INTRODUCTION TO

URBAN STORMWATER MANAGEMENT IN GEORGIA

Prepared for the Federal Emergency Management Agency
Cooperative Agreement EMA-K-0079

CIRCULAR 9

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

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By

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INTRODUCTION

In Georgia, flood damages result from excessive rainfall filling stream and river channels to flood stage and then inundating surrounding land. The hydrologic cycle traces the path of precipitation (Figure 1).

On the average, Georgia receives about 50 inches of rain per year. As described in "Average Annual Rainfall and Runoff in Georgia, 1941 - 70" (Carter, 1983), the average annual runoff for the State is about 15 inches. Runoff values are generally highest in the extreme northeastern portion of the State and lowest in the southern Coastal Plain.

Urbanization increases the amount of runoff contributed to channels and quickens the travel time. Forests and grasslands once able to accommodate floodwaters in natural depressions or lakes are removed and replaced by parking lots or other impervious ground cover. In general, storm drainage systems are designed to accommodate only the lower frequency floods and cannot handle the larger, more severe events. As a result, homes and businesses not in an identifiable floodplain can be damaged by runoff generated by upstream development.

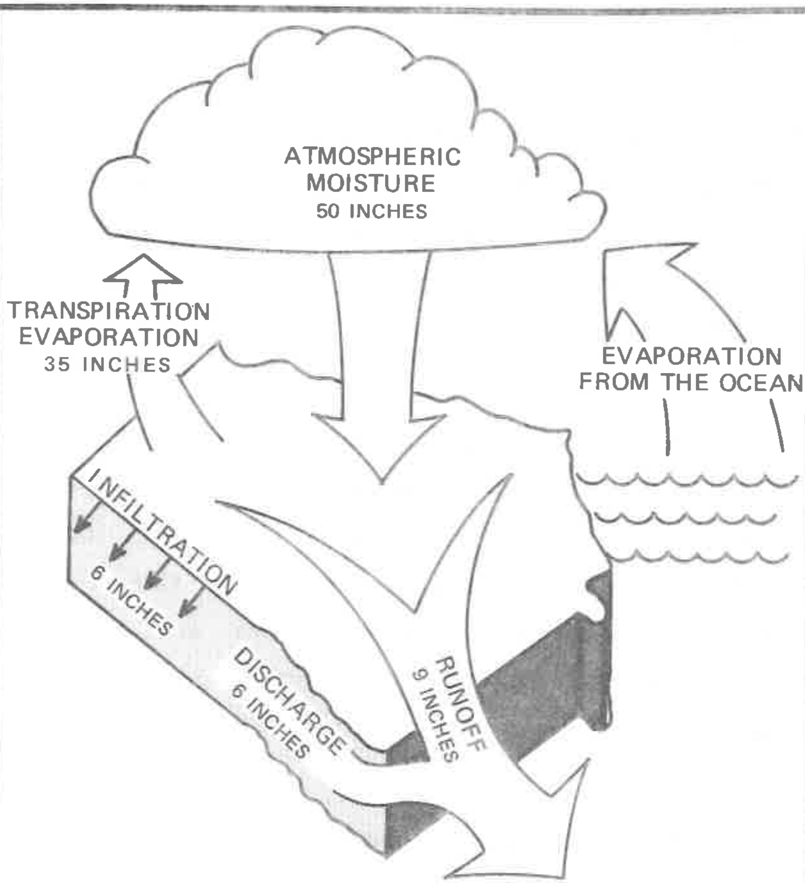

Figure 1. The annual water cycle in Georgia.

This information pamphlet is designed to identify the nature of stormwater damages and offer potential strategies for reducing these losses. The following are questions commonly asked about stormwater management.

QUESTION 1:

WHAT IS URBAN STORMWATER MANAGEMENT? HOW DOES IT RELATE TO FLOODPLAIN MANAGEMENT?

Urban stormwater management and floodplain management both deal with the control and management of areas prone to flooding. The two are distinguished by the size of the areas affected by flooding, the problems which generate the flooding condition, and the methods used to reduce damages.

