pedestrian paths to maximize convenience and safety while at the same time minimizing impervious surface area (Source: The Rouse Company, no date)

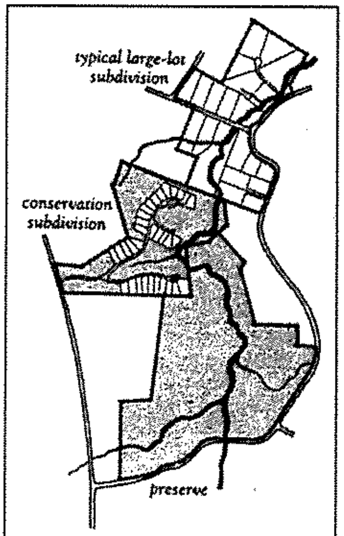


Figure 5
THREE PARCELS ON A STREAM VALLEY

Discussion:

Infrastructure planning involves making wise decisions to direct growth and development. Areas of previous development are preferred over undeveloped land, and areas with existing utilities are preferred over areas where utilities will have to be expanded. Scattered, undirected development called urban sprawl can increase impacts to water quality from stormwater runoff and strain local governments' ability to economically provide utilities and other public services. Urban sprawl often encroaches upon undeveloped areas while leaving behind unused land that has already been developed. The first step in infrastructure planning is to identify areas suited for development and redevelopment. The second step is to provide incentives for developers to encourage cooperation. Incentives include such as subsidies for developing recommended areas and higher rates to discourage development in new areas. Infrastructure planning can incorporate stormwater runoff management and protection of water quality by discouraging intensive development near water bodies and reducing the amount of new land cleared for development.

Level Spreader

Benefits:

- *Provide a nonerosive outlet for concentrated runoff by dispersing flow uniformly across a stable slope*

Limitations:

- *Designed to release small volumes of water and should be limited to 5 acres*

Costs:

- *Low cost structures*

Discussion:

Conduct level spreaders in undisturbed soil. The lip must be level to ensure uniform spreading of storm water runoff and the outlet slope uniform to prevent the flow from concentrating. Water containing high sediment loads should enter a sediment trap before release in a level spreader. A level spreader should be utilized where concentrated flows would otherwise enter a buffer zone or vegetative filter area.

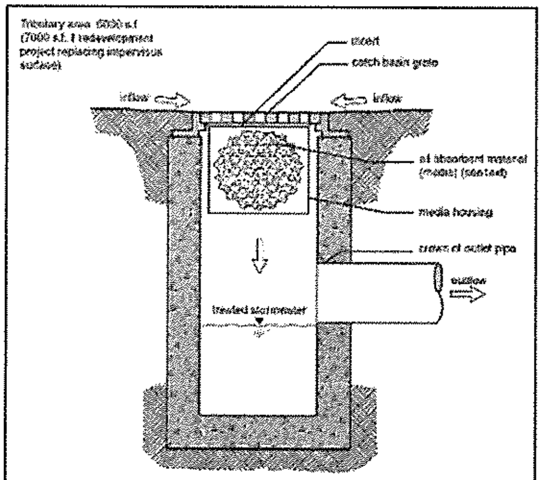
Manufactured Products for Stormwater Inlets

Benefits:

- *Provide removal of suspended particles and floatable pollutants.*

Limitations:

- *Independent studies suggest only moderate pollutant removal rates result from use of manufactured products, especially for dissolved pollutants and fine particles.*
- *Regular inspection and frequent maintenance are necessary.*



SECTION VIEW
NTS

The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Discussion:

Manufactured products for stormwater inlets treat stormwater at the point it enters into the storm drain. Examples include such products as hydrodynamic separators (swirl separators) and catch basin inserts. Both are available in various designs suited for varying site conditions. Swirl separators are typically precast units that use internal components to create a swirling motion as the stormwater passes through to provide energy for settling out of suspended particles. Initial studies suggest pollutant removal rates are relatively low, and recommended uses are for pretreatment to other stormwater management practices. Catch basin inserts simply fit into most existing catch basins and storm drain inlets and provide filtration of the runoff entering the drain. Catch basin inserts can be made of several different types of materials to provide removal of specific pollutants such as specialized fabrics for the capture of oil and grease pollutants. Both methods discussed above are most effective for removing floatables and particulates such as litter and debris. Regular inspection and intensive maintenance are required for effective use of manufactured products for stormwater inlets in order to remove debris and buildup.

