REDUCING IMPACTS OF STORMWATER RUNOFF FROM NEW DEVELOPMENT

1

INTRODUCTION

"Surface runoff, as a result of excess rainfall, is a natural process. Surface runoff is nature's chisel which has formed the landscape as we know it today. The landscaping process involves the erosion of upland areas and the subsequent building of floodplains and wetlands. Without man's interference, this landscaping process is very slow with the underlying rock, soil and surface vegetation tending to resist the chisel. This process is normally so slow that changes are barely perceptible from decade to decade or even century to century. With time, this process reaches a state of equilibrium, thus creating a favorable habitat for aquatic life." [1]

Either through ignorance of ecosystem functions, poor planning, unwise land use decisions, or just plain indifference to natural stormwater runoff processes, humans, through construction and development activities, have created a number of problems for themselves and nature. The first and perhaps most obvious problem is development of floodplains, putting life and possessions in jeopardy. Second, the development and urbanization of uplands has increased erosion and accelerated the runoff process altering natural runoff patterns and increasing the flood hazard. Finally, many of civilization's contaminants are transported in stormwater runoff which ultimately can enter and degrade the quality of streams, rivers, lakes, wetlands and estuaries.

Through their planning and regulatory functions, local governments have the principal responsibility for controlling developmental activities in New York State. This role carries with it the responsibility for ensuring that developmental activities are undertaken with the safety of future inhabitants in mind, and in a manner that is compatible with the protection and enhancement of natural resources ... including water resources.

The traditional way of handling stormwater has been to get it off-site as quickly as possible. This has contributed to flooding, water quality degradation and loss of fisheries habitat and recreational opportunities in streams, lakes, wetlands and coastal embayments in many areas of New York State.

The purpose of this manual is to provide local officials involved in land use planning and project reviews with technical guidance on stormwater management and erosion and sediment control in newly developing areas. Application of the stormwater management and erosion control standards and practices in this manual can assist local planning boards and staff with site-plan reviews and environmental impact assessments by helping to ensure that the impacts of new development on water resources, including flooding and water quality degradation, are minimized. Developers and consultants will find the standards, design criteria, planning guidelines and hydrologic methodologies useful in sizing, siting and designing facilities to control stormwater runoff from land areas undergoing development.

STORMWATER RUNOFF: WHAT IS IT?

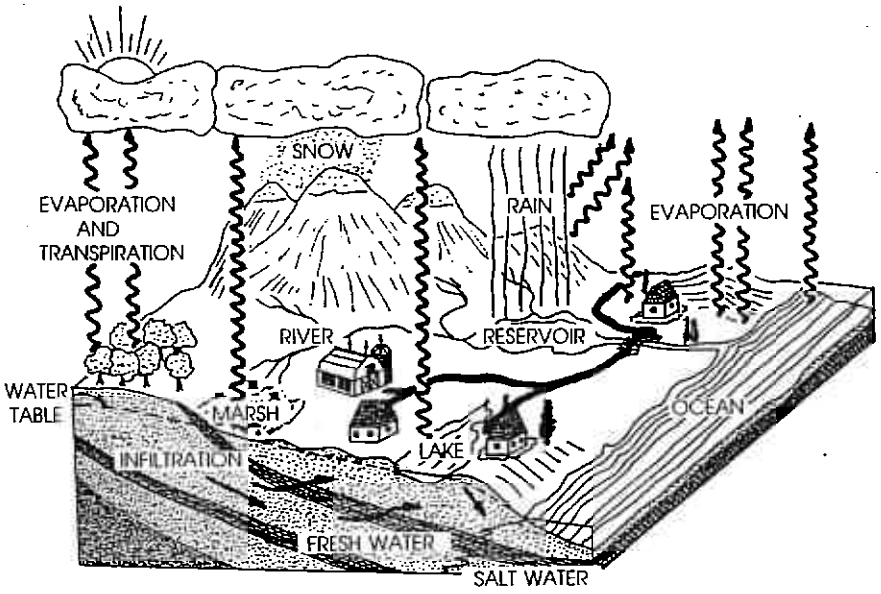
The hydrologic cycle, shown in Figure 1, can be used to bring about an understanding of stormwater runoff.

The first stage of runoff formation occurs as atmospheric moisture condenses into rain droplets or snowflakes. Runoff formation begins after rain (snow) reaches the earth's surface. Runoff generated by precipitation has three components:[2]

- *Surface Runoff*—a residual of precipitation after accounting for all losses. The losses include depression storage and ponding, infiltration, and evapotranspiration from the earth's surface. The subtraction of these losses from precipitation will yield excess or net rain which becomes surface runoff.