Urban stormwater damages occur as a result of uncontrolled development and inadequate drainage systems. The basin margins are usually contained within the community, giving the local government jurisdiction to control the problem with preventive or corrective measures such as open space storage or retention reservoirs.

By contrast, floodplain management is appropriate when overbank flooding occurs, particularly in a large watershed affecting several municipalities. Thus, one community does not have the power to control the problem. A further distinction is that floodplain management is generally required by federal regulation, whereas stormwater management is a local option.

QUESTION 2:

WHAT EFFECT DOES URBANIZATION HAVE ON THE VOLUME AND FLOW OF STORMWATER RUNOFF?

In a nonurbanized area, a great deal of the stormwater can be handled by infiltration or by storage in lakes or natural depressions. In an area that has undergone urbanization, however, the percentage of land in its natural state decreases as impervious surfaces (streets, parking lots, etc.) increase, causing larger volumes of stormwater runoff. The process of progressive urbanization has the following effects:

(1) Urbanization causes higher flood peaks due to increased velocities of flow leaving roofs, gutters and lined channels or conduits, as opposed to natural surfaces or channels.

(2) Urbanization causes a decrease in the amount of time from the beginning of continuous rainfall to peak flow. This means that the stormwater flow reaches its peak much quicker than under natural conditions.

These effects are depicted in a runoff hydrograph in Figure 2. In addition, the figure shows the possible reduction in both volume and peak flow with storage or impoundment.

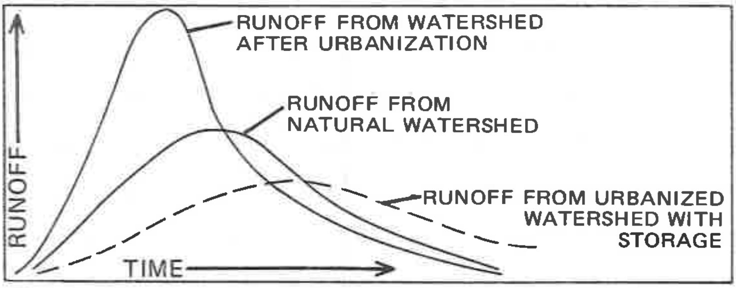

Figure 2. Effect of urbanization and storage on a runoff hydrograph.

QUESTION 3:

WHY AREN'T MOST EXISTING URBAN DRAINAGE SYSTEMS FULLY EFFECTIVE?

To understand why many existing methods of handling drainage are not fully efficient, consider how they are designed to operate. The three major types of urban drainage systems are:

(1) Sanitary Sewer Systems, which collect domestic and industrial wastewater and transport it to a sewage treatment facility through closed conduits.

(2) Storm Drainage Networks, which collect surface runoff and unpolluted water from industrial and commercial sources and discharge it directly into watercourses.

(3) Combined systems, which consist of one drainage network for both sanitary sewage and stormwater. These major systems are augmented by minor systems such as drainpipes, roadway gutters and roof leader connections.

All of these systems were designed, built and installed to offer the maximum level of convenience during the less intense storms. In most cases, little consideration was given to excess accumulation during the larger storms, producing runoff in excess of the capacity of the drainage system. When this occurs, flooding and property damage result. Figure 3 illustrates the effect of progressive stages of urbanization on evapotranspiration, runoff and infiltration.

