CITY OF WEST MEMPHIS

STORMWATER MANAGEMENT

MANUAL

CITY OF WEST MEMPHIS
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TABLE OF CONTENTS

CITY OF WEST MEMPHIS
STORMWATER MANAGEMENT POLICIES

INTRODUCTION

The topography of West Memphis is typical of most delta communities located in the lower Mississippi River alluvial valley. Because there is little fall to the land, drainage must receive special attention. West Memphis has made a major commitment to achieve good drainage by providing a flood pumping station that can move up to 400,000 gallons of water per minute over the Levee to the River. During a five year period beginning in 1987, the community spent $10 million to reduce existing flooding and drainage problems and to provide the capacity for well managed growth. In the process, this manual was developed. It is recognized that overly restrictive policies can hamper private development, but a lack of stormwater management can result in flooding problems that hamper development even more. It is the objective of this manual to minimize future problems through aggressive stormwater management policies. The City wants to encourage developments, but will not jeopardize the progress made in controlling flooding and drainage problems by waiving the requirements found in this manual. These requirements will be strictly enforced.

Drainage systems must have hydraulic characteristics that accommodate the maximum expected flow of stormwaters for a given watershed, or portion thereof, for the specified duration and intensity of rainfall.

Drainage must be designed to (1) account for both on- and off-site stormwaters, (2) honor natural drainage divides, (3) discharge stormwaters into the natural drainage by tying into the existing system at natural elevations, at non-erosive velocities, and (4) discharging the stormwater into an existing facility of sufficient capacity to receive it.

Drainage structures must be constructed to be maintained at a reasonable cost. To facilitate design, construction, and maintenance, drainage must meet the Design Standards of the City of West Memphis. Determination of the size and capacity of an adequate drainage system shall take into account the planned development in the watershed or affected portions thereof. The design must not adversely affect adjacent properties.

It is the responsibility of the developer or property owner to intercept and acceptably handle the runoff as it flows onto his/her property from the upstream watershed, and conduct it through his property to an adequate outfall at the downstream property line or beyond. The outfall must be sufficient to receive the proposed runoff without deterioration of the downstream system due to erosion or flooding. Adequate temporary drainage must be maintained where ponding or excessive erosion damage will occur during construction prior to completion of the permanent storm drainage system.

SUMMARY OF DESIGN REQUIREMENTS

1. The Ten Year Storm is the design frequency, see Section III.B.b. for the frequency-intensity-duration relationship.

2. No open, unprotected, earthen ditches are allowed.

3. Post development peak run-off rates must not exceed pre-development peak runoff rates.

4. All underground drainage systems that will be turned over the City for maintenance must be constructed from Reinforced Concrete Pipe (RCP) a minimum of 18 inches in diameter (except for street crossing culverts which may be a minimum of 15 inches). Cross drains under City streets and for at least one foot beyond the Right-Of-Way must have rubber gasket connections. Private systems can use material of the owner's choice.

5. A Grading Plan showing existing and proposed elevations, ridge lines, drainage areas, erosion control, and all improvements, including diameters, slopes, lengths, flowline and weir elevations, and design and actual capacity of said improvements, is required for all developments.

   In subdivisions, run-off should be directed towards the street Run-off cannot be directed to the back of the lots and use of backyard collection systems are not allowed without specific permission of the City Engineer. This includes swales, ditches, inlets, and culverts.

   Commercial and industrial run-off must be picked-up by an internal drainage system. Run-off is not allowed to flow out into the street or uncontrolled onto neighboring property.

TABLE OF CONTENTS

SECTION I

GENERAL POLICIES

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GENERAL POLICIES

A. POLICY ON STREET DRAINAGE

The minimum design storm frequency is the Ten Year Storm as defined in Section Ill, DESIGN CRITERIA, and all structures shall also be protected from the One Hundred Year Storm. It is the developer's responsibility to determine if a higher frequency is needed to fully protect the improvements for their intended use during a more rare vent.

Although it is not practical to eliminate travel lane flooding, the level of service provided by street drainage must allow the centermost 6.5 feet of all streets to be free of ponded run-off for the Ten Year Storm. The only exception shall be Arterial Streets which must have the centermost 15 feet open and free from ponded run-off for the Ten Year Storm. Procedures for performing gutter flow calculations are given in SECTION III.I.1.b.

There shall be no significant gutter spread on bridges or overpasses.

Swales or water tables will not be permitted across street intersections.

Gutter flow must be able to overflow or "break over" to a nearby inlet before topping the curb or encroaching on the centermost lanes as described above. Inlets shall not be located within the corner radius. Inlet location and spacing shall be based on inlet capacity and width of gutter spread calculations as presented in SECTION III.I.1.b. If the Design Engineer wishes to forego general gutter spread calculations on residential streets, he may do so by spacing inlets so that the maximum flow into any inlet does not exceed 5.1 cfs. The City Engineer reserves the right to require gutter spread calculations on specific inlets at his discretion.

B. POLICY ON PIPES AND CHANNELS

SECTION Ill, DESIGN CRITERIA, gives the methods for computing the runoff from drainage basins. The minimum allowable design return period is the Ten (10) year frequency.

All underground drainage systems that will be turned over to the City for maintenance must be constructed from Reinforced Concrete Pipe (RCP) a minimum of 18 inches in diameter (except for street crossing culverts which may 15 inches). Cross drains under City streets and for at least one foot beyond the Right-Of-Way must have rubber gasket connections. Private systems can use material of the owner's choice.

The minimum allowable velocity in concrete channels will be 2.5 feet/sec.

The maximum allowable velocity in concrete channels will be 12.5 feet/sec.

C. POLICY ON ON-SITE DRAINAGE IMPROVEMENTS

1. The post development peak flow rate of water from all sources leaving a subdivision or other developed areas shall not exceed the pre-development peak flow rate unless approved by the City Engineer. This applies both to subdivisions and to commercial and industrial developments. Under certain conditions, and at the sole discretion of the City Engineer, off-site improvements may be allowed to compensate for increased post-development run-off peak rates. See section E. below.

2. The stormwater drainage solution for each subdivision shall be consistent with limits as determined by the City Engineer and/or in conformance with an approved comprehensive watershed- plan. The overall stormwater management system for the City of West Memphis, of which each subdivision becomes an integral part, is predicated on each development accommodating water from upstream while mitigating the impact of outflow on downstream areas and preventing ponding on upstream areas.

3. The developer shall construct, at his expense, all channels, pipe systems, structures, and storage basins with sufficient hydraulic capacity to control stormwater runoff and emergent groundwater originating within and upstream of the development. Drainage improvements shall also incorporate appropriate building site and lot grading, and erosion and insect control.

   a. The size and quantity of "As-Built" drainage facilities shall substantially conform to the drainage plan approved for the development. The required drainage facilities include all underground pipe, inlets, catch basins, manholes, detention and detention ponds, open-channels, porous pipe, french drains, and surface slopes.

   b. All open-channel drainage improvements shall be constructed with a steel reinforced, concrete channel liner. A six foot high chain link fence shall be installed along the top of the structure to prevent direct access into the channel.

4. All drainage structures and other improvements such as widening, deepening, relocating, clearing, protecting or otherwise improving stream beds and other water courses on- or off-site must be constructed to eliminate breeding areas for mosquitoes and other insect pests. Of particular note are dry detention ponds. Due to the flat terrain, dry detention ponds in West Memphis rarely function as dry basins and provisions must be made to prevent swampy conditions from developing in the bottom of the basin. Unless the developer can show that sufficient grade exists to completely drain such detention ponds, French drains, concrete trickle ditches, or other effective internal drainage conveyances must be provided.

5. In subdivisions, the developer shall provide each builder with a detailed, coordinated grading plan showing proper drainage of all lots and building sites. Lot and site grading by individual builders shall conform to the coordinated grading plan furnished by the subdivision developer. All lots and building sites within the subdivision shall be graded to provide positive drainage away from all principal use buildings, and all accessory use buildings covering two-hundred (200) square feet or more of the lot or site. A minimum of 0.5 percent slope (or steeper, if required by lending agency) shall be required to provide positive drainage of the yards to adjacent streets, or to an adequate drainage system. Unless an established drainage system already exists, backyard drainage, with or without easements, will not usually be permitted. Deviations from this requirement may be allowed for unusual topographic conditions only with prior approval of the City Engineer. See Appendix B for a copy of Ordinance 1383, SECTION 2 that also deals with grading plans. If a conflict is perceived between this section and Ordinance 1383, then the more strict interpretation will apply.

6. There shall be no uncontrolled surface water discharge from commercial and industrial developments into streets, roads or adjoining properties. Each commercial or industrial development shall provide an internal drainage system for collection of on-site stormwater runoff in order to convey the controlled runoff to the City's drainage system. All design and construction shall be in accordance with an approved drainage plan.

D. POLICY ON DETENTION OF STORM WATERS

The City does not require detention ponds, it only requires that post-development peak run-off rates not exceed pre-development peak run-off rates. It is up to the developer to determine the most efficient and economical way to accomplish this, with final design subject to City review and approval. Use of storage in parking lots, in underground reservoirs or pipes, or surface containment by earthen berms are possible alternatives to detain run-off.

In most cases the City will not assume maintenance responsibility for a detention facility. It will be up to the owner to maintain the facility and failure to do so will cause the City's Code Enforcement Department to take the necessary steps to have the owner correct the situation.