Narrower Residential Streets

Benefits:

- *Reduction in impervious area for residential developments.*

Limitations:

- *Public and developer fears of inadequate on-street parking, safety, inadequate space for emergency and large vehicle access, and inadequate space for utility corridors.*
- *Local ordinances may restrict use of narrower residential streets.*

Costs:

Based on a cost of $15/yd^2, reduction of street width by 4 ft. can result in a cost savings of $35,000 per mile.

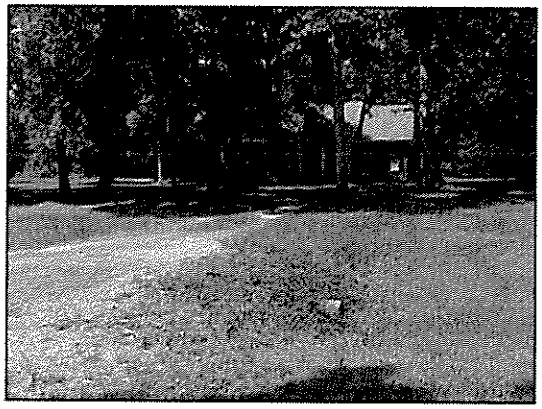
Effectiveness:

5-20% overall reduction in impervious area for residential developments (Schueler, 1995).

Discussion:

Narrower residential streets involves reducing the width of paved surface used to create roadways in residential areas. Common design practices for residential streets allow space for two parking lanes and two moving lanes. Reduction of the width of these streets by as little as a few feet can significantly reduce impervious areas in residential neighborhoods. Local or state zoning laws and ordinances often require minimum widths for residential streets and may need to be modified before this measure can be applied. Narrower streets are suitable for areas where traffic is less than 500 or fewer average daily trips or streets that serve about 50 single-family homes. Narrower streets should not be considered for high traffic streets such as arteries or for streets where traffic is expected to increase over time. Concerns over inadequate parking space, car and pedestrian safety, access for service and emergency vehicles, and placement of utilities are common objections to reducing residential street widths.

On-Lot Treatment



Benefits:

- *Reduce runoff and increase infiltration.*
- *Reduce the need for additional stormwater management measures.*

Limitations:

- *Requires cooperation of homeowners.*
- *Only treat runoff from a portion of total residential impervious area.*

Costs:

Materials such as rain barrels cost approximately $100 and dry wells cost approximately $200. Cisterns are more expensive and costs depend greatly on size and materials used.

Discussion:

On-lot treatment refers to practices designed to receive and treat stormwater runoff from individual residential lots. The use of on-lot treatment can be an effective method of maintaining pre-development hydrology, providing for groundwater recharge, avoiding increased flow rates associated with impervious surfaces, and helping maintain low-flow volumes in receiving streams. On-lot treatment uses two basic methods: infiltration and collection. Examples of on-lot treatment practices include cisterns, rain barrels, dry wells, and grassed swales. Pollutant removal rates can be high if pollutants are contained in the runoff. The practice is typically used to collect runoff from rooftops. Systems designed to collect runoff from lawns and rooftops can provide greater protection from many of the pollutants associated with residential runoff such as fertilizers. Public education regarding the proper use of pesticides and fertilizers should be utilized to reduce the risk of contamination to groundwater. In areas with high water tables near the surface, infiltration methods should be avoided. On-lot treatment requires cooperation of the residents. On-lot treatment does not address impervious surfaces such as streets, which can make up a large percentage of a residential area's impervious surface.