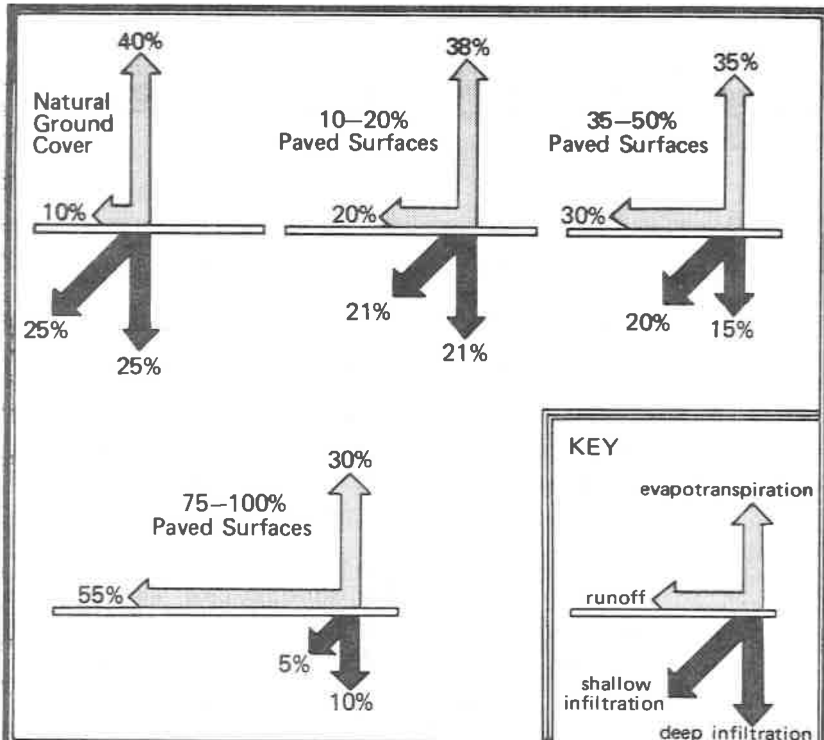

Figure 3. Schematic illustrating how infiltration rates vary with different amounts of paved surfaces.

QUESTION 4:

WHAT ARE THE MOST SERIOUS PROBLEMS RESULTING FROM THE LACK OF PROPER URBAN STORMWATER MANAGEMENT?

As far as most people are concerned, flooding is always a serious issue. The damage, loss of property and the task of cleanup are monumental problems. Flooding as a result of inappropriate urban stormwater management is particularly serious due to the likelihood of exposure to pollutants, increased sedimentation and quicker stormwater peak. Figure 4 shows the drainage pattern of stormwater flooding through city streets.

The presence of pollutants carried in stormwater has recently become a concern of engineers, community officials and the public. Stormwater runoff may carry such pollutants as pesticides, fertilizers, animal refuse and automobile waste. Municipalities which employ a combined system (one for both sanitary and stormwater) face a special problem. Combined sewers are designed to route wastewater directly into watercourses when the network capacity is exceeded. This could include the discharge of raw sewage into flood waters.

Another serious problem to be considered is the question of legal responsibility. As described by Shaeffer and Wright (Urban Storm Drainage Management, 1982) the following general guidelines appear to apply:

(1) Liability for Negligence- if a storm drainage network is installed and then is not properly maintained, the community may be liable if damages result. [City of Vicksburg v. Porterfield, 164 Miss., 581, 145 So. 355 (1933)].

(2) Strict Liability (no negligence)- in certain cases, drainage works designed to accelerate flow in channels can result in liability [City of Houston v. Wall, 207 S.W. 2d 664, Tex Civ. App. 1947].

(3) General Violation of Surface Water Rules-communities have been found liable under the following general rules:

a. Civil Law Rule: liability was found for collecting drain water and casting it upon another's land in unnatural volumes [Dayley v. City of Burley, 524 P. 2d 1073, 96 Idaho 101 (1974)].

b. Common Enemy Rule: by not providing a sufficient outlet for collected stormwater, the court held that the city had no right to discharge collected water in greater volume or velocity than would naturally occur [Oklahoma City v. Bethel, 175 Okla. 193, 51 P. 2d 313 (1935)].

c. Reasonable Use: liability was found where a city had not increased the size of a drainage outlet from an enlarged drainage ditch, when this would have been the reasonable thing to do [Chudzinsky v. City of Sylvania, 372 N.E.2d 611, 53 Ohio App. 2d 151 (1976)].

Under common law, there is no obligation on the community's part to provide for drainage and flood control facilities [Oklahoma City v. Evans, 173 Okla. 586, 50 p 2d 234 (1935)]. Having provided such facilities either voluntarily or by statutory mandate, however, public entities are treated much like private parties when their facilities cause damage (Shaeffer and Wright, 1982).