The City may consider accepting a wet-bottom detention pond as part of a park. To qualify as a park, the site must have a sufficient amount of usable acreage for park activities, i.e. playground equipment, picnic benches, pavilions, etc. The developer shall submit a Park Plan to the Planning and Development Office and the Park Commission for review, and approval must be obtained in advance from both of these City agencies before the City Engineer's Office will accept such a stormwater detention pond. In return for City acceptance of future maintenance of the pond, the developer must, at his own expense, provide and install all required park equipment as well as an aeration fountain(s) in the pond. The pond must contain a minimum of three feet of water and must also have level controls that will allow it to be completely drained for maintenance access and it must also contain a French Drain or concrete trickle ditch which will function to control seepage when it has been emptied for maintenance. Unless soil studies are submitted to support a steeper slope, detention pond banks, for City maintenance, must not be steeper than 3.5 to 1. Under no conditions will they be accepted steeper than 3 to 1.

E. POLICY ON OFF-SITE DRAINAGE IMPROVEMENTS

In certain cases, the City Engineer may accept off-site improvements in lieu of onsite detention. The improvements can include an off-site detention pond that picks up the development's run-off downstream, or one situated upstream to intercept and store run-off from other developments. Another option could be improvements to a major ditch. Such improvements could include widening the ditch and laying the banks back to a 4 to 1 slope. The improvements would continue along the ditch for such distance as will provide compensating storage. It will be the developer's responsibility to acquire any extra property needed for the improvements, the resulting maintenance easement, any wetlands or discharge permits needed, and any for any vehicular crossings or connecting drainage systems.

The location of off-site detention ponds must be approved not only by the City Engineer, but also by the Planning and Development Office and by the Drainage District. Such sites must be consistent with approved land use policies. The developer is responsible for acquiring any property needed. Unless the site is accepted as a park as outlined in Section D above or is a widened ditch, the developer will be responsible for maintaining the facility and may be required to enter into a maintenance contract with the City and/or post a maintenance bond.

F. RIGHT TO APPEAL

Decisions of the City Engineer may be appealed, in writing, by the Applicant or party suffering adverse impacts within ten (10) working days of the date on which the City Engineer rejects the proposed plan. The appeal must be submitted to the Mayor and City Council and will be heard at their next regularly scheduled meeting.

TABLE OF CONTENTS

SECTION II

SUBMITTAL REQUIREMENTS FOR CONSTRUCTION APPROVAL

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SUBMITIAL REQUIREMENTS FOR CONSTRUCTION APPROVAL

A. TYPES OF PLANS SUBJECT TO APPROVAL

1. Subdivisions
2. Commercial Sites
3. Industrial Sites
4. Parking Lots (10,000 Sq. Ft. or greater and/or as required by City Engineer)
5. Earthfills or excavations
6. Utility Construction near Channels
7. Any new construction, other than a single family residence
8. Any add on or expansion construction, other than a single family residence
9. Any plans that require review and approval by the Design Review Committee (DRC) and/or the Planning Commission

B. GRADING, DRAINAGE & EROSION CONTROL PLANS

The grading, drainage, and erosion control plans shall be of quality suitable for reproduction and shall include, as a minimum, the following information:

1. A complete plan of the propose development at a minimum scale of 1"=100'. This plan is to include existing and proposed contours at 1' intervals with a benchmark referenced and described. NGVD elevations are to be used exclusively. Contours must extend 100' offsite or to the centerline of all roads surrounding the site. Location Map and Drainage Basin Map shall be included. Drainage Basin Map identifies the Basin(s) that the improvements are in, see Appendix A for the comprehensive Basin Map.
2. Hydrologic and hydraulic calculations for design conditions as outlined in the following sections of this manual including:

I. Design calculations and plans for Drainage System including:

a. Drainage areas (acres) entering and leaving the site. Individual drainage areas within the site are to be delineated and the direction of runoff indicated by flow arrows and slopes.

b. Proposed and existing drainage structures, including inlets and outlet details, catch basins, junction boxes, culverts, cross drains, headwalls, with profiles, size, lengths, type, slope, and invert elevations, top of grate elevations in addition to flowline, and percent grades of all pipes and corresponding capacity.

c. Available capacity of existing piping system (if tying into one).

d. Inlet spacing calculations (see SECTION III.I.1.b.).

II. Design calculations and plans for Detention system, if required, including:

a. Stationing
b. Profile
c. Cross Section
d. Outlet Details
e. Hydrographs and Routing Information
f. Emergency overflow details

III. Design calculations and plans for Off-site Improvements, if required.

3. Plans and calculations must be dated, stamped, and signed by an engineer registered in the State of Arkansas. Calculations must include engineer's and firm's name, phone number, and address.

4. Easement and right-of-way requirements for all drainage systems, detention basins, and off-site improvements.

5. Proposed and existing impervious surface areas, proposed and existing buildings on the site, property lines, easements, and right-of-ways.

6. Proposed curbs and material type.

7. Where special structures (such as headwalls, impact basins, trashracks, etc), manholes, box culverts, or junction boxes are used, detailed plans showing dimensions, reinforcement, spacing, sections and other required data must be provided. As appropriate, structures must have fully developed inverts to the springline and must be constructed of the following materials:

1. Poured in place, reinforced concrete.

2. Masonry brick with poured in place reinforced concrete base and top. Both the inside and outside shall be plastered with mortar.

3. Concrete block filled with concrete with poured in place reinforced concrete base and top. Both the inside and outside shall be plastered with mortar.

8. Grading Plan. The minimum slope for positive drainage for yards shall be 0.5%, or steeper as required by lending agency. See SECTION I.C.5 & 6 grading policies.

9. All fill areas shall be indicated, with the limits and elevations shown on plan.

10. Maintenance Agreements, if required.

11. Temporary erosion and sediment controls measures to be used during construction (straw bales, silt fences, etc.).

12. An assessment of the impact of a One Hundred Year Storm, including a map outlining said Storm's associated flooded water surface area.

13. Omission of any of the above requirements for detailed plans and calculations shall render the application incomplete, and it will be returned to the engineer.

C. STREET PLANS AND PROFILE SHEETS

See the City of West Memphis Street Ordinance for street plans and profile requirements. The following additional information must be included:

1. The existing ground shall be profiled at the centerline and Right-Of-Way left and right on 50 foot stationing and at grade break points.

2. All vertical control points pertaining to proposed centerline profile (PVC,PVI,PVT), all low points and street intersections with stations and elevations.

3. All grades in percent with associated vertical curve data and street cross sections.

4. Centerline finished grade elevations every 25', to the nearest hundredth of a foot, shall be shown tabulated along the bottom of the profile sheet.

TABLE OF CONTENTS

SECTION III

DESIGN CRITERIA

SECTION Ill

DESIGN CRITERIA

A. DETERMINATION OF DESIGN DISCHARGE

In order to properly determine the design storm runoff for a given drainage area, consideration must be given to the design storm rainfall, the runoff coefficient as affected by the surface condition, the geometry of the watershed, and the influence of the time of concentration.

The design of a storm drainage system must meet the following five conditions:

a. The system must adequately dispose of surface runoff resulting from the selected design storm. The minimum design storm frequency is the Ten Year Storm as defined in Subsection B.b. of this Section (page III-3). It is the developer's responsibility to determine if a higher frequency (more rare event) is needed to fully protect the improvements for their intended use.

b. Runoff resulting from 100-year storm must be disposed of without flooding any buildings.

c. The storm drainage system must optimize reliability of operation with minimal maintenance and operational requirements.

d. The storm drainage system must be adaptable to future expansion with reasonable additional cost.

e. All designs must consider full development upstream.

The overall drainage system is conceptually divided into two parts, minor systems and major systems. Major systems contain open channels; minor systems do not. The use of the terms 'minor' and 'major' in no way determines the relative importance of either system. The use of the two terms serves only to delineate the difference between techniques for determining the design discharge for the drainage area under consideration.

A minor system is defined as a drainage system consisting of streets, street gutters, inlets, and underground collection systems. When the collection system terminates or extends into an existing earthen ditch or concrete-lined channel, the drainage basin will be classified as a major drainage system.

B. DETERMINATION OF RUNOFF

a. General

The following four methods have been accepted and/or developed for use in the City of West Memphis:

1. The SCS Graphical Peak Discharge Method.

2. The Rational Method (Rational Hydrographs are not allowed, and the Rational method cannot be used for design of Detention basins).

3. The Soil Conservation Service (SCS) dimensionless unit hydrograph as reported in the SCS National Engineering Handbook, Section 4, Hydrology.

4. The USGS Method.

The fourth method involves the empirical equations developed by the USGS and reported in Water Resources Investigations Report 89 4100, "Estimating Flood Hydrographs for Arkansas Streams". This is used in conjunction with WRIR 86-4335, "Magnitude and Frequency of Floods in Arkansas". Note that Crittenden County is in Hydrological Area "A".

The design runoff for minor drainage areas may be designed using Methods one, two, or three. If the drainage basin under consideration is a major system (contains open channels), methods two and four may be used.

TABLE III-1.

Appropriate Drainage Design Method vs. Type of Drainage

Type of Drainage	Drainage Area (acres)	Method
Minor	0 < 200 Acres	Rational Method (exclusive of Detention design), SCS Graphical Peak Discharge Eq., or SCS Dimensionless Unit Hydrograph
Major	20 to 600 Acres	USGC Regression Eq. or SCS Methods
Major	0.5 < 2,000 Acres	SCS Dimensionless Unit Hydrograph

The initial step in the design of a storm drainage network is the establishment of the peak flowrate to be carried. If storage or pumping is involved, the volume and time distribution of flow must be known, but in most cases only the peak has to be determined for a storm with a specified return period (which should be established on a risk basis, taking potential damage into account). The City requires a ten year minimum return period with buildings protected from the one hundred year return period.