Open Space Design

Benefits:

- *Provide reduction in pollutants.*
- *Provide reduction in runoff volumes and velocities.*
- *Provides aesthetic quality, area for recreation, and habitat for wildlife.*

Limitations:

- *Developers often fear open space subdivisions will be less marketable, or that the review process will take too long.*
- *Local ordinances may restrict the use of many open space principals.*
- *Requires homeowner's cooperation for maintenance of open space.*

Costs:

Open space design can provide cost savings as less area is cleared and the need for stormwater management practices is reduced. One example (Liptan and Brown, 1996) demonstrated a cost savings of $800 per lot for site development. Other examples report average cost savings for infrastructure ranging from 11 to 66%.

Effectiveness:

CWP (1996) reports nutrient levels in runoff decreased by 45 to 60% when two conventional subdivisions were replaced by open space subdivisions.

Discussion:

Open space design involves concentrating development on a given site in order to preserve open areas and green space. Open space design involves rethinking typical site development practices giving extra consideration to preserving the natural integrity of the site. Areas that can provide overall benefits to the end product, such as stream corridors, are identified for preservation. Open space design can reduce negative impacts from stormwater runoff associated with development such as increased runoff from impervious surfaces and pollutant inputs. Open space design has been shown to reduce construction costs while increasing property values. Costs associated with additional stormwater management measures, clearing costs, and downstream flooding due to increased runoff volumes can be reduced using open space design. Local ordinances can put restrictions on development that may prohibit many of the components of open space design and may need to be revised in order to implement open space design. Developers' misconceptions of open space design principals (fears of longer plan reviews, higher costs, and lower market value) are often major limitations to implementation. Open space designs should include provisions for the acceptable uses and maintenance of open spaces.

Ordinances for Post-Construction Runoff

Benefits:

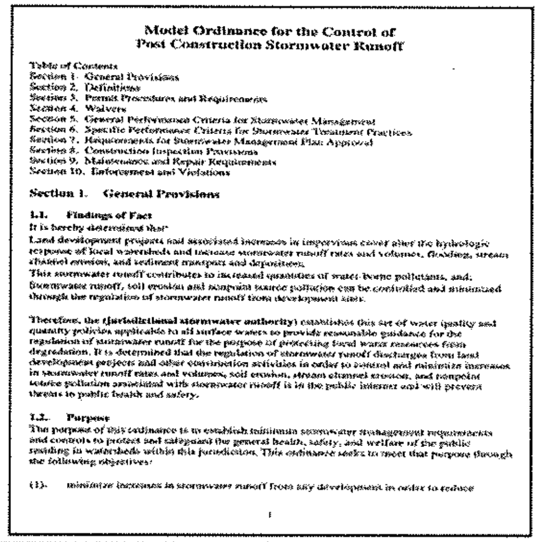
- *Provide enforceable measures to minimize storm water runoff from a site.*
- *Provide enforceable measures to improve water quality of runoff from a site.*
- *Provide a means of mandating and enforcing stormwater management practices for development.*

Limitations:

- *Cost for drafting, implementing, and enforcing ordinances.*

Costs:

Costs include time for personnel to develop, implement, and enforce ordinances.



Model Ordinance for the Control of Post Construction Stormwater Runoff

Table of Contents

Section 1. General Provisions

1.1. Findings of Fact

It is hereby determined that:

Land development projects and associated increases in impervious cover alter the hydrologic response of local watersheds and increase stormwater runoff rates and volumes, flooding, stream channel erosion, and sediment transport and deposition;

This stormwater runoff contributes to increased quantities of water-borne pollutants, and;

Stormwater runoff, soil erosion and nonpoint source pollution can be controlled and minimized through the regulation of stormwater runoff from development sites.

Therefore, the **(jurisdictional stormwater authority)** establishes this set of water quality and quantity policies applicable to all surface waters to provide reasonable guidance for the regulation of stormwater runoff for the purpose of protecting local water resources from degradation. It is determined that the regulation of stormwater runoff discharges from land development projects and other construction activities in order to control and minimize increases in stormwater runoff rates and volumes, soil erosion, stream channel erosion, and nonpoint source pollution associated with stormwater runoff is in the public interest and will prevent threats to public health and safety.