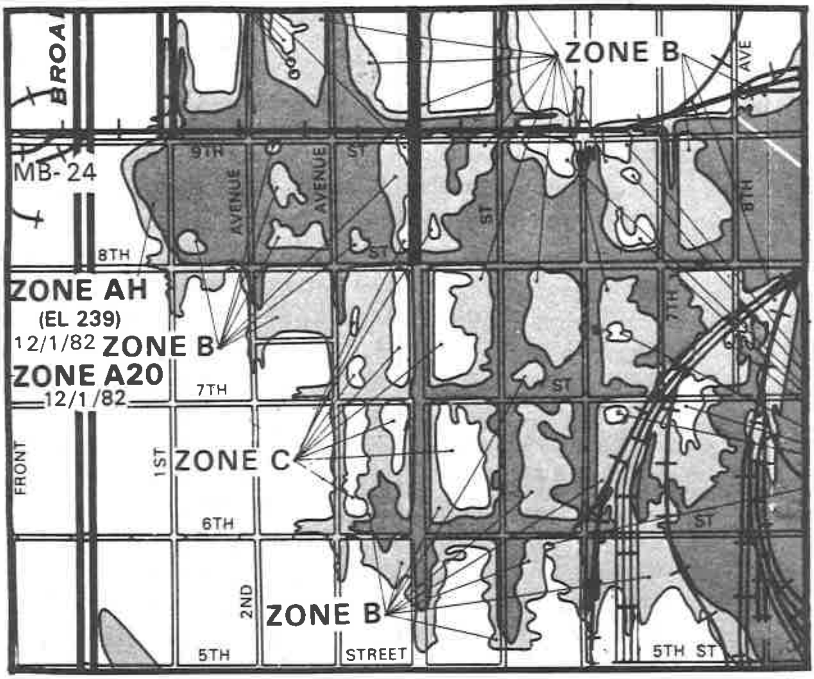

Figure 4. Flood map of Georgia community showing stormwater flooding along city streets.

QUESTION 5:

WHAT ARE SOME COMMON STRATEGIES OF URBAN STORMWATER MANAGEMENT?

The main concept in dealing with urban runoff is the realization that the problem is one of space allocation. There will always be a fixed volume of water produced by a specific frequency rainfall event. Urban runoff management devises measures to deal with the timing of storage and release of precipitation. The measures discussed on the following pages are intended to illustrate concepts of dealing with the problems, rather than to present detailed engineering criteria. The two basic approaches are natural and man-made storage:

(1) Natural Storage- development should preserve as much of the natural ground contours as possible. During site preparation, it is desirable to retain as much top soil as feasible to be used in areas to be revegetated. A significant amount of rainfall will infiltrate into the ground where there is topsoil with sufficient organic matter. In the development area, designs should include grassed waterways or swales and open spaces such as lawns and parks. Vegetative cover plays an important role in runoff control. In addition to increasing the infiltration rate of soil, vegetation absorbs the energy of falling rain and provides friction control by slowing the velocity of runoff (Minnesota Dept. of Natural Resources, 1981).

(2) Man-Made Storage- construction of storage facilities can be considered as a possible alternative for reducing and delaying runoff. These measures can provide multiple uses, such as sediment control and recreational benefits. Man-made storage can be located at a variety of points throughout the basin, depending on the type and severity of the problem. Possible locations are:

   (a) Upstream Storage- its purpose is to store runoff which originates upstream of the area to be protected.

   (b) Within Area Storage- this typically is provided at a development site to account for increased localized development.

   (c) Downstream Storage- its purpose is to provide acceptable outlets for discharge from the storm sewer system.

A useful concept in designing an efficient stormwater system is the dual purpose major/minor system. Such a system uses two sets of facilities: The "minor" system is designed for frequent storm events and the "major" system handles the overflow from the minor system in more severe storms. The major system usually consists of roads and open channels for drainage and may cause temporary inconvenience. The system should include plans for protecting basements when the minor system capacity is exceeded (Weatherbe, 1979). Very few systems could accommodate extreme events such as occurred in Thomaston, Ga. in 1982. An estimated 5 inches of rain fell in a little over one hour. Figure 5 shows the resulting damage.