Drainage projects almost always involve ungaged basins so that flows must usually be synthesized from rainfall-runoff data. This is usually accomplished by applying a computed time of concentration for the point of interest to a rainfall frequency analysis and then converting the resulting rainfall intensity to effective runoff by SCS Methodology or by direct values for peak discharge per acre from reports like WRIR 89-4109 and WRIR 86-4335. The Rational Method may be used only in Minor systems and shall not be used for detention basin design.

Urban drainage consists of two sequentially connected segments. The first is the surface drainage system which conveys the runoff to the inlets, and the second is the collection system itself.

All storms have indefinite durations with varying precipitation and runoff intensity, and as a result, the flow in the drainage system is unsteady. Factors which control the selection of the appropriate design procedure for a project include the size and type of the project, the accuracy required, and the cost and availability of the computational method. Sophisticated methods tend to produce more reliable designs than simple methods, but due to the limited number of pipe sizes available, simple methods usually produce similar designs. As a result, one of the more feasible design methods is to go "top down" from the upper reaches of the drainage basin to the downstream discharge point, and then carefully review all suspected problem areas. If a drainage management plan is proposed for a subdivision or a development, then prior to computation of storm discharge quantities, the engineer must have completed at least a preliminary grading plan and street layout.

b. Rainfall Intensity, Duration, Frequency Relation

Rainfall intensity-duration-frequency (TP-40 from Technical Paper No. 40 published by the U.S. Department of Commerce in May, 1961, reprinted January 1963) for the West Memphis area are presented in Table III-2. The table presents durations at 1 minute intervals from 5 minutes to 60 minutes and then for 2 hour, 3 hour, 6 hour, 12 hour, and 24 hour intervals for return periods of 2, 5, 10, 50, and 100 years. This table shall be used in the design of all storm management facilities.

TABLE III-2.

Rainfall Intensity*-Duration-Frequency for the West Memphis Area

Inches per Hour

TIME	2 Year	5 Year	10 Year	50 Year	100 Year
5 Min.	5.880	6.720	7.320	9.120	9.960
6 Min.	5.674	6.496	7.082	8.833	9.64
7 Min.	5.472	6.277	6.850	8.552	9.338
8 Min.	5.276	6.063	6.624	8.278	9.038
9 Min.	5.084	5.855	6.403	8.012	8.747
10 Min.	4.898	5.652	6.188	7.752	8.463
11 Min.	4.716	5.455	5.979	7.500	8.187
12 Min.	4.540	5.263	5.776	7.254	7.918
13 Min.	4.368	5.077	5.578	7.016	7.658
14 Min.	4.202	4.896	5.386	6.785	7.405
15 Min.	4.040	4.720	5.200	6.560	7.160
16 Min.	3.896	4.563	5.033	6.360	6.942
17 Min.	3.774	4.430	4.893	6.192	6.760
18 Min.	3.669	4.316	4.772	6.047	6.603
19 Min.	3.577	4.215	4.665	5.919	6.465
20 Min.	3.494	4.124	4.569	5.804	6.342
21 Min.	3.419	4.041	4.482	5.700	6.229
22 Min.	3.350	3.965	4.401	5.603	6.124
23 Min.	3.285	3.894	4.326	5.512	6.027
24 Min.	3.225	3.827	4.255	5.427	5.935
25 Min.	3.168	3.763	4.187	5.346	5.848
26 Min.	3.113	3.703	4.123	5.268	5.765
27 Min.	3.061	3.645	4.062	5.194	5.685
28 Min.	3.011	3.590	4.003	5.122	5.607
29 Min.	2.963	3.536	3.945	5.053	5.532
30 Min.	2.916	3.484	3.890	4.985	5.460
31 Min.	2.871	3.433	3.836	4.919	5.389
32 Min.	2.826	3.384	3.783	4.855	5.319
33 Min.	2.783	3.336	3.731	4.792	5.251
34 Min.	2.741	3.288	3.680	4.730	5.185
35 Min.	2.699	3.242	3.631	4.669	5.119
36 Min.	2.658	3.196	3.582	4.609	5.054
37 Min.	2.618	3.151	3.533	4.550	4.991
38 Min.	2.579	3.107	3.486	4.492	4.928
39 Min.	2.540	3.063	3.439	4.434	4.865
40 Min.	2.501	3.020	3.392	4.377	4.804
41 Min.	2.463	2.977	3.347	4.320	4.743
42 Min.	2.425	2.935	3.301	4.264	4.682
43 Min.	2.388	2.893	3.256	4.209	4.622
44 Min.	2.351	2.851	3,211	4.154	4.563
45 Min.	2.314	2.810	3.167	4.099	4.503
46 Min.	2.278	2.769	3.123	4.045	4.445
47 Min.	2.242	2.729	3.079	3.991	4.386
48 Min.	2.206	2.688	3.036	3.937	4.328
49 Min.	2.170	2.648	2.993	3.884	4.270
50 Min.	2.135	2.609	2.950	3.830	4.213
51 Min.	2.100	2.569	2.907	3.777	4.156
52 Min.	2.065	2.530	2.864	3.725	4.099
53 Min.	2.030	2.490	2.822	3.672	4.042
54 Min.	1.995	2.451	2.780	3.620	3.985
55 Min.	1.961	2.412	2.738	3.568	3.929
56 Min.	1.926	2.374	2.696	3.516	3.873
57 Min.	1.892	2.335	2.654	3.464	3.817
58 Min.	1.858	2.297	2.613	3.413	3.761
59 Min.	1.824	2.258	2.571	3.361	3.706
60 Min.	1.790	2.220	2.530	3.310	3.650
2 Hrs.	1.050	1.320	1.500	1.910	2.120
3 Hrs.	0.780	0.980	1.130	1.420	1.570
6 Hrs.	0.480	0.590	0.680	0.860	0.950
12 Hrs.	0.280	0.350	0.400	0.510	0.560
24 Hrs.	0.167	0.200	0.240	0.300	0.330

*The conversion of inches per hour to depth for a given time period is d = i*t; i.e., the depth of rainfall for a return period for the time of concentration or period under study; i.e., T = 50 years, t = 24 hours; hence, i = 0.30 inches/hour; therefore, d = 0.30 inches x 24 hours = 7.20 inches or for t = 30 minutes, d = 4.985 inches/hours x 30/60 hours = 2.49 inches.

C. DESIGN STORM FREQUENCY

The minimum design storm frequency is the Ten Year Storm. It is the developer's responsibility to consider the particular use of the improvements being made and to use a higher storm frequency, i.e., a 25, 50, 100 year or higher storm, if so warranted. Buildings must be protected from the 100 year event.

D. RUNOFF TIMES

The time-variable is very important in determining both peak discharges and time-varying discharges, i.e., runoff hydrographs. For minor drainage the time-variable will be reflected as time of concentration; for major drainage, the time-variable will be reflected as lag time (Tl), time of concentration (Tc), time to peak (Tp), and duration of computation interval(/\T).

E. TIME OF CONCENTRATION

For minor drainage, the time of concentration, Tc, will be the time variable used in the determination of peak discharges. Tc is defined as the longest time, without unreasonable delay, that will be required for a drop of water to flow from the upper limit of a drainage area to the point of concentration. This is usually taken as the longest typical flow path. The Tc to any point in a storm drainage system is a combination of the time for water to flow over the surface of the ground (Tt - "inlet time", see section F) and the time of flow in the drain (Tf, see section G). The shortest time of concentration required shall be five (5) minutes.

Some cautions to be exercised in the determination the Tc are as follows:

1. The path along which the Tc is determined should be representative of the drainage area as a whole. On some irregularly shaped drainage areas, it is possible to find a Tc along a particular path which is representative of only a small portion of the drainage area. This is not the intent. Use the longest path typical of the entire basin. The proposed use of the property, i.e., subdivisions or parking lots, should be considered when developing longest path of flow.

2. Overland flow shall be considered channelized at such time as the distance traveled exceeds 250 feet.

F. INLET TIME, Tt

The Kinematic Wave Equation (Federal Highway Administration HEC-12) will be used for calculating the travel time for overland flow conditions for a minor drainage system, i.e., subdivision, site developments, etc. The length of overland flow shall be limited to 250 feet.

The Kinematic Wave Equation:

$$Tt = 0.93*[(L^{0.6}*n^{0.6})/(I^{0.4}*S^{0.3})] \qquad \text{(Eq. III-1)}$$

where,

Tt = the overland flow travel time (minutes)

L = the overland flow length (feet)

S = the average slope of overland flow path (Ft/Ft)

n = Manning's roughness coefficient for overland flow

I = Rainfall intensity, (Inches/Hour)

NOTE: Manning's n values listed in Table III-3, next page, were determined specifically for overland flow conditions and are not appropriate for conventional open channel flow calculations!

The use of the kinematic equation entails an iteration procedure:

1. Assume a trial value of rainfall intensity, I.

2. Solve the equation for the travel time.

3. Compare the computed travel time with the corresponding time for the intensity assumed in step 1.

4. If they are not in agreement select a new trial intensity and repeat the process until the actual and assumed rainfall intensities match.

TABLE III-3.

