Section 9
Storm Runoff Storage

9.01 General

The introduction of impervious cover and improved runoff conveyance serves in many cases to increase flood peaks quite dramatically over those for existing conditions. When physical, topographic, and economic conditions allow it, channel improvements downstream of the development are often used to prevent increased flooding. When this is not feasible, a widely used practice is runoff detention or retention storage, wherein the storm volume is held back in the watershed and released at an acceptable rate. This section of the manual presents information on storage techniques, including guidance for the design of appropriate storm runoff storage facilities.

9.02 Master Plans

Development in a watershed can have complex and far-reaching consequences on the overall hydrologic regime. For this reason, careful plans for anticipating and meeting the long term flood control and drainage needs of the City of Lewisville have been drawn up on a watershed by watershed basis. Each watershed "master plan" has been formulated to provide the most practical and efficient basin-wide approach to the hydrologic consequences of ongoing or future development, including proper coordination of storm detention facilities and channel improvements. Accordingly, the Office the the City Engineer must be consulted concerning preferred watershed flood control strategies and alternatives.

9.03 Storage Classification

Storage Systems may be classified as either on-line or off-line facilities. They may be designed for either detention or retention of stormwater.

A. Retention Storage

In a retention storage facility, runoff is captured and released only after the storm event is over and the downstream water surface has subsided.

B. Detention Storage

The vast majority of flood control storage is handled by detention facilities. The purpose of detention storage is to hold storm runoff back but release it continuously at an acceptable rate through a flow-limiting outlet structure, thus controlling downstream peak flows.

C. On-Line Storage

An on-line storage facility is one in which the total storm runoff volume passes through the retention or detention facility's outflow structure.

D. Off-Line Storage

An off-line storage design is one in which storm runoff does not begin to flow into the storage facility until the discharge in the channel reaches some critical value above which unacceptable downstream flooding will occur. An off-line facility serves to store only the high flow rate portions of the flood event.

9.04 Design Procedures

The design process for a stormwater. runoff detention facility proceeds generally as described below:

A. Hydrologic Design

1. Inflow Hydrograph

The design inflow Hydrograph for the 100-year storm event must be determined by an appropriate hydrologic methodology. A discussion of the proper procedure for determination of a design inflow Hydrograph can be found in Section 2.0 of this manual.

2. Allowable Release Rate

The maximum allowable release rate from the detention facility must be determined. The outflow structure for a storage facility shall be sized such that the allowable release rate shall be limited to the discharge for existing conditions for the 100-year frequency design storm. The outflow structure capacity shall be determined using the methodologies discussed in Section 8.0 of this manual.

B. Hydraulic Design

1. Preliminary Pond Sizing

A preliminary sizing of the detention facility can be carried out graphically as shown in Figure 9-1. A straight line is drawn from the origin to the maximum allowable outflow on the recession limb of the Hydrograph. The runoff volume depicted between the plotted Hydrograph and the straight line approximates the necessary storage.

2. Preliminary Outflow Structure Sizing

The outflow structure may be sized preliminarily as follows:

a. Determine the maximum allowable water surface elevation in the pond for the 100-year frequency inflow Hydrograph.

b. Estimate the flow line elevation for the outflow structure at the outlet.

c. Estimate the size of the structure required to pass the allowable outflow rate based on headwater elevation at the 100-year water level in the pond and a tailwater elevation at the estimated flow elevation in the outflow channel.

d. Estimate the size of overflow spillway required to pass the extreme storm events.

3. Design Tailwater Depth

In order to route the inflow Hydrograph through the detention facility, a relationship must be established between the volume of storage in the pond and the corresponding amount of discharge through the outflow structure. In cases of outlet-controlled flow, this relationship is directly dependent on the elevation of the tailwater at the outlet of the outflow structure.

For the purpose of establishing an outflow rating curve under outlet-control conditions, the engineer must make a judgement as to what will be the proper tailwater level for use in calculating the storage-discharge relationship.

In general, it should be noted that an unreasonably high choice for the tailwater depth will result in an oversized outflow structure and thus minimize attenuation of the peak outflow, especially for smaller storm events. An unreasonable low choice for the tailwater depth will result in an undersized outlet structure and the risk that the pond will be overtopped during the design storm event. The Office of the City Engineer may be consulted as to preferred policy at the site of interest.

4. Final Sizing of Pond Storage and Outflow Structure

The inflow Hydrograph should then be routed through the trial pond configuration (preferably using the Modified Puls routing option in HEC-1). A comparison can be made between the maximum discharge and the maximum allowable discharge. At this juncture, adjustments can be made in the pond storage and/or outflow structure in order to assure that the maximum discharge is not exceeded. Several routing iterations will probably be required for determination of the optimal storage volume and outflow structure.

Detention or retention facilities shall be sized such that at least one foot of freeboard shall be maintained during the 100-year storm event.

5. Storm Sewer Hydraulic Gradients

The hydraulic gradients in storm sewers shall be determined using procedures outlined in Section 5.0 of this manual. When storm sewers outlet into a detention facility, the starting water surface elevation for these calculations shall be the 100-year maximum pond elevation.

In order to determine the 100-year flood levels in the detention facility, the 100-year inflow Hydrograph is routed through the pond. It is recommended that the 100-year maximum water level in the main channel be used as the constant value of the tailwater elevation for determining the outflow structure rating curve for the 100-year storm.

6. Allowances for Extreme Storm Events

Design consideration must be given to storm events in excess of the 100-year flood. An emergency spillway, overflow structure, or swale must be provided as necessary to effectively handle the extreme storm event. In places where a dam has been utilized to provide detention directly in the channel, due consideration must be given the consequences of a failure, and if a significant hazard exists, the dam must be adequately designed to prevent such hazards.