Figure 5- Urban Flooding, April 15, 1982-
Thomaston, Ga. Photo courtesy, The Home Journal, Thomaston.

QUESTION 6:

WHAT STORAGE CONCEPTS AND METHODS CAN BE USED?

The following are brief examples of storage techniques that can be used for a residential, commercial or industrial site, as taken from Urban Storm Drainage Management (Sheaffer and Wright, 1982.) The list is not inclusive; thus, local initiatives in planning, design and implementation of storage methods should be encouraged. Some methods are:

(1) Driveway Storage- Driveways can be constructed so that runoff from the lot and/or roof is routed to a depressed section. The design of the outlet system will regulate the discharge into the drainage system.

(2) Cistern/Covered Pond- Runoff from the lot can be routed to a tank of adequate volume with emergency overflow. Depending on the subsurface material, the water can be infiltrated after the storm subsides.

(3) Parking Lot Storage- Grading of parking lots for storage is one of the most effective means of reducing runoff. Outlets could be either grated storm outlets or cuts in surrounding berms to regulate design flow.

(4) Open Space Storage- Recreation areas, such as soccer or football fields, create little runoff of their own, but provide excellent storage potential. Using parks as storage areas reduces the total system cost by combining capital and maintenance requirements into multi-purpose facilities.

(5) Retention Reservoirs- These pools function to store runoff from a flood event and not to discharge it during the event. A permanent conservation pool can be designed into the facility and utilized for recreation.

(6) Detention Reservoirs- These operate by reducing peak outflow to less than peak inflow. The total volume is the same, but it is simply distributed over a longer duration. The area is normally dry and thus may conflict with recreational uses when storage is needed.

(7) Slow-Flow Drainage Patterns- Usually implemented in residential areas, drainage plans can be devised which reduce water velocity and allow for temporary storage. As an alternative to curbs and gutters, grassed depressions with a subsurface drain can limit the effects of urbanization. Storage may be augmented by providing controls (weirs, checks, etc.) to create, in effect, a series of linear reservoirs.

QUESTION 7:

HOW LARGE A STORM SHOULD THE SYSTEM BE ABLE TO HANDLE?

It would be ideal to design a system to accommodate all storm events. This, however, is neither practical nor warranted. As presented in an Illinois Stormwater Management Handbook (see reference 7), the following are common design standards:

1) storm sewers- 10- to 25-year discharge.
2) detention/ retention facilities - 25- to 100-year discharge.

The appropriate design standard would depend on the purpose of the facility. Drainage control built for convenience rather than for protection of lives and property may be designed to a less stringent standard.

QUESTION 8:

HOW CAN SOLUTIONS TO DRAINAGE PROBLEMS BE FINANCED?

While not an inclusive list, the following may offer some funding possibilities.

(1) Contribution of land and/or funds by developers: Two methods of payment are possible: one method is to require a permanent maintenance deposit with the sum being invested and the interest used to pay maintenance costs; a second method is to finance with an initial sum to be used for a given period (i.e. 15 years) after which the costs are absorbed by the general municipality budget.

(2) Drainage fees: Property owners whose runoff drains into city storm sewers and drainage facilities would be considered customers of the storm sewer utility, just as charges would be made for city water facilities. Flat rates can be charged for different types of residential properties and commercial establishments would be charged a higher rate. An option may be given for calculating the actual runoff to more accurately determine the appropriate fee.

(3) Credit for on-site detention: Since the amount of runoff would be lessened, the drainage fee would be reduced.

(4) Surcharge: Extra fees should be charged to developed properties in flood hazard areas because of the extraordinary public costs involved in protection of properties and providing emergency services.

QUESTION 9:

HOW ARE THESE STRATEGIES BEST IMPLEMENTED?