Roughness Coefficients (Manning's n) for Sheet Flow Only

Surface Description	n
Smooth surfaces(concrete, asphalt, gravel, or bare soil)	0.017
Fallow (no residue)	0.050
Cultivated Soils	
Residue cover <= 20%	0.060
Residue cover > 20%	0.170
Grass	
Short grass, prairie	0.150
Dense grass	0.240
Bermuda grass	0.410
Range (natural)	0.130
Woods	
Light underbrush	0.400
Dense underbrush	0.800

G. TIME OF FLOW IN THE DRAIN, Tf

The time of flow in the drain is determined as time of flow in a gutter, pipe, swale, etc. Some instances will occur such that time of flow in the drain will be zero.

Drain flow time, Tf, is the ratio of flow length to flow velocity:

$$Tf = L/(60*V) \qquad \text{(III-2)}$$

Where

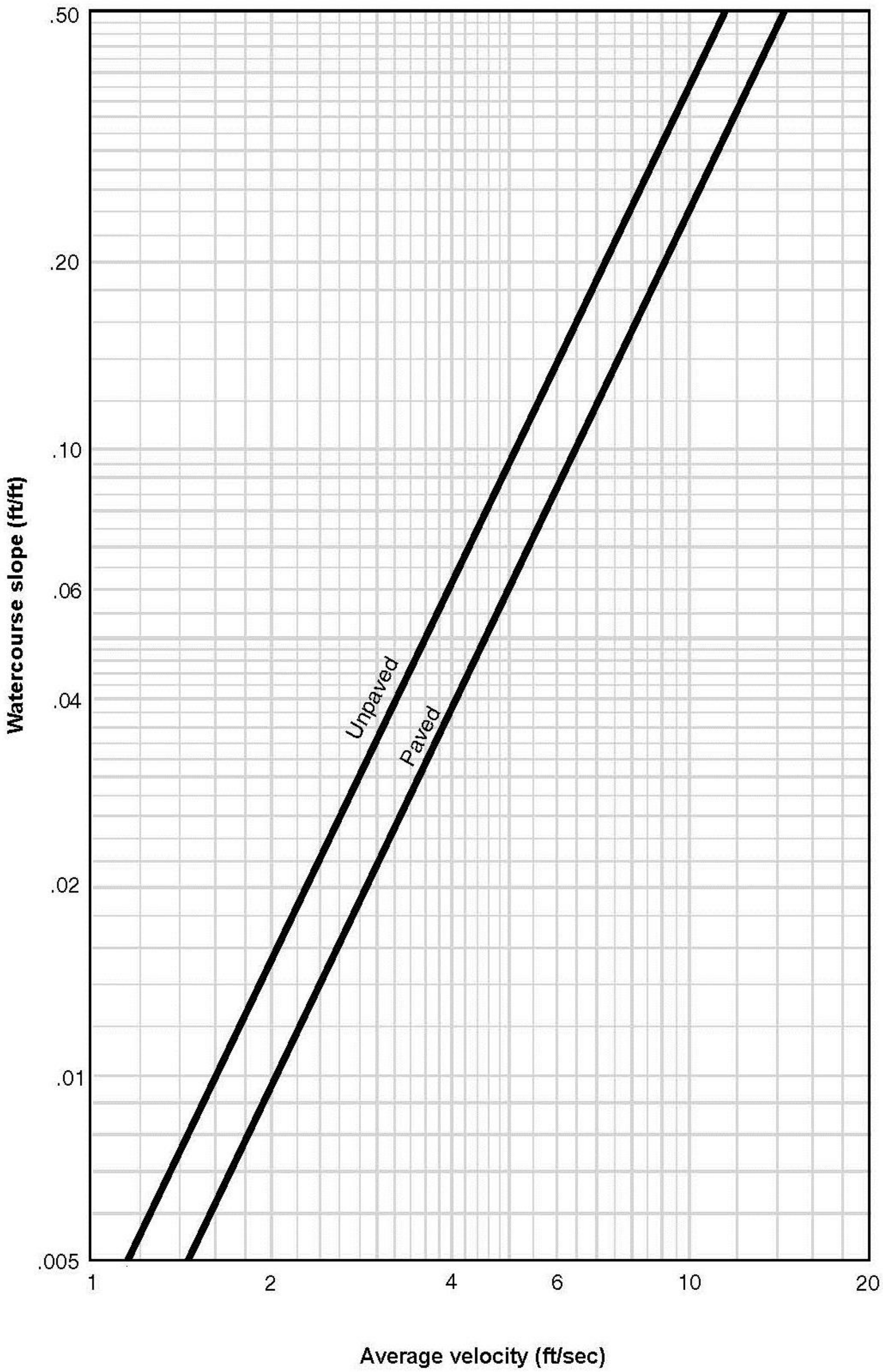
L = length of flow in feet

V = average velocity in feet per second, see Figure III-2, next page.

60 = conversion factor from seconds to minutes

Figure III-2

Estimating Travel Time for Shallow Concentrated Flows



From 210-VI-TR-55, Second Edition, June 1986

Confluence of Peak Flows - At the confluence of two or more collection streams, a procedure for adjusting the total summation of peak flow rates is required in order to account for each stream's time of concentration at the junction. The following procedure provides an estimate of the confluence peak flow rate assuming that the runoff hydrograph is triangular in shape.

Qa,Ta,Ia are respectively, the peak runoff flow rate, time of concentration, and rainfall intensity that correspond to the collection stream with the LONGER time of concentration. Qb,Tb,Ib correspond to the collection stream with the SHORTER time of concentration. Qp and Tp corresponds to the confluence peak Q and time of concentration. The following situations are possible:

1. If the collection streams have the same time of concentration, the Q values are summed directly,

$$Qp = Qa + Qb; \; Tp = Ta + Tb \qquad \text{(Eq. III-3)}$$

2. If the collection streams have different time of concentration, the SMALLER of the tributary Q values may be adjusted as follows:

Case 1- The most frequent case is where the collection stream with- the longer time of concentration has the larger Q. Then the smaller Q value is adjusted by the ratio of rainfall intensities.

$$Qp = Qa + Qb(Ia/Ib); \quad Tp = Ta \qquad \text{(Eq. III-4)}$$

Case 2 - In some cases, the collection stream with the shorter time of concentration has the larger Q. Then the SMALLER Q is adjusted by a ratio of the Tc values.

$$Qp = Qb + Qa(Tb/Ta); \quad Tp + Tb \qquad \text{(Eq. III-5)}$$

For consideration of major drainage, the time variable used to define the peak discharge and/or flood hydrograph is lag time. Lag time is defined as the time in hours from the center of mass of rainfall excess to the center of mass of the resulting runoff. The following lag time equation has been developed by the USGS and reported in WRIR 89-4109. The equation considers the significance of drainage area, channel conditions, and percent imperviousness of the drainage basin. The lag time will be used to determine the computation interval (duration of the unit hydrograph) as defined by equation III-6. If a flood hydrograph is needed, then a 24-hour rainfall will be the required length of rainfall used to develop runoff hydrographs.

H. USGS LAG TIME, LT

LT= 34800(A^1.15)Q100^-1.04 (Eq. III-6)

Where,

LT = lag time, hours

A = drainage area, square miles

Q100 = the discharge, in CFS for the 100 year flood, where the equation for the 100 year flood is given later in this section.

The SCS dimensionless unit hydrograph requires two additional time-variables for definition, namely, Tc, time of concentration and, Tp, lime to peak. Time of concentration, Tc, is as previously defined, but for application to the SCS dimensionless unit hydrograph is mathematically defined as:

Tc= (5/3) LT (Eq. III-7)

where LT is defined by equation III-6.

The time to peak, tp, for the SCS dimensionless unit hydrograph is defined as the time from beginning of rainfall excess to the peak flow rate of the hydrograph. The time to peak, tp, is defined as:

tp = (Tc + /\T) /1. 7 (Eq. III-8)

The computation interval of unit hydrograph, T, is the selected time interval between computations in defining the unit hydrograph. The computation interval, /\T(deltaT, or time increment), is defined by the range of

(L T/5) < /\T < (LT/3) (Eq. III-9)

The SCS Graphical Peak Discharge Method can be used until the watershed area reaches 20 acres. Above that point the peak rate of runoff will be estimated by the SCS dimensionless unit hydrograph method or USGS regression equation until the watershed area reaches 600 acres. For watershed areas above 600 acres, runoff discharge estimates will be made by using the SCS dimensionless unit hydrograph.

I. DESIGN PROCEDURES

1. MINOR DRAINAGE AREAS

a. Determining Peak Discharge - The acceptable technique for determining peak discharge for minor drainage basins will be the Rational Method or the SCS Graphical Peak Discharge Method.

i. Rational Method - In this method, the time of concentration is the time required for the runoff to become established from the most remote part of the area under design. This is time sensitive, it applies to the time from the most remote location, not the distance to the most remote location. The formula used is

$$Q = C*i*A \qquad \text{(Eq. III-10)}$$

Where,

Q = the peak runoff rate in cfs

C = the runoff coefficient (See Table III-4, next page)

i = the average rainfall intensity in in./hr

A = drainage area in acres

The average rainfall intensity, i, is determined by applying the Time of Concentration, Tc, to Figure III-1. Tc is calculated as follows:

Tc= Ti (time of overland flow) + Tg (time of gutter flow)

Tc= 2(.0078[Li/(Si) 0.5)]^.77 + Lg/[2.5 ft per sec(60 sec/min)] (Eq. III-11)

Where,

Li = Length of overland flow, in feet

Si = Slope of overland flow

Lg = Length of gutter flow, in feet

The minimum value for Tc is 5 minutes.

ii. The SCS Graphical Peak Discharge Method is based on the relationship between time of concentration (Tc), ratio of initial abstraction to total rainfall (Ia), and storm type (Type II). The method is expressed by the following equation:

$Qp = qu*A*Q*F$ (Eq. III-12)

Where,

Qp = the discharge at a given point in cubic feet per second.

qu = unit peak flow in cfs/inch.

