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Chapter 8

DESIGN OF DRAINAGE CONVEYANCES

I. INTRODUCTION

A typical urban drainage system has two separate and distinct components, the major and the minor systems. Storm sewers, a part of the minor system, often have been the only **planned** portion of these drainage works. When their capacity is exceeded, the excess often flows overland, causing damage and losses. The purpose of the major drainage system is to accommodate the runoff that exceeds the capacity of the minor system.

The storm drainage system uses the energy available from the difference between its upstream and downstream elevations, or the energy added by pumps. The total available energy normally is used to maintain proper flow velocities, including sufficient velocities to insure a self-cleansing system, with minimum head loss. The design of storm drainage systems therefore involves the balancing of hydraulic losses, which must be kept within the limits of available energy, with the need for adequate energy to maintain self-cleansing velocities. The wider the variations in the rates of flow, the more difficult it is to meet both requirements (ASCE 1969).

This chapter focuses on the design of conveyance facilities common to the major and minor systems, including storm sewers, streets, open channels, culverts, and bridges. Details on their hydraulic design are presented in Chapter 6, and one should be completely familiar with that Chapter (and with Chapter 5, Hydrology and Introduction to Water Quality) before proceeding with any design. All of the facilities described closely interrelate, and major and minor system planning and design should be conducted concurrently.

The designer should treat the design effort as an iterative process involving the developer, regulators, planners and landscape architects, the general project civil engineer, and others (National Association of

Homebuilders 1991; Urban Land Institute 1975). All of these individuals have much to contribute, and optimum drainage solutions usually are those generated by various parties with different points of view (Spirn 1984; American Society of Civil Engineers 1985).

II. FREQUENCY OF DESIGN RUNOFF

Historically, storm drainage systems were designed solely for the rapid removal of stormwater, and hydrological considerations were largely restricted to sizing conduits (American Society of Civil Engineers 1985). The performance criterion was how effectively the land had been drained. It is common now, however, to require that these systems meet several regulatory criteria, including containment of flows and their pollutant burdens. The designer therefore is faced not only with the problem of assuring that flooding will be minimized, but also that the system will meet established limits on the discharge of pollutants.

The selection of a frequency of design runoff, commonly (and erroneously) called the "design storm," to satisfy the various regulatory criteria must be carefully done. As noted in Chapter 5, it can be easily shown (McPherson 1978; WPCF 1989) that, for a given rainfall event, the return frequencies of peak runoff flow, flow volume and the pollutants associated with that flow will probably be different from each other, as well as different from the return frequency of the rainfall itself.

The normal level of protection expected from the **minor system** ranges from once in two years to once in ten years (used in most cities in North America). Typical return frequencies were presented in Table 5.1. It must be recognized that site-specific conditions can justify deviations from Table 5.1, and "blind" acceptance of these values is not appropriate. As noted in Chapter 1, there has not been, over the years, any adequate rationale developed for the selection of any particular design return frequency for either the minor or the major system.

The return frequency of design runoff used for the **major system** typically ranges from 25- to 100-years, and should be selected based on an evaluation of the specific project under consideration and any local or regulatory requirements. Once the overall design return frequency has been set, the system should be examined for points where deviation may be justified or necessary. If this analysis reveals serious problems with the existing major system, then remedial measures should be considered (Denver Urban Drainage and Flood Control District 1984), such as over-designing the minor system to compensate for deficiencies that may exist in the major system. The marginal economic benefits to be obtained should be calculated, if possible, to provide information for the economic (political) decisions that inevitably follow.