Most often, the largest step taken to solve a problem is to recognize that it exists. Public awareness is a key ingredient in improving the quality of urban stormwater facilities. Citizens can identify small scale problem areas and, with greater local involvement, their willingness to support funding alternatives may be higher. The problem must be recognized as a cooperative interaction between citizens and local groups. Remedial measures may be taken as an intermediate solution to problems with existing urban drainage systems. When installing new systems, it makes sense to use the most cost-effective system rather than the system with the least cost.

GLOSSARY

Base Flood- the flood having a one percent chance of being equalled or exceeded in any given year.

Civil Law Rule- holds that the upper landowner has drainage easement over lower properties.

Common Enemy Rule- holds that both upper and lower property owners can protect themselves from surface waters, as long as there is no negligence.

Detention Storage- a permanent structure for the temporary storage of runoff which is designed so as not to create a permanent pool of water.

Development- any man-made changes to improved or unimproved real estate, including but not limited to building, mining, dredging, filling, grading, paving, excavation or drilling operations.

Drainage Basin- the land area from which surface runoff drains into a stream system.

Flood or Flooding- a general and temporary condition of partial or complete inundation of normally dry land from the overflow of inland or tidal waters and the unusual rapid accumulation of surface waters from any source.

Floodplain Management- the operation of an overall program of corrective and preventive measures for reducing flood damages, including but not limited to emergency preparedness plans, flood control works, and floodplain management regulations.

Freeboard- a factor of safety usually expressed in feet above a flood level for floodplain management purposes.

Infiltration- the passage or movement of water into soil.

Off-site Stormwater Management- the design and construction of a facility necessary to control stormwater runoff from more than one development.

On-site Stormwater Management- the design and construction of a facility necessary to control stormwater within an immediate development.

Retention Storage- a permanent structure that provides for the storage of runoff by means of a permanent pool of water.

Runoff- the amount of water flowing in a stream. It includes overland flow, return flow, interflow and baseflow.

Reasonable Use Rule- based on the general principle that one must use his property in a manner that does not injure the property of another. It recognizes the right of each owner to deal with his property as he wishes, but he must act reasonably in all circumstances.

Stormwater Management- a system of vegetative, structural and other measures that control the increased volume and rate of surface runoff caused by man-made changes to the land and eliminate pollutants that might be carried by surface runoff.

Watershed- the total drainage area contributing to runoff to a single point.

REFERENCES

1. Carter, Robert F., Average Annual Rainfall and Runoff in Georgia, 1941 - 70, Georgia Geologic Survey Hydrologic Atlas 9, 1983.

2. Federal Emergency Management Agency, National Flood Insurance Program Regulations, 44 CFR 31177, section 59, subpart A- general, May 31, 1979, 5 p.

3. Fetter, C.W., Jr., Applied Hydrogeology, Charles F. Merrill Co., Columbus, Oh., 1980, 488 p.

4. Minnesota Depart. of Natural Resources, Urban Stormwater Management: Information Brochure No. 4, St. Paul, Minn., 1981, 11 p.

5. Shaeffer, John R., and Wright, Kenneth R., Urban Storm Drainage Management, Marcel Dekker, New York, N.Y., 1982, 271 p.

6. Singer, P., Basics of Hydrology in Urban Areas, Sewer and Watermain Design Course: Municipal Engineers Assoc., Toronto, Can., 1979, 50 p.

7. Southwestern Illinois Metropolitan and Regional Planning Commission, Stormwater Management; Local Assistance Series 4A, Chicago, Ill., 1982, 39 p.

8. State of Maryland, Stormwater Management Guidance, Maryland Legal Register, Vol. 10, Issue 10, May 13, 1983.

REFERENCES (Cont'd)

9. Tourbier, J.T., and Westmacott, R., Water Resources Protection Technology: A Handbook of Measures to Protect Water Resources in Land Development, Urban Land Institute, Washington, D.C., 1982.

10. Weatherbe, D.G., Introduction to Stormwater Management, Sewer and Watermain Design Course: Municipal Engineers Asso., Toronto, Can., 1979, 33 p.

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