A = area in square miles that is tributary to the point of design.

Q = runoff depth in inches.

F = surface storage correction factor for swamp areas (dimensionless).
(See Table III-5, next page)

TABLE III-4.

RUNOFF COEFFICIENTS "C" FOR THE RATIONAL METHOD

Type of Development	Runoff Coefficient
Sub-division	
Residential	0.50
Duplex	0.60
Zero Lot Residential	0.65
Apartments	*
Commercial	*
Industrial	*

*Note: Only sub-divisions are allowed to drain runoff into public streets. All other developments must have privately maintained, internal drainage systems as part of their stormwater management plan. Therefore, it is left to the developer to determine the runoff coefficient appropriate for their particular use.

TABLE III-5.

STORAGE CORRECTION FACTOR 'F' FOR SCS GRAPHICAL PEAK DISCHARGE METHOD

Percentage of Pond and Swamp Areas	F
0.0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

a. Gutter and Inlet Design

The City standard is as follows:

For residential streets, the maximum allowable gutter spread is 75% of the lane width. The standard residential street width is 27 feet, with a resulting allowable gutter spread of 9.75 feet (assume each lane is 13 feet wide). The standard cross slope is 2%. Therefore the maximum depth of water at the curb is .2 feet (2% X 9.75 feet). The standard inlet design is a combination curb opening with a 6 by 72 grate in the sag condition. The maximum inlet flow is determined by the equation:

$Q = 16.75(d)1.5$ (Eq. III-13)

where Q is the discharge into the inlet

and d is the depth of the water at the curb in feet

Based on this standard, the maximum flow at the inlet is 5.1 cfs. Inlets should be spaced so that this flow is not exceeded.

If the above standards are used, then the maximum flow of 5.1 cfs per inlet will be accepted as a given and the following sub-sections i through v do not apply (sub-section vi does apply). The engineer must state at the beginning of the calculations that this is the intent. If other inlets or cross slopes are to be used or there is cause to use a higher Q, then detailed calculations must be presented to show that the following standards are met:

i. Permissible Spread of Water, Flow in Gutters

Spread of water refers to the amount of water that is allowed to collect in streets during the design storm. The permissible spread of water in a residential street shall not exceed more than 75% of a traffic lane on each side. For collectors and arterials, the permissible spread of water shall not exceed more than 50% of a traffic lane on each side. Inlets shall be located at street intersections, low points of grade, or where the gutter flow exceeds the permissible spread of water criteria. Inlets shall be recessed behind the curb so that the inlet depression or the inlet grate does not fall within the traffic lane.

ii. Maximum Velocity

Velocity of gutter flow will not exceed 2.5 feet per second.

iii. Gutter Capacity

Use the Modified Manning's Formula to calculate gutter capacity.

Modified Manning's Formula:

Q = 0.56(Z/n)(Sx^5/3)(So^1/2)(d^8/3) (Eq. III-14)

Where,

Q = discharge (cubic feet/second)

Z = 1/Sx (or equivalent)

Sx = cross slope of pavement

n = Manning's coefficient (n = 0.016)

So = longitudinal grade of street

d = depth of water at face of curb (feet)

For unequal gutter and pavement slopes, the equivalent Z for unequal slopes can be calculated using the following equation:

$$Z3 = Z1 [1 + (Z2/Z1 - 1)[(T-W)/(T+W(Z2/Z1-1))]^{8/3}] \quad \text{(Eq. III-15)}$$

where,

Z3 = reciprocal of cross slope of equivalent section

Z1 = reciprocal of cross slope of gutter (16 for 6-30 curb and gutter)

Z2 = reciprocal of cross slope of pavement (64 for 3/16 inch per foot standard straight slope design)

W = width of gutter (feet)

T = top width of water surface (feet)

iv. Inlet Location

With the maximum spread fixed and with a given pavement cross slope and longitudinal slope, the flow in the gutter and street is also fixed and can be calculated as previously explained. The spacing of the inlets on a continuous grade is related to the drainage area needed to generate the discharge corresponding to the allowable spread on the pavement. The flow bypassing each inlet must be included in the flow arriving at the next inlet. Design and space inlets so that no more than 50 percent of the gutter flow reaching each inlet will pass on to the next inlet downstream, provided this carryover is not objectionable to pedestrian or vehicular traffic and the inlet is not in a sump. Inlets shall be placed at all low points in the gutter grade.

Where a curbed roadway crosses a bridge, the gutter flow should be intercepted and not be permitted to flow onto the bridge.

At intersections, inlets shall be placed and sized so that encroachment into the intersection is no greater than that allowed on the street for the design storm.

v. Types of Inlets

A storm water inlet is an opening into a storm sewer system for the entrance of surface runoff. The standard West Memphis inlet design is a combination curb opening with a 6 by 72 grate in the sag condition. This will be accepted without further design calculations. If other inlet configurations are used, then design calculations demonstrating their capacity adequacy must be submitted.

vi. General Guidance

At the intersection of streets, the curb and gutter gradient around the radius is to be 0.5 percent or greater. If the flow is to split in the radius, the elevation of the high point of the curb and gutter must be shown on plans.

For drainage pipes located in streets, a minimum cover of two (2) feet is required between top of curb elevation and outside top of the drainage pipe so as to ensure that the drainage pipe is deep enough in the roadbed so as not to damage the pipe and to ensure proper hydraulic head is provided in the inlet box. Drainage inlets are not acceptable in the comer radius of curb and gutter at intersections. Inlets will be required on both sides of the street when the street gradient within 150 feet of the intersection is 5 percent or greater (to prevent intersection water overrun).

2. MAJOR DRAINAGE AREAS

Discharge calculations for the design of stormwater management facilities in major drainage areas shall be done by an appropriate unit hydrograph method. Method 1 consists of appropriate utilization of the USGS Regression Equations, while method 2 is the SCS dimensionless unit hydrograph technique. If only peak discharges are required for design, then the regional equations as proposed by the USGS may be used within constraints of Table III-6. If a time distribution of the runoff is required, i.e., design of detention basin, then a 24-hour runoff hydrograph developed by the SCS unit hydrograph will be acceptable. If conflicts arise as to the peak discharges determined by various methods, then the peak discharges as determined by the unit hydrograph method will govern. The use of the USGS regression equation shall be limited to drainage areas less than 600 acres.

a. USGS Regression Equations

Table III-6 (next page) gives the regression equation and the standard error of regression to predict peak discharges as a function of frequency for the West Memphis area.

b. Design Runoff Hydrograph

If a time distribution of a certain runoff hydrograph is needed for the design of a stormwater management facility, i.e.; stormwater detention basins, then the unit hydrograph as defined by the SCS unit hydrograph method will be applied. Discharge hydrographs can be developed for individual floods by using the unit hydrograph method and the appropriate rainfall excess. The USGS WRIR 89-4109 presents techniques for computing the lag time (equation III-6) as previously discussed.

TABLE III-6.

Regression Equation & Standard Error for Peak Discharge (USGS WRIR 89-4109)

Equation	Standard Error of Regression, in Percent
Q2 = 107 A^0.83*S^0.28*L^-0.33	30
Q5 = 149 A^0.88*S^0.36*L^-0.40	28
Q10 = 175 A^0.90*S^0.40*L^-0.42	29
Q25 = 205 A^0.92*S^0.45*L^-0.44	33
Q50 = 226 A^0.93*S^0.48*L^-0.45	36
Q100 = 245 A^0.94*S^0.51*L^-046	40

Note that the standard error for some basins may be more than is acceptable, and if so, it precludes the use of the equation in that basin.

Where,

Qx = the estimated discharge, in cubic feet per second for the indicated recurrence interval x

A = the drainage area, in square miles, and

S = the average channel slope, in feet per mile. If S is greater than 30, use 30 for S, and

L = channel length, in miles.

NOTE: These equations are for region "A" in Arkansas only!

c. Unit Hydrograph Procedure

Most engineers deal with runoff in terms of peak flow. In many cases this is adequate, but urbanization and stormwater management can require development of the temporal distribution of runoff volume. This section describes a relatively simple method for synthesizing runoff distribution with respect to time. Emphasis will be on precipitation, abstractions from precipitation, and the runoff process. Evaporation, soil water movement, base flow, and some other features of the hydrologic cycle will not be treated, because they are usually not of primary importance in urban hydrology.

In ungaged drainage basins, the engineer will normally develop the runoff distribution and frequency by assuming that the frequency of the event is identical to that of the rainfall producing it and by using drainage basin parameters which are easily determined from maps and from site visits. Three basic procedures are involved in this process.