Detention facilities which measure greater than six feet in height are subject to 31 Texas Administrative Code (TAC) Chapter 299 (Subchapters A through E), which went into effect May 13, 1986, and all subsequent changes. The height of a detention facility or dam is defined as the distance from the lowest point on the crest of the dam (or embankment, excluding spillways, to the lowest elevation on the centerline or downstream toe of the dam (or embankment) including the natural stream channel. Subchapters A through E of Chapter 299 classify dam sizes and hazard potential and specify required failure analyses and spillway design flood criteria. See Appendix A.

7. Erosion Control

The erosional tendencies associated with an open channel are similar to those found in a detention pond. For this reason, the same types of erosion protection are necessary, including proper revegetation and pond surface lining where necessary. Proper protection must especially be provided as pipe outfalls into the facility, pond outlet structures and overflow spillways where excessive turbulence and velocities will cause erosion.

9.05 General Requirements for Detention Pond Construction

The structural design of detention facilities is very similar to the design of open channels. For this reason, all requirements from Section 7.0 pertaining to the design of lined or unlined channels shall also apply to lined or unlined detention facilities.

A. Pilot Channels

Construction of a pilot channel is required to facilitate complete drainage of the detention facility. The pilot channel shall meet the following specifications:

1. Unlined pilot channels shall be two feet deep at a minimum, have a minimum invert slope of 0.001 ft./ft., and have maximum sideslopes of 3:1.
2. Concrete pilot channels shall have a minimum depth of two inches and a minimum invert slope of 0.005 ft./ft.
3. The floor of the detention facility shall be graded toward the pilot channel at a minimum slope of 0.005 ft./ft. and at a recommended slope of 0.0095 ft./ft.

B. Outlet Structure

Significant erosion protection at the outlet structure is required due to extreme headwater conditions and erosive velocities typically present. The following erosion protection measures shall be required at the outlet structure.

1. Pipes, culverts, and conduits shall be carefully constructed with sufficient compaction of the backfill material as recommended in the geotechnical analysis. Generally, compaction density should be the same as the rest of the structure.
2. Reinforced concrete pipe used in the outlet structure shall conform to ASTM C-96 Class III with compression-type rubber gasket joints conforming to ASTM C-443.
3. The use of pressure grouting around the outlet conduit should be considered where soil types or conditions may prevent satisfactory backfill compaction. Pressure grouting should also be used where headwater depths could cause backfill to wash out around the pipe.

9.06 Geotechnical Investigation

1. It is required that a geotechnical investigation at the proposed detention facility site be undertaken to insure proper design. This study shall be submitted to the Office of the City Engineer and should address the following:

   a. Pond sideslope stability.
   b. Suitability of excavated material for use as fill.
   c. Groundwater elevation.
   d. Potential for seepage through the dam and requirements for seepage control.
   e. Dam stability.
   f. Effect on stability of adjacent structures and required control measures.

9.07 Required Analyses

A. The engineer shall be required to submit a summary of the technical calculations used in the design of any stormwater. storage facility. This shall include at a minimum:

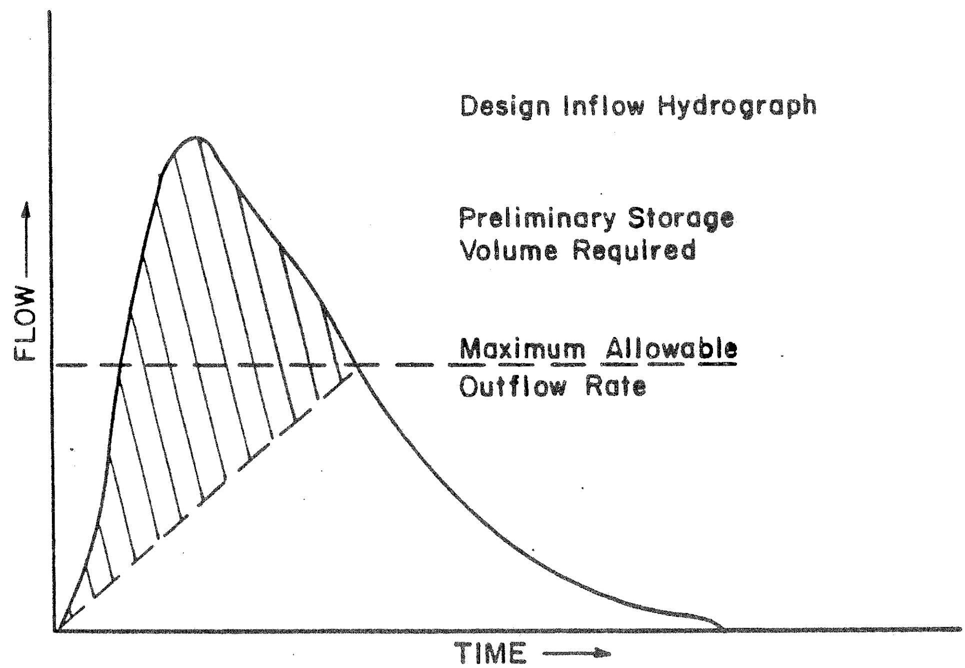
1. Hydrologic calculations for the 100-year existing and future condition flows.

2. A summary table delineating existing discharge, proposed discharge, and post-detention discharge for each storage facility.

3. Routing calculations for the 100-year inflow Hydrograph through the detention facility.

4. Calculations used to determine outflow structure rating curves.

5. Geotechnical Report as delineated in Section 9.06.



PRELIMINARY SIZING OF
STORAGE FACILITY

Figure 9-1

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