1.2. Purpose

The purpose of this ordinance is to establish minimum stormwater management requirements and controls to protect and safeguard the general health, safety, and welfare of the public residing in watersheds within this jurisdiction. This ordinance seeks to meet that purpose through the following objectives:

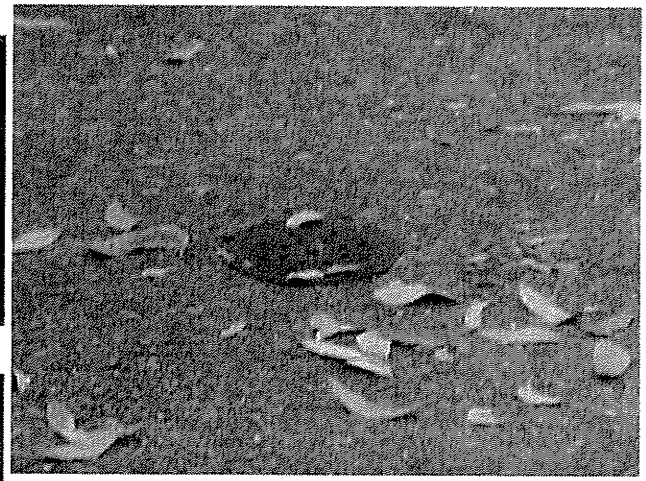
(1). minimize increases in stormwater runoff from any development in order to reduce

1

Discussion:

Ordinances for post-construction runoff promote public welfare by guiding, regulating, and controlling the design, construction, use, and maintenance of any development or other land disturbance activity. Ordinances should be designed to meet the needs of the community; therefore, the issues of concern in a given community must be identified. Several resources are available that provide guidance for the development of stormwater management ordinances. Ordinances for stormwater management typically involve general provisions, definitions of terms, permitting requirements and procedures, waiver eligibility, performance and design criteria, plan review requirements and procedures, inspection and maintenance requirements and procedures, and enforcement and penalty provisions. The best-planned and most well written ordinances are useless unless they are enforced.

Parking Lot Storage



Benefits:

- *Protects downstream areas from flooding*
- *Protects from stream channel degradation*
- *Protects from pollutant loads caused by urban development*

Costs:

- *Costs can be minimal if incorporated into surface parking lot storage, but expensive if subsurface storage is utilized.*

Discussion:

This practice involves the use of impervious parking areas or landscape islands as temporary impoundments during rainstorms. Parking of stormwater systems can be designed to temporarily detain stormwater in specially designated areas, and release it at a controlled rate. It is important that these facilities be designed to minimize potential safety hazards and inconvenience to motorists and pedestrians.

Sand and Organic Filters

Benefits:

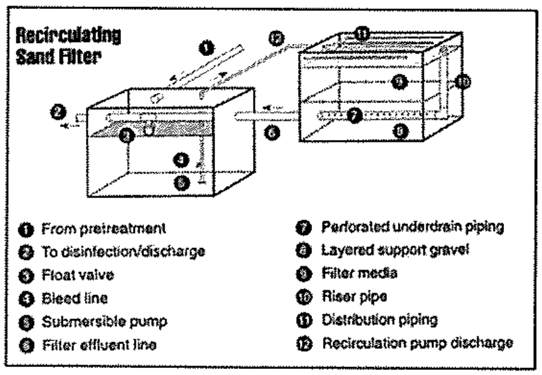
- *Sand filters can provide effective pollutant removal.*
- *Sand filters are applicable to a wide variety of site conditions.*

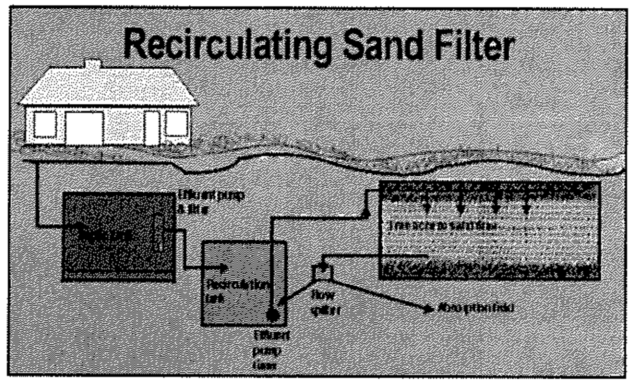
Limitations:

- *Sand filters provide very little flow or volume reduction.*
- *Sand filters require frequent inspection and high maintenance.*
- *Sand filters are not suited for treating large drainage areas.*

Costs:

Little data is available for costs. Brown and Schueler (1997) estimate construction costs to average \$5.00 per ft^3 of stormwater treated.





Discussion:

Sand and organic filters typically involve a simple two-stage design with the first stage allowing for settling of coarse particles, and the second stage using a sand or organic material filter media to remove smaller suspended particles. Treated runoff leaving the sand filter can then be conveyed to the storm drain system. Several design variations of the basic two-stage setup can be applied to suit site conditions and can include both aboveground and below ground designs, perimeter filters, and sand or organic material filter media. Most designs require several feet of drop (depending on the size) to provide adequate flow through the system. Sand filters are often used in combination with other management practices to from stormwater management systems. Filters are typically not designed to treat large areas or large volumes of runoff. Design should include sizing the filter apparatus to accommodate the anticipated volumes of runoff and provide overflow devices or flow splitters to allow for unexpected volumes. Intense maintenance is required for the operation of sand filters, and the settling basins and filter materials must be regularly inspected to check for sediment accumulation.

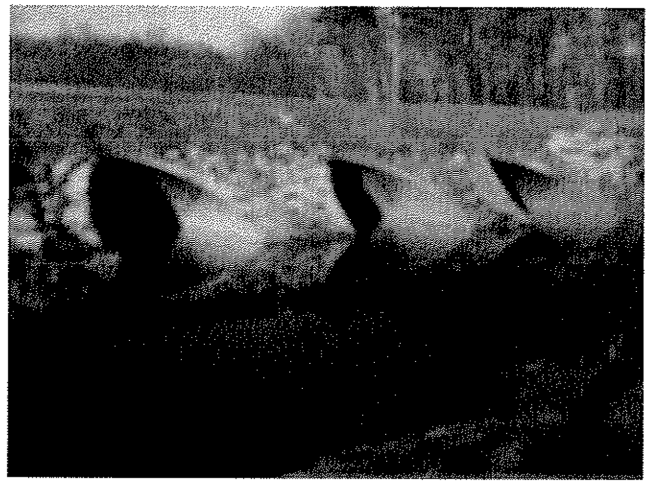
Stream Crossing (permanent)

Benefits:

- *Structures will not erode, overtop, or cause flooding*

Costs:

- *Costs can be extremely expensive and depend on the type of crossing.*



Discussion:

Stream crossings are direct sources of water pollution. They cause flooding and safety hazards and can be expensive to construct. If washed out or damaged, they can also cause costly construction delays. Plan the development to complete work on each side separately to minimize stream crossings. Stream crossings are of three general types: bridges, culverts, and fords. In selecting a stream crossing practice consider: frequency and kind of use, stream channel conditions, overflow areas, potential flood damage, surface runoff control, safety requirements and installation and maintenance costs.

Trees, Shrubs, Vines, and Ground Covers

Benefits:

- *Provide superior, low-maintenance, long-term erosion protection*
- *Useful where site aesthetics are important*
- *Useful on steps or slopes where maintenance is difficult*
- *Useful for wildlife habitat improvement*
- *Useful as windbreaks or screens*

Costs:

- *Costs vary but are generally low and depend on the types of vegetation used.*

Discussion:

There are many different species of plants from which to choose, but care must be taken in their selection. It is essential to select planting material suited to both the intended use and specific site characteristics. None of the plants, however, are capable of providing the rapid cover possible by using grass and legumes. Vegetative plants must include close-growing plants or adequate mulch with all plantings of trees, shrubs, vines, and ground covers.

Urban Forestry

Benefits:

- *Urban forests provide breaks in impervious cover.*
- *Increase aesthetic appeal.*
- *Increased property values.*

Limitations:

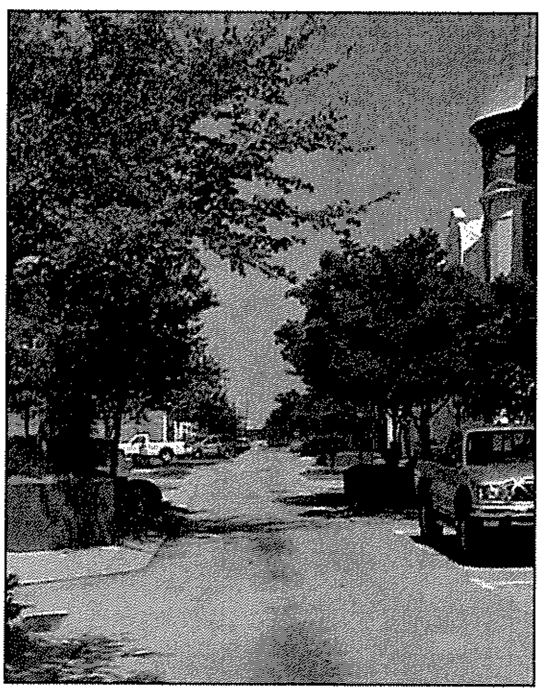
- *Ordinances and easements used to establish urban forestry programs may be contrary to development pressures in some areas.*

Costs:

- *Costs vary and depend on program elements. Grants may be available for certain projects.*

Discussion:

Urban forestry is a branch of traditional forestry that focuses on trees and forests in and around towns and cities. Urban forests can increase infiltration of stormwater, provide shading, and increase the aesthetic quality of an area. Urban forests have been shown to increase property values in an area. Programs should identify critical areas that are suited for implementation of urban forest initiatives. In developing urban forestry programs, preservation of existing trees is preferred. Programs should establish guidelines for selecting and protecting desirable trees during site clearing. Maintenance for forested areas is minimal and will depend greatly on the uses of the area.



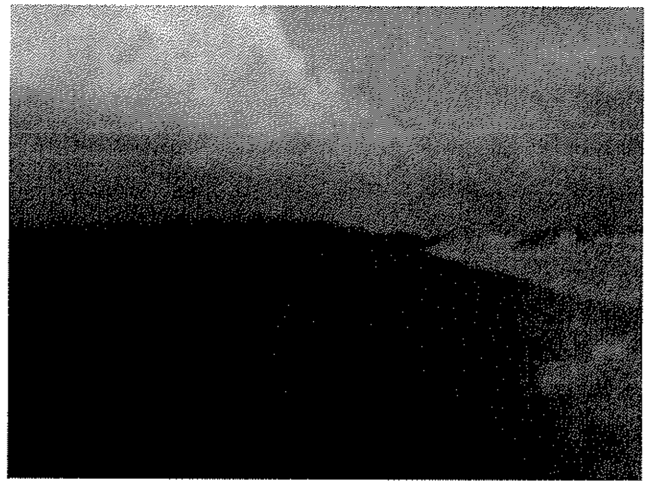
Vegetative Dune Stabilization

Benefits:

- *Protect backshore areas from ocean storms, shoreline erosion, and encroachment by migrating sand.*
- *Grasses grow upward through accumulating sand to hold it as the dune grows.*

Costs:

- *Low costs are generally associated with vegetative planting.*



Discussion:

Adapted native vegetation can be used to stabilize coastal dunes and sandy areas disturbed by construction, and to rebuild frontal dunes. The perennial grasses, American beachgrass, sea oats, and bitter panicum, are the primary dune stabilizers and have been extensively planted for this purpose. Vegetative planting is the most effective way to establish these grasses. Primary considerations in planting dune grass include finding a source of plant material and timing plantings so they have maximum chance of success. American beachgrass is excellent for initial dune stabilization but is often not persistent. If 10 percent sea oats and bitter panicum are included in beachgrass plantings these will fill in bare spots and provide persistent cover. Sand fences accelerate sand accumulation and can be used in combination with vegetation to rebuild frontal dunes.

Vegetative Streambank Stabilization

Benefits:

- *Aesthetically pleasing*
- *Provide a habitat for fish and wildlife*
- *Afford a self-maintaining cover*
- *Less expensive and damaging to the environment*

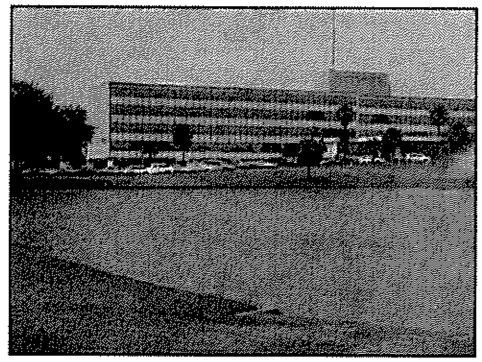
Costs:

- *Costs are low*

Discussion:

Upstream development accelerates streambank erosion by increasing the velocity, frequency, and duration of low. A s a result, many natural streams that were stable become unstable following urbanization. Streambanks may be stabilized by selected vegetation or by structural means. In many cases, a combination of vegetative and structural measures should be used. Wherever possible, it is best to protect banks with living plants that are adapted to the site. Evaluate the erosion potential of the stream carefully and establish appropriate vegetation whenever site conditions permit. Stream channel velocities for the 10-year storm should generally be less than 6 ft/s for effective stabilization by vegetative means. A private consulting engineer should be contacted for the design of this practice.

Wet Extended Detention Ponds



Benefits:

- *Provide flood control by reducing peak flows.*
- *Provide pollutant removal through settling and biological action.*
- *Have long life span.*
- *Can treat large drainage area.*
- *Can increase property values.*

Limitations:

- *Space required for construction may limit use in densely urban areas.*
- *Maintenance to control sedimentation and vegetation may be required.*

Discussion:

Wet extended detention ponds are often called stormwater ponds, detention ponds, and wet ponds. These basins are designed to receive stormwater runoff and maintain a permanent pool of water year round. Wet ponds are among the most cost-effective stormwater practices. Wet ponds are also one of the most effective practices at removing stormwater pollutants. The ponds can provide pollutant and sediment removal as well as attenuation of floodwaters. Stormwater detention time allows for settling of suspended particles and plant and algae provide uptake of several major stormwater pollutants. Storage capacity above the normal permanent pool level can provide additional time for settling and room for reduction of peak stormwater flows. Wet ponds are capable of receiving runoff from a large area and typically require a drainage area of greater than 25 acres to maintain a permanent pool. Studies have shown that wet ponds can actually increase property values. Wet ponds may not be feasible for use in heavily urbanized areas where adequate space is not available. Inspection and maintenance of wet ponds may be required and may include removal of accumulated sediments and management of aquatic vegetation.

Zoning

Benefits:

- *Provide stormwater management by requiring better site designs.*
- *Can serve to wisely manage development by establishing special requirements designed to protect sensitive areas such as forested areas or riparian corridors.*

Limitations:

- *Local political and economic issues may present obstacles to zoning restrictions in some areas.*

Costs:

- *Costs may be associated with the time it takes to revise current zoning and land use regulations, gain support and adopt new zoning regulations.*

Discussion:

Zoning for stormwater management involves developing classification schemes for land use that consider the threats to water quality from stormwater runoff. Zoning is a tool used to develop comprehensive, long term, effective planning for land use. Zoning can be a powerful tool for stormwater management and can prevent potential stormwater runoff problems during the design phase of development. Zoning for stormwater should first identify the water resources that could potentially be impacted by development in a given area, then address measures suitable to providing safeguards to these resources.