1. Develop a precipitation-time-intensity relationship for the return period of interest.

2. Determine abstractions from precipitation and subtract them from precipitation to arrive at the effective rainfall.

3. Convert the effective rainfall distribution to a runoff distribution.

These three procedures can be accomplished through the use of the parameters listed below:

i. Parameters

1. Return period (years) = Tr
2. 24-hour precipitation depth (inches) = P24
3. Time increment (hours)= D or /\T
4. SCS Runoff Curve Number (CN#) = CN
5. Drainage area (acres) = A
6. Channel slope
7. Channel length
8. Q100

The method presented in this section provides a step-by step procedure for developing runoff hydrographs. The SCS Type II method of rainfall distribution is used, while the SCS dimensionless unit hydrograph procedure is used for composite runoff hydrograph. It should be noted that no one method is valid for all situations, and all results must be carefully evaluated before use.

ii. Precipitation

This procedure will consider only precipitation in the form of storm rainfall and will be limited to synthetic patterns as opposed to historic rainfall data from recording rain gauges. The purpose of this is to make the method more suitable for use with programmable calculators or spread sheets available for most microcomputers.

Rainfall depth-duration-frequency data is readily available from U.S. Weather Bureau Technical Paper No. 40, and the procedure described herein will be based on the 24-hour depth of rainfall given in TP-40 for the West Memphis, Arkansas, area. The U.S. Soil Conservation Service has adopted four storm patterns based on the 24 hour rainfall of the required frequency. The Type II curve is applicable to the West Memphis and Crittenden County area.

The rainfall is distributed as a percentage mass curve for the 24-hour period in accordance with the following equations:

From 0 to 11.75 hours:

Px = P24*(0.387 - 0.17 *abs [T - 11.75])^1/3 (Eq. III-18)

From 11.75 to 25 hours:

Px = P24*(0.387 + 0.371 *abs [T- 11.75])^1/5 (Eq. III-19)

These mass curves were designed to give a reasonable match to the depth-duration curve developed from TP-40 for the selected frequency.

iii. Effective Rainfall

Precipitation abstractions are rainfall losses that do not appear as runoff. Therefore, runoff (effective rainfall) is equal to precipitation minus abstractions. Typical abstractions are evaporation, infiltration, interception and surface storage. For most urban situations, only infiltration and surface storage need to be taken into account. The SCS combines infiltration and surface storage to compute effective rainfall by the equation:

Q= ((Px - 0.2*S)^ 2)/(Px+0.8*S) (Eq. III-20)

Where,

Q = accumulated rainfall excess in inches

Px = accumulated precipitation in inches

S = storage parameter given by:

$$S = (1000/CN) - 10 \qquad \text{(Eq. III-21)}$$

Where CN is the SCS Runoff Curve Number identified in Table III-7.

The SCS determines CN values as a function of hydrologic soil group and cover complexes or land use. Table III-7 illustrates CN's as a function of hydrologic soil group and cover complexes. Table III-8 explains the hydrologic significance of soil groups referenced in Table III-7. A soil survey for Crittenden County, Arkansas, is available. However, due to the great amount of construction and development that has taken place in this area, other impervious factors may need to be included in a composite CN factor. When using this chart, keep in mind that external factors such as soil compaction may also cause a shift from one soil group to another less impervious one. The City of West Memphis has adopted 25 percent imperviousness as a minimum. A composite CN will be determined in a manner similar to equation C-2.

The CN of an area is an indicator of its runoff volume for a given amount of rainfall, with pervious areas having a low number and impervious or poorly vegetated areas having a high number. Antecedent Condition II will be used for the West Memphis area.

After the CN has been determined, the rainfall excess equation is used to determine the accumulated rainfall excess as a function of total accumulated precipitation. Because of the squared term in the numerator, Q should be set to zero when Px is less than 0.2S.

TABLE III-7.

Runoff Curve Numbers For Urban Areas
(Page 1 Of 3)

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	**Average percent impervious area**	**A**	**B**	**C**	**D**
Fully developed urban areas ***(vegetation established)***					
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc., (excluding right-of-ways)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-ways)		98	98	98	98
Paved: open ditches (including right-of-ways)		83	89	92	93
Gravel (including right-of-ways)		76	85	89	91
Dirt (including right-of-ways)		72	72	87	89
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1 /8 acre or less (town house)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (previous areas only, no vegetation)		77	68	91	94

TABLE III-7, Continued

Runoff Curve Numbers For Urban Areas
(Page 2 Of 3)

Cover description			**Curve numbers for hydrologic soil group**			
Cover type	**Treatment**	**Hydrologic condition**	**A**	**B**	**C**	**D**
Fallow	Bare Soil	-	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR+ CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C = CR	Poor	69	78	83	87
		Good	64	74	83	87
	C + terraced (C&)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR+ CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T-CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

TABLE III-7, Continued

Runoff Curve Numbers For Urban Areas
(Page 3 Of 3)

Cover description		**Curve numbers for hydrologic soil group**			
Cover type	**Hydrologic condition**	**A**	**B**	**C**	**D**
Pasture, grassland, or range - continuous forage for grazing	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow - continuous grass, protected from grazing and generally mowed for hay	-	30	58	71	78
Brush - brush-weed-grass mixture with brush the major element	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods - grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads - buildings, lanes, driveways and surrounding lots	-	59	74	82	86
Herbaceous - mixture of grass, weeds, and low growing brush with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85

Notes to Table III-7

1) Average runoff conditions and Ia= 0.2*S.

2) The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system. Impervious areas have a CN of 98, and impervious areas are considered equivalent to open space in good hydrologic condition.

CN's for other combinations of conditions may be computed using Figure 2-3 or 2-4.

3) CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4) Composite CN's for natural desert landscaping should be computed using Figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert scrub in poor hydrologic condition.

5) Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

TABLE III-8.

Definition of SCS Hydrologic Groups

SOIL TYPE	DEFINITION
A.	These soils have a high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission. (Low runoff potential).
B.	These soils have a moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep, to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C.	These soils have a slow infiltration rate when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
D.	These soils have a very slow infiltration rate. They are chiefly clay soils with a high swelling potential, soils with a permanent high water table, soils with clay pan at or near the surface, and shallow soils over nearly impervious material (high runoff potential).

iv. Runoff Hydrograph Development

The purpose of the runoff hydrograph is to provide a plot of runoff flow rate against time at the basin outlet. Individual basin characteristics will modify the time distributions of the excess rainfall (hyetograph) to form the plot of the runoff flow rate (hydrograph). The volume of the two curves is identical, but the shape is quite different. The simplified hyetograph in the upper portion of the figure has the same volume as the hydrograph in the lower portion but is plotted on a different scale. The time to peak, tp, of the hydrograph is the elapsed time from the beginning of the segment of effective rainfall to the peak flow rate of the hydrograph. The time to peak, tp, is defined by equation III-8. The duration, D, is equivalent to the computation interval, T, defined by equation III-9.

v. Unit Hydrograph

The unit hydrograph is the hydrograph which would result from a single unit of rainfall excess occurring uniformly over the basin in a specified duration (D). The unitgraph is usually based on a one inch rainfall excess, and it assumes that the unitgraph proportional to the volume of rainfall excess in the period. Unitgraphs for a given duration can be used to develop runoff hydrographs for storms that occur in any multiple of that duration. Usually the duration is chosen such that it is from 20 to 33 percent of the time to peak. This allows adequate resolution with minimum computation.

Time parameters of the unitgraph (D, tp, and LT) are estimated from basin characteristics as follows. The lag equation, equation III-6, is

LT = 3480A^1.15*Q100^-1.042 (Eq. III-6)

Where equation III-8 defines the time to peak, tp,

tp =(Tc + D)/1.7 (Eq. III-8)

and units are as previously defined. The SCS estimates the peak flow rate of the unitgraph by the equation:

QP = (645.3 A//\T) (Eq. III-22)

Where QP is in feet/second and is the maximum difference between ordinates from the SCS dimensionless unit hydrograph.

Equation III-23 gives the value of the peak discharge for the unit hydrograph as:

UP= (484 A)/tp (Eq. III-23)

The peak discharge determined by equation III-23 assumes a unit hydrograph that has 3/8 of its area under the rising limb. There may be a slight difference in the peak discharges as determined by equation III-22 and equation III-23 since the value from equation III-22 requires interpolation of the SCS dimensionless unit hydrograph at multiple values of the computation interval /\T, and the discharge at tp may be slightly missed.

TABLE OF CONTENTS

SECTION IV

DETENTION

SECTION IV

DETENTION

A. GENERAL

1. Approval of Design and Construction

   Any person, firm, or corporation proposing to construct any stormwater detention facility within the city shall apply to the City Engineer for approval of the location, dimensions, design and construction methods, and materials of such facility. The application shall be in writing and shall contain such information including maps, plats, diagrams, design data, detailed drawings, specifications, and calculations as herein required.

   If the City Engineer finds that a proposed stormwater detention facility will conform to accepted standards, the City Engineer shall issue his approval in writing.

   If the City Engineer finds that a proposed stormwater detention facility will not conform to accepted standards, the City Engineer shall issue his notice of disapproval in writing.

2. Purpose

   The overall purpose of urban stormwater detention facilities is to control and utilize runoff in a sound manner such that only minor inconvenience is experienced by the people and property of the areas, both upstream and downstream of the facilities. Stormwater detention is quite effective in preventing nuisance flooding immediately downstream of changes in land use. The effect of temporary storage of runoff on the shape of a hydrograph is pronounced and significant.

   All stormwater detention facilities construction within the City shall be in accordance with the minimum design requirements and specifications as set forth in this chapter.

3. Applicability

   Post-development stormwater run-off must not exceed the pre-development stormwater run-off for the ten year storm. As private developers prepare their stormwater management plans, it will be their analysis that will determine the best way for them to meet the post-development run-off requirement. When they decide that detention is the most efficient way to meet the requirement, then they must meet the provisions of this section.

