

### City of DeSoto, Texas

## Drainage Design and Stormwater Pollution Prevention Manual

2001

(Updated November 2012)



# CITY OF DESOTO DRAINAGE DESIGN AND STORM WATER POLLUTION PREVENTION MANUAL

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# CITY OF DESOTO DRAINAGE DESIGN AND STORM WATER POLLUTION PREVENTION MANUAL

#### 1 INTRODUCTION

#### 1.1 Objectives

The quality of life for the citizens of DeSoto depends in part upon adequate drainage facilities. This Manual establishes criteria, procedures and data for drainage evaluation to ensure the adequacy of new drainage facilities. The intent is to minimize potential negative drainage impacts caused by development.

The use of this Manual will provide a consistent approach to analyzing drainage and constructing drainage improvements within the City of DeSoto. Because many engineering methods for analyzing drainage exist, these criteria for analyzing drainage are established to provide continuity of drainage design throughout the city.

#### 1.2 Manual Development

This Manual has been developed using certain guiding criteria or assumptions. These guidelines will assist the user in utilizing the Manual. The guidelines are as follows:

- 1. The user of this Manual is expected to be a registered professional civil engineer who is skilled in the appropriate disciplines necessary to evaluate drainage problems. Therefore, the terms used and the methods discussed in the Manual should be familiar to the user.
- This Manual does not contain the solution for drainage problems. It establishes
  criteria and procedures to be used in designing drainage facilities in the City of
  DeSoto.
- 3. The criteria required by this Manual are the minimum requirements. More stringent criteria may be required if the City Engineer determines it is necessary in the interest of the City. Such determination will be made on a case-by-case basis.
- 4. The design engineer bears total responsibility for the adequacy of his design. Approval of plans or calculations by the City does not relieve the engineer of this responsibility.
- 5. This Manual is not intended to limit creativity in developing solutions for drainage problems. Evaluation of the applicability of innovative solutions and new products is encouraged. The intent is to encourage use of currently accepted procedures and the most current data and technology.

- 6. This Manual recommends procedures, but does not present the theory on which the procedures are based. The user should be familiar with the published sources that set forth this information.
- 7. Design aids published elsewhere and commonly available may be referenced, but are not reproduced in this Manual.

#### 1.3 Warning and Disclaimer of Liability

The degree of flood protection established in this Manual is considered economically reasonable, and is based on scientific and engineering considerations. However, runoff that exceeds that from the design storm can occur, and flood heights greater than the design height can occur. This Manual does not imply that land outside right-of-ways or easements will be free from flooding or flood damages.

The criteria set forth in this Manual shall not create liability on the part of the City of DeSoto, Texas, or any official, employee or consultant thereof, for any flood damages that result from reliance on this Manual or any administrative decision lawfully made.

#### 2 GENERAL POLICY

#### 2.1 Drainage

The owner or developer of the property to be developed shall be responsible for the design and construction of all storm drainage facilities on and through the subject property. This responsibility includes all existing and proposed on-site drainage, the drainage directed to that property by prior development, and drainage that will result when upstream areas are fully developed. Proposed on-site drainage facilities must be designed to properly discharge the design flows resulting from fully developed watershed conditions.

Provisions shall be made to allow for connection to the on-site storm drainage system from upstream, off-site drainage areas.

The post-construction storm water protection policies provided within this manual establish baseline criteria for the minimization of impacts to water quality. The owner or developer is responsible for mitigating water quality impacts from the development or redevelopment project.

A preliminary planning conference must be initiated by the developer's engineer with the City Engineer prior to the submittal of any development plan in which erosion control, floodplain encroachment, wetlands issues, or natural channel requests are involved to determine the developer's responsibility in the design of these required drainage improvements and/or any required permitting.

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Increases in storm water runoff due to new development must not adversely affect adjoining property or properties downstream as far as a recognized watercourse, as defined below. Runoff from sites larger than one (1) acre must not exceed predevelopment levels. Multi-phase developments will be considered as a single entity in determining the requirement for detention.

In all new developments where storm water runoff has been collected