A lack of stabilization at this project site resulted in soil being transported to this stream during storm events to the detriment of fisheries habitat. What's more, the close proximity of the building to the stream indicates a lack of protection for the stream corridor. Building set back requirements and vegetative cutting restrictions can be used to protect the stream. This manual speaks to these and other issues related to stormwater runoff and provides planning board members with guidance to prevent such problems.

Figure 1: The Hydrologic Cycle



ADOPTED FROM: TEXAS WATER COMMISSION

• *Interflow*—is that portion of water infiltrating into the soil zone which moves in a horizontal direction, due to lower permeability of subsoils, and eventually reaches a surface waterbody. The amount of inter flow is again residual from infiltration after subtraction ofthe groundwater recharge, soil moisture storage, and evapotranspiration from soil and vegetation cover.

• *Groundwater Runoff (base flow)*—is defined as that part of precipitation which infiltrates through the soil profile to replenish groundwater. Most stream flows during prolonged drought periods are sustained by groundwater runoff. That portion of stream flow sustained by groundwater runoff is considered the base flow.

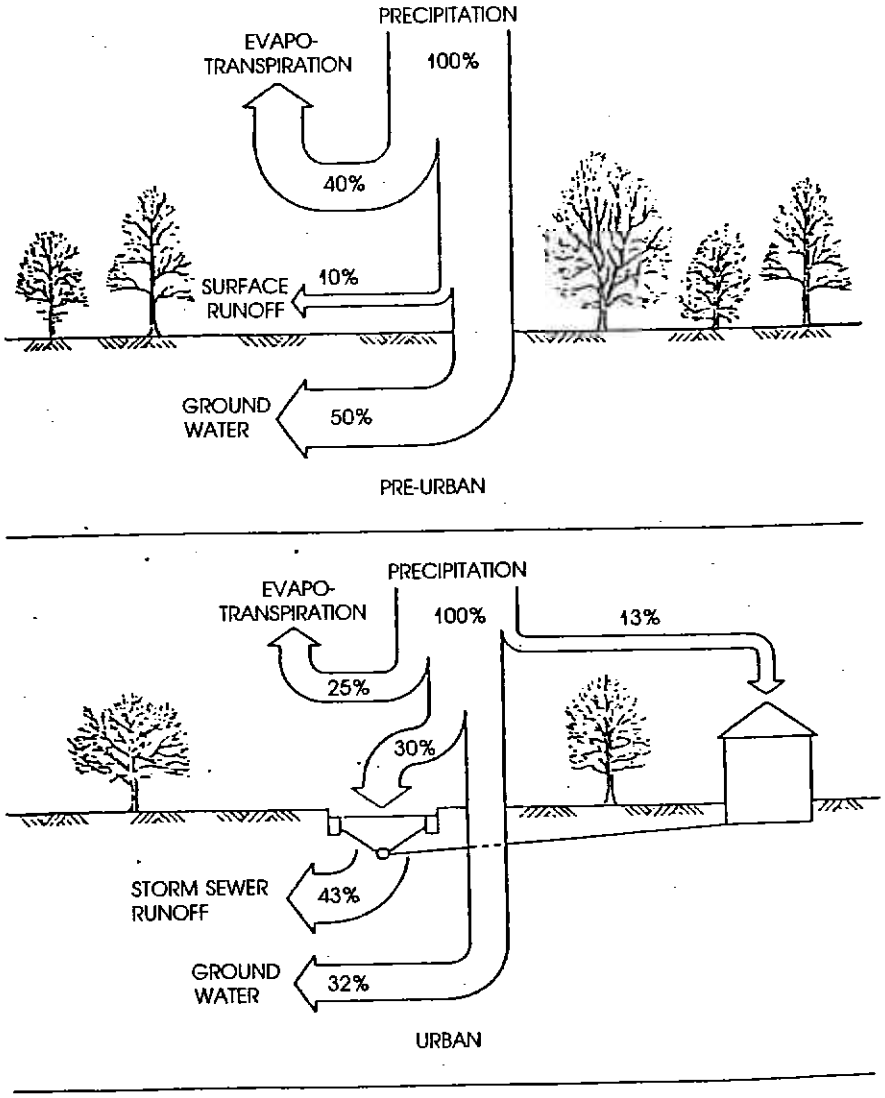
STORMWATER RUNOFF: THE PROBLEM

Problems of flooding and water quality degradation in urbanizing or developing areas can be explained in a relatively straightforward manner. As more and more land becomes covered with buildings, roads, parking lots and sidewalks and other impervious surfaces, stormwater is prevented from percolating into the soil. Instead, it runs off those impermeable surfaces and drains directly, and rapidly to the nearest waterbody. This increases the peak flow, both in terms of volume and flow rate, and the size of the flood plain resulting in more frequent flooding and accelerated erosion of stream channels. This large percentage of direct runoff

also reduces the amount of water left for soil moisture replenishment and groundwater recharge (see Figure 2). The reduction in groundwater means, in turn, a reduction in the base flow of water available to streams during periods of dry weather to the detriment of fish populations and other aquatic organisms.

Furthermore, as land is cleared and graded and made ready for development, soil becomes exposed and subject to the forces of erosion. Soil particles transported in stormwater runoff can be deposited as sediment in a stream or

Figure 2:



Hydrologic Changes Resulting from Urbanization (Based on Values from L.B. Leopold, USGS Circular 554, 1968). Source: Environment Canada; Modern Concepts in Urban Drainage, Conference Proceedings No. 5; Canada-Ontario Agreement on Great Lakes Water Quality: Toronto, Ontario; March 1977.

As land is cleared and graded and made ready for development, soil becomes exposed and subject to the forces of erosion.

other waterbody and can adversely impact fish and wildlife habitat. Also, deposition of sediment in a stream can elevate the bed of the stream channel resulting in more frequent flooding.

While the need to manage stormwater runoff for flood prevention purposes has long been acknowledged, pollution problems associated with stormwater runoff have been less widely recognized. In urban areas, paved and roof surfaces collect pollutants which then are rapidly washed into drains and surface waters during storms rather than first being treated by vegetative cover and soil. The Environmental Protection Agency has calculated that runoff from the first hour of a moderate-to-heavy storm in a typical U.S. city will contribute more pollutional load than would the city's untreated sanitary sewage during the same period of time. Studies in New York State conducted as part of the Nationwide Urban Runoff Program (NURP) have confirmed that contaminants contained in urban and suburban runoff such as sediments, phosphorus, nitrates, coliform bacteria as well as lead and other heavy metals can impair water quality in streams, lakes, wetlands and estuaries.

STORMWATER MANAGEMENT: THE CONCEPT

"Stormwater management" may be defined (1) for quantitative control, as a system of vegetative and structural measures which can be used to control the increased volume and rate of surface runoff caused by man-made changes to the land so as to maintain existing patterns of flood magnitude and frequency, and (2) for qualitative control, as a system of vegetative, structural and other measures which can be used to control or treat pollutants carried by surface runoff[3]. The purpose of this section is to elaborate on this definition by providing a conceptual overview of stormwater management.

The U.S. Environmental Protection Agency has calculated that runoff from the first hour of a moderate-to-heavy storm in a typical U.S. city will contribute more pollutional load than would the city's untreated sanitary sewage during the same period of time. (Photograph courtesy of John George–DEC).

The Goal of Stormwater Management

THE GOAL OF STORMWATER MANAGEMENT IS SIMPLE. THE QUANTITY AND QUALITY OF STORMWATER RUN-OFF FROM ANY SPECIFIC DEVELOPMENT SHOULD NOT BE SUBSTANTIALLY ALTERED FROM PREDEVELOPMENT CONDITIONS.

Traditional approaches of stormwater drainage are aimed at removing stormwater from a site as quickly and as efficiently as possible; this is where the trouble begins. The term "efficient" refers to how quickly water can be concentrated and removed from where it is not wanted. Since pollutants can be transported by stormwater runoff, generally, the more "efficient" the stormwater drainage system, the greater the pollution load to the receiving water body. "Efficient" stormwater drainage systems also increase the rate and volume of runoff thereby contributing to flooding and scouring of streambanks which results in erosion, stream channel enlargement, and sedimentation to the detriment of fish populations[4]. In an ideal stormwater runoff design solution, water falling on a given site should be absorbed or retained on-site to the extent that after development, the quantity and quality of water leaving the site would not be significantly different than if the site had remained undeveloped[5].

Stormwater Management: Objectives

Programs for stormwater management in developing or urbanizing areas typically have several objectives as follows:

- prevent increased runoff from new land development to reduce potential flooding and flood damage;
- minimize the erosion potential from a development or construction project;
- assure the adequacy of existing and proposed culverts and bridges;
- increase water recharge into the ground;
- enhance the quality of stormwater runoff to prevent water quality degradation in receiving waterbodies;
- reduce streambank erosion to maintain stream channels for their biological functions as well as for drainage;
- prevent reductions in stream base flow caused by new land development.

The above objectives can be achieved by installing and maintaining properly designed stormwater management facilities.

Protecting Sensitive Environmental Resources

Numerous practices and measures can be used to control and treat stormwater runoff. Many of these practices are discussed and illustrated in Chapter VI. It should be pointed out, however, that with few exceptions, none of the practices for managing stormwater runoff are 100 percent effective. Therefore, in planning for the protection of a sensitive environmental resource, such as a high quality trout stream, water supply, lake, wetland, or coastal estuary, the most appropriate approach may be to restrict growth and development in the contributory drainage through proper planning and zoning.

Conceptual Framework for Stormwater Management

The purpose of this section is to provide a conceptual framework for gaining a better understanding of stormwater management. Accordingly, stormwater management in its broadest sense, consists of controlling runoff from developed areas and land areas which are undergoing development to achieve the above goal and objectives. Whether by applying practices to control runoff from newly developing areas, or by retrofitting practices to control runoff from areas of existing development, stormwater can be managed by employing one or more of the following components which, when viewed in total, comprise a comprehensive approach to stormwater management:

- on-site management of stormwater;
- regional management of stormwater;
- watershed-wide management of stormwater.

Each of the above components will be discussed briefly to provide for an overview of the approaches to stormwater management. *While most, if not all, of the practices and procedures included in this manual can be employed to address storm-related problems on a regional scale, and to a more limited extent on a watershed-wide scale, the user of this manual should understand that the guidance in this document is intended primarily for on-site management of stormwater runoff from new development.*

- On-site Management of Stormwater

On-site management of stormwater runoff is done on a project-by-project basis usually within the framework of a regulatory program. Under the on-site approach, developers are required to design and install stormwater management practices for a specific project site, such as a subdivision or shopping plaza. The role of government in the on-site approach is to adopt performance standards and to review stormwater management plans prepared by the developer to ensure that practices and facilities are designed and installed in conformance with the adopted standards.

The major drawback of relying entirely on an on-site stormwater control strategy is that flooding can be aggravated if the random placement of stormwater management facilities within several small watersheds or drainages is such that peak rates of discharge from each facility happen to converge at one location downstream at the same time. The way to avoid this is to conduct hydrologic studies of the watershed so that the volume and rates of discharge from each on-site facility can be coordinated and properly routed.

- Regional Management of Stormwater

Under the regional approach to stormwater management, a single stormwater facility is strategically located to control stormwater runoff from multiple development projects[6]. Compared to on-site control, there are greater "front-end" costs for a regional stormwater management system, including studies to site and design the regional facilities and the financing

associated with constructing these facilities in advance of future urban development. The maximum drainage area for a regional stormwater facility usually is in the range of several hundred acres.

As in the on-site approach, regional stormwater facilities may be designed to remove pollutants as well as to control the volume and peak rates of runoff. Regional facilities also can be used in conjunction with on-site systems. Stormwater may be treated through the use of on-site management practices to improve water quality before being discharged to the regional system. In this case, the primary function of the regional system is to control the volume and peak rates of stormwater runoff.

Regional stormwater management has several major advantages over complete reliance on the on-site approach. For example, land developers typically recognize that economies-of-scale available at a single regional stormwater facility should produce lower capital costs in comparison with several on-site stormwater facilities. Also, land developers tend to prefer the regional approach because it eliminates the need to set aside acreage for an on-site stormwater management facility, and therefore could permit an increase in the buildable acreage within the developable site[7]. Another major advantage of the regional approach is that, through "retrofitting," regional stormwater facilities can be designed to control runoff from areas of existing development and/or areas which are partially developed and are undergoing further development.

The major disadvantages of the regional approach to stormwater management include the following: local governments must perform advance planning studies to site regional facilities; and local governments must finance, design and construct regional facilities before the majority of future urban development occurs while being reimbursed by developers over a build-out period that can be 5-20 years in duration[8]. As in the case of on-site stormwater systems, regional systems also can result in increased flooding downstream if discharges from multiple regional facilities are not properly coordinated and routed.

- Watershed-wide Management of Stormwater

Under the watershed-wide approach to stormwater management, studies are undertaken with the aid of simulation

Community image and appearance are enhanced when stormwater facilities such as this retention pond at General Telephone, Marion, Ohio are attractively designed and landscaped. (Photograph courtesy of Bruce K. Ferguson).

models to predict hydrologic and water quality changes in the watershed resulting from anticipated or proposed changes in land use. The predictive capability that watershed modelling provides also enables planners to evaluate cumulative water quantity and quality impacts resulting from land development and the effectiveness of alternative control measures.

Under the watershed-wide approach, the control and management of stormwater runoff, whether from areas of existing development or from newly developing areas, can include on-site stormwater management practices, regional systems, or a combination thereof. Stormwater management implemented on a watershed-wide scale ordinarily will require the establishment of a county or regional authority to coordinate multi-jurisdictional land use and development plans to ensure they are consistent with stormwater management plans, goals and objectives.

STORMWATER MANAGEMENT: OPPORTUNITIES FOR LOCAL GOVERNMENT

Changing Perceptions About Urban Stormwater

Many municipalities in New York State have adopted stormwater drainage provisions in their zoning ordinances, subdivision regulations, and site plan review procedures. However, few have undertaken stormwater management planning to achieve multiple purposes and objectives such as water quantity and quality management, increased recreational opportunities, open space protection and groundwater replenishment. Nevertheless, perceptions and attitudes about stormwater in newly developing and urbanizing areas are changing. Effective stormwater management planning can do more than solve problems such as downstream flooding and pollution. When stormwater is viewed as a resource to be managed, stormwater management facilities can provide a community with recreational benefits, as in the case when large retention ponds are used for boating and fishing. Stormwater management also can helpto maintain summertime stream flows and lake levels. Finally, as many of the photographs in this manual show, attractively designed and landscaped stormwater management facilities can provide aesthetic amenities which enhance the quality of development and, in turn, the image and appearance of a community.

The Role of Local Government in Stormwater Management

Possible roles for local governments in stormwater management include the following:[9]

- **Planning:** The municipality may develop policies, programs, regulations, and other recommendations to chart the future course of the community in terms of stormwater management.

- **Regulation:** Stormwater runoff controls for subdivisions, planned unit developments, and industrial or commercial development can be reviewed and approved by local government during site plan review, subdivision review, and as part of an environmental review under SEQR.

- **Design and Construction:** Municipalities may design and construct stormwater management facilities ahead of development, for example, in a regional stormwater management strategy, and charge a user's fee to offset construction and maintenance costs.

- **Inspection and Maintenance:** Municipalities may inspect stormwater facilities to ensure they are being properly maintained. Maintenance can be undertaken by property owners within a contractual arrangement in a homeowner's association. Alternatively, local government can elect to maintain stormwater facilities through the use of general revenues or the creation of a special town or county drainage district.

In the case of urbanizing or rapidly developing counties, construction and maintenance of publicly-owned regional or off-site stormwater management facilities is a responsibility increasingly being assumed at the county level of government in many areas of the United States including Nassau County on Long Island.

MANUAL LAYOUT AND ORGANIZATION

This manual contains seven chapters and one appendix. Chapter I provides manual users with a conceptual overview of stormwater management, and it acquaints them with goals and objectives typically associated with stormwater management. Chapter I also describes local opportunities for stormwater management.

Chapter II has been prepared to foster a greater awareness and understanding of the impact that stormwater runoff has on rivers, streams, lakes, wetlands, coastal embayments and estuaries.

Chapter III provides an analytical framework for reviewing a stormwater management and erosion control plan. The various analyses that must be performed by a developer seeking plan approval are described in this chapter.

Chapter IV outlines the structure and content of a stormwater management and erosion control plan. A format for organizing and presenting physical resource information, for comparing runoff characteristics under pre- and post-development conditions, and for identifying and describing proposed stormwater management and erosion control practices for controlling runoff and erosion from a specific project site is provided in this chapter.

Chapter V contains specific performance standards for siting, sizing and designing stormwater management and erosion control facilities. These performance standards are central to the State's stormwater management and erosion control program.

Chapter VI describes management practices which can be used to control stormwater runoff from the development site. Also, specific design criteria are provided for each management practice described in this chapter.

After they have been installed, stormwater management practices need periodic upkeep and maintenance. Chapter VII briefly discusses several institutional options available for facilitating proper maintenance. Maintenance guidelines for specific

stormwater management practices also are provided in Chapter VII.

Appendix A contains a Model Stormwater Management and Erosion Control Ordinance. This ordinance is intended to facilitate achievement of recommended stormwater management objectives. In addition, the ordinance will satisfy stormwater management provisions (-450) and erosion control provisions (-540) of the National Flood Insurance Community Rating System[10]. The specific provisions for preparing a stormwater management and erosion control plan outlined in Chapter IV of the manual should be incorporated into Section Eight of the Ordinance. The performance standards for erosion control and stormwater management in Chapter V. should be incorporated into Section Ten of the Ordinance.