B. DEFINITIONS

For purposes of this chapter the following definitions of words and terms shall apply:

1. Dam - an artificial barrier or embankment having greater than six feet difference in elevation between the crest of the emergency spillway and the lowest point in the cross section taken along the centerline of the dam and which does or may impound water.

2. Detention Basin - any area or structure which serves as a means of temporarily storing stormwater runoff.

3. Detention Storage - the temporary detaining or storage of stormwater on or beneath the ground surface, on rooftops, parking lots, or by other means under predetermined or controlled conditions.

4. Development - any change in land use, or improvement on any parcel of land that increases stormwater runoff.

5. Discharge - the rate of outflow of water from detention storage.

6. Drainage Area - the geographical area contributing stormwater runoff to a point under consideration; i.e. a watershed, tributary area, or catchment area.

7. Dry Bottom Basin - a detention basin or facility not intended to have a permanent pool.

8. Ten Year Flood - a flood having a ten percent chance of occurrence in any given year. The ten year flood is assumed to be caused by a ten year storm.

9. Ten Year Storm - a rainstorm of a given duration and depth of precipitation having a ten percent change of occurrence in any given year.

10. Freeboard - the difference in elevation between the design water surface in the detention facility and the elevation at which uncontrolled overtopping of the facility begins.

11. Hyetograph - intensity distribution of a rainfall event with respect to time.

12. Hydrograph - flow rate distribution of a storm water runoff with respect to time at the point under consideration, or of detention basin outflow.

13. One Hundred Year Flood - a flood having a one percent change of occurrence in any given year. The one hundred year flood is assumed to be caused by a one hundred year storm.

14. One Hundred Year Storm - a rainstorm of a given duration and depth of precipitation having a one percent change of occurrence in any given year.

15. Project - any development involving the construction, reconstruction, or improvement of structures and/or grounds.

16. Stormwater Runoff - the waters derived from precipitation falling within a drainage area, flowing over the surface of the ground or collected in channels or conduits.

17. Wet Bottom Basin - a detention basin intended to have a permanent pool.

C. MAXIMUM RELEASE RATE

The maximum allowable release rate of stormwater runoff generated on-site shall not exceed the pre-development peak rate of runoff as calculated by the engineer of record for the 10 year storm using the SCS 24 hour Type II distribution or other approved method. All calculations and design shall be performed by an engineer registered in the State of Arkansas.

The City Engineer may make exception to this requirement for the following types of projects:

1. Single family residential projects of size less than three (3) acres;

2. Multi-family projects of less than one (1) acre;

3. Commercial projects of less than 15,000 square feet;

4. Industrial projects of less than 9,000 square feet;

D. DETENTION STORAGE VOLUME

The volume of storage provided in detention basins shall be sufficient to store the stormwater runoff generated by the development during a ten year flood, less the discharge as permitted in other sections of this chapter. Storage volume shall be sufficient to store excess flows resulting from a ten year storm using a Type II SCS 24 hour rainfall distribution or other approved methods.

The rate of discharge from a detention facility and the rate of discharge of stormwater runoff from areas of the development not controlled by the detention facility shall not collectively exceed the maximum allowable release rate.

E. PROJECT SITE INFORMATION

Detention basin storage type, capacity required and release rates are to be determined by the Design Engineer. To assist in the review of the proposed system the following project information shall be provided to the City Engineer by the Design Engineer:

1. A topographic map of the project site and immediately adjacent areas, of suitable scale and contour interval, which shall define the location of streams, extent of floodplains and calculated high water elevations, and shorelines of lakes and ponds.

2. The size, location, and flowline elevations of all existing sanitary and storm sewers, and the location of any existing sewage treatment facilities which fall within the project limits and within a distance of five hundred feet beyond the boundaries of said project.

3. A proposed grading plan and/or site plan showing existing and proposed contours, buildings, parking lots, platted lots, and other development features.

4. The developer's engineer must receive approval from both the City Planner and the City Engineer on the location, size, shape, or other desired design features of proposed detention basins.

5. Drainage area map showing upstream drainage areas tributary to the development, and to each proposed detention facility along with the location and size of the controlling downstream drainage structure.

6. Special Study to determine effects of development, if required by City Engineer.

F. PLANS, SPECIFICATIONS AND CALCULATIONS

The following plan and design information for detention facilities and appurtenances shall be submitted to the City Engineer for approval prior to construction.

1. Finalized site plan, development plan, and facilities information as furnished pursuant to the previous section;

2. Complete plans for grading, storm sewers, inlets, outflow structures, dams, emergency spillways, and other appurtenances;

3. Slope, type, size, and complete flow calculations for all existing and proposed storm sewers, outlet structures, spillways, and other waterways;

4. The grading plan shall show existing and final contours, and a line defining the high water elevations to be expected during the one hundred year flood. Proposed cross sections and grades of overflow swales shall also be included;

5. Stage-storage curves for proposed detention facilities plotted in units of detention facility water surface elevation (and depth) as ordinates, and cumulative volume of storage as abscissas. Values used to develop the curves shall also be presented in tabular form;

6. Stage-discharge curves for outlet works plotted in units of detention facility water surface elevation (and depth) as ordinates, and discharge rate in cubic feet per second (cfs) as abscissas. Values used to develop the curves shall also be presented in tabular form;

7. Inflow and outflow hydrographs plotted in units of cubic feet per second of inflow and outflow as ordinates, and time from start of storm as abscissas;

8. Inflow and outflow hydrographs, detention pond elevations, and storage in tabular form. The elevation at which the peak discharge occurs should be included.

9. Required Preliminary Studies - When application is made for subdivision or zoning, a conceptual stormwater detention plan shall be provided by the developer. This plan shall show general locations of detention ponds and approximate areas, depths and storage volumes required. Concurrent with the developer's application for rezoning or subdivision to the Office of Planning and Development, the developer shall submit the conceptual stormwater detention plan and the project site information required by the project site information section to the City Engineer.

G. METHODS OF DETENTION AND GENERAL STANDARDS

The following conditions and limitation shall be observed in selection and use of method of detention:

1. General Location - Detention facilities shall be located within the parcel limits of the project under consideration. No detention or ponding will be permitted within City road right-of-ways. Location of detention facilities immediately upstream or downstream of the project will be considered by special request if proper documentation is submitted with reference to practicality, feasibility, and proof and ownership or right-of-use of the area proposed. Conditions for general location of detention facilities are identified in the following sections.

2. Dry Reservoirs - Dry reservoirs shall be designed with proper safety, stability, and ease of maintenance facilities, and shall not exceed eight (8) feet in depth. Whenever possible, side slopes for grass reservoirs shall be one (1) foot vertical for four (4) feet horizontal (4:1). Maximum side slopes for grass reservoirs shall not exceed one (1) foot vertical for three (3) feet horizontal (3: 1). If bottom slope of the grass reservoirs are less than 1.0%, then a paved trickle ditch or enclosed French Drain will be required. In no case shall the limits of maximum ponding elevation (100 year storm) be closer than thirty (30) feet horizontally from any building and less than one (1) foot vertically below the lowest sill or floor elevation. The entire reservoir area shall be seeded, fertilized, mulched, sodded or paved as required prior to final plat approval or issuance of certificate of occupancy. Any area susceptible to, or designed as, overflow by higher design intensity rainfall (100-year frequency) shall be sodded.

3. Open Channels - Major, existing, earthen ditches may be widened and used as either on-site, or off-site, detention areas provided that the limits of the maximum ponding elevation (100 year storm) are not closer than thirty (30) feet horizontally from any building, and less than one (1) foot below the lowest sill or floor elevation of any building. No ponding will be permitted within a City road right-of-way. Bank side slopes shall be one (1) foot vertical for four (4) feet horizontal (4:1). Note: Most major ditches in West Memphis fall under the jurisdiction of a regional drainage district. In addition to meeting the City requirements, approval must be obtained from the appropriate drainage district.

   The Developer is responsible for acquiring any additional property needed and the resulting maintenance easement, any wetland or discharge permits needed, and any cross drains.

   For design of other typical channel sections, the features of safety, stability, and ease of maintenance shall be observed by the Design Engineer.

   The side slopes of ditches widened as detention facilities shall be seeded, fertilized, and mulched. The hydraulic or water surface elevations resulting from channel detention shall not adversely affect adjoining properties.

4. Permanent Lakes - Permanent lakes with fluctuating volume controls may be used as retention areas provided that the limits of maximum ponding elevations (100 year storm) are no closer than thirty (30) feet horizontal from any building and no less than one and a half (1.5) feet below the lowest sill or floor elevation of any residential structure.

   Maximum side slopes for the fluctuating area of permanent lakes shall be as given in 2 above.

   The minimum, permanent, depth of water in the lake shall be three (3) feet. To accommodate silting that will occur, especially during construction, the initial, minimum depth shall be four (4) feet. Any facility that will be turned over to the City must have controls to completely drain the lake.

   Facilities are only accepted by the City when they are a part of a larger park and an agreement for City acceptance must be obtained in advance from the Department of Planning and Development. To qualify as a park, the Department of Planning and Development requires a minimum amount of usable acreage must surround the lake for recreational activities. In return for being released from future maintenance responsibilities, the Developer must install playground equipment, picnic benches, pavilions, and/or other items required by the Parks Department. In addition, the Developer must install an aeration fountain in the pond.

   The pond must also have level controls that will allow it to be completely drained for maintenance access and must have a French Drain or concrete trickle ditch.

   The entire fluctuating area of the permanent reservoir shall be seeded, fertilized and mulched, sodded or paved. Any area susceptible to, or designed as, overflow by higher design intensity rainfall (100-year frequency) shall be sodded. An analysis shall be furnished for any proposed earthen dam construction. Borings of the foundation for the earthen dam will be required. Earthen dam structures shall be designed by a professional engineer registered in the State of Arkansas.

5. Storage - paved parking lots may be designed to provide temporary detention storage of stormwater on a portion of their surfaces. Generally such detention areas shall be in the more remote portions of such parking lots. In areas that will be used for car parking, the depth of storage shall be limited to a maximum depth of 5.0". Where storage is to be deeper than 5.0", such areas shall be precluded from parking use, and shall be located so that access to and from parking areas is not impaired. In areas that will be used for truck parking, the depth of storage shall be limited to a maximum depth of one foot. In no case should the maximum limits of ponding be designed closer than ten (10) feet from a building for the 100 year storm.

The lowest sill or floor elevation for a residential development shall be one and a half (1.5) feet above the 100 year storm ponding elevation.

6. Other Storage - all or a portion of the detention storage may also be provided in underground or surface detention areas including, but not limited to, oversized storm sewers, vaults, tanks, swales, etc.

7. Construction - Standards for construction of inlets, pipes, manholes, paved ditches and other detention basins appurtenances shall be approved by the City Engineer and in accordance with the appropriate section of this manual and the City's construction specifications.

8. Emergency Spillways - emergency spillways shall be sized to carry the one hundred year flood assuming the detention basin is already filled to design storage capacity. Design Engineer shall perform hydrograph routing with the pond at design capacity.

   Freeboard for earthen detention basins shall be a minimum of one foot difference in elevation between the top of the settled embankment at the spillway and the water surface, with the emergency spillway flowing at design depth.

9. Appearance - The use of detention facilities for purposes other than the temporary storage of runoff is encouraged. Whenever possible the designer should incorporate detention basins in parking lots, playgrounds, ponds, or common areas to enhance the esthetic appearance of a facility.

   Pipes, drainage structures, outlet works, or other necessary structural features of detention ponds shall be devised so as to be minimum in number and inconspicuous.

10. Access - Provisions shall be made to permit access and use of auxiliary equipment to facilitate emptying, cleaning, maintenance, or for emergency purposes.

11. Control Structures - Detention facilities shall be provided with obvious and effective control structures. Plan view and sections of the structure with adequate details shall be included in plans, along with design calculations.

    The design discharge (Q) for the low-flow pipe shall not exceed the allowed maximum release rate.

The maximum discharge shall be designed to take place under total anticipated design-head conditions.

Sizing of the low-flow pipe shall be by inlet control or hydraulic control or hydraulic gradient requirements.

Low-flow pipes shall not be smaller than fifteen (15) inches in diameter minimize maintenance and operating problems except in parking lot where minimum size of openings shall be designed specifically for each condition. A barscreen on a minimum 2:1 slope to reduce blockage by debris is suggested on the low flow-pipe.

Detention basin outflows shall discharge directly into the downstream drainage system.

Storm sewers shall not discharge into earthen dry bottom detention basins except for the purposes of providing detention storage. Lower flows shall be carried entirely in storm sewer systems or concrete channels in accordance with other provisions of this manual.

H. EASEMENTS

Two types of easements shall be provided in plans for detention facilities.

1. Private Drainage Easements - Private drainage easements will be required on all portions of the detention system which are not incorporated in a public drainage easement. Such areas shall be denoted on the development plat by "Reserved for Storm Water Detention". The facilities located in these private easements shall be the responsibility of the property owner or owners association lo maintain.

2. Public Drainage Easement - In general, all detention facilities will remain as private properties and will not be accepted by the City for maintenance. As noted above, under special cases, the City may accept a detention pond for maintenance if it is a part of a larger park. One exception to this policy will be for detention area that are a part of a major ditch. As described in Section G. 3. Of this chapter, detention may be obtained by widening an existing major ditch. Since such major ditches are a crucial component of the City's overall drainage system, the City will accept widened areas for maintenance. A public drainage easement is required for the entire area that is being widened plus a top of bank strip a minimum of 25 feet in width. In return for being allowed to use the ditch for detention and for being released from future maintenance responsibility, the Developer shall also construct an asphalt pathway along the 25 foot top of bank strip. The pathway shall be 8 to 10 feet wide, a minimum of 2 inches thick, and

shall be constructed on a limestone gravel base at least 4 inches thick. If the pathway is being constructed on poor material such as an expansive clay, a filter fabric must be placed between the gravel and the soil. The cross-section must be approved in advance by the City Engineer and the Developer must provide a 12 month maintenance bond for the pathway. While the intent of the pathway is to provide year-round maintenance access by the City, it may also be used for public recreation, such as walking/jogging pathways.

I. MAINTENANCE

Detention facilities, when mandatory, are to be built in conjunction with storm sewer installation and/or grading. Since these facilities are intended to control increased runoff, they must be partially or fully operational soon after the clearing of the vegetation. Silt and debris connected with early construction shall be removed periodically from the detention area and control structure in order to maintain a close to full storage capacity.

Maintenance of the portion of the detention facilities not located in a public drainage easement is the responsibility of the property owners or association. Maintenance shall consist of but not be limited to the following items:

1. Outlet cleaning.
2. Mowing.
3. Herbicide spraying.
4. Litter control.
5. Removal of sediment from basin and outlet control structure.
6. Repair of drainage structure.

The responsibility of all maintenance of the detention facilities and subdivisions projects shall remain with the developer until the project has been accepted by the City. Upon acceptance of the subdivision by the City, maintenance responsibility shall transfer to the City for all components located in the public drainage easements and to the property owner or owners association for all components of the detention system located in the private easements.

The following note shall be clearly placed on the final plat of any development requiring on-site storm water detention facilities:

The areas denoted by "Reserved for Storm Water Detention" shall not be used as a building site or filled. The storm water detention systems located in these areas, except for those parts located in a public drainage easement, shall be owned and maintained by the property owner and/or owners association. Such maintenance shall be performed so to ensure that the system operates in accordance with the approved plan located in the City Engineer's Office. Such maintenance shall include, but not be limited to: removal of sedimentation, fallen objects, debris and trash; mowing; outlet cleaning; and repair of drainage structures.

J. VARIANCES

Any request for variance from these regulations shall be submitted in writing to the City Engineer.

K. DETENTION BASIN DESIGN

The design of a detention basin involves the following steps:

1. Determine the purpose for which the basin will be used.
2. Determine the existing and proposed inflow hydrograph to the basin for the design storm.
3. Determine the maximum allowable release rate.
4. Compute the volume of storage needed.
5. Determine the depth-storage relationship for the basin.
6. Select the outlet structure(s) compatible with the basin uses and determine the depth-outflow relationship.
7. Determine the routing curve and perform the routing for the basin.

Inflow hydrographs can be developed using the procedure previously discussed in Section A.

The method used to determine the volume of storage at a particular depth is similar to the average end area method used to determine cut and fill quantities. The storage volume at a given depth is always the total volume of storage below that depth.

All of the various outlet structures operate as three basic hydraulic structures: orifices, tubes, and weirs. Weirs can be sharp or broad-crested; some can function as either type depending on the head to which they are subjected. Tubes can be short or long. A single outlet can act as a weir and then as an orifice at various times depending on the head of water to which it is subjected. The basic equation for an orifice is:

$$Q = CA\,(2gH)^{1/2} \qquad \text{(Eq. IV-1)}$$

Where,

- Q = Discharge, cubic feet per second
- C = Coefficient of discharge, dimensionless, usually 0.6
- A = Cross sectional area of orifice, square feet.
- g = Acceleration due to gravity, 32.16 feet/second^2
- H = Head above the center of the orifice, feet.

Tables of values for the coefficient of discharge can be found in King's Handbook of Hydraulics. Experiments on submerged orifices indicate that submergence does not affect the coefficient. The coefficients of discharge for short tubes can also be found in King's.

The general equations for horizontal-crested and V-notch weirs can be found in King's Handbook of Hydraulics. The coefficient of discharge is dependent on the head of the weir, the height of the weir crest above the stream bed, and the degree of submergence. If a weir is partially submerged, the effect is to reduce the discharge. The amount of this reduction can be determined from a set of curves presented in King's Handbook of Hydraulics along with tables of coefficients of discharge for horizontal-crested weirs.

Temporary storage of water in detention basins reduces the peak flow leaving the basin. The amount of reduction is a function of the amount of storage. The procedure for estimating the effects of storage on the outflow hydrograph from a basin is called routing. The most commonly used method is called the Modified Pulse method and is based on a solution of the continuity equation, the depth storage curve and the depth-outflow curve. In a given time interval the difference between inflow and outflow is equal to the change in storage as expressed in the following equation:

$$I - 0 = \frac{ds}{dt} \qquad \text{(Eq. IV-2)}$$

The routing period, dt, must be sufficiently short so that the variation in the hydrograph during the period is approximately linear.

By installing several detention basins in single watershed, the timing of discharges will be changed. This change in timing can result in combining flows downstream from different sub-watersheds. The combined flows can create increased peak flows downstream that would not have occurred without the basins. In a watershed with existing detention basins, the effects of basin location and the timing of flows must be thoroughly analyzed to prevent such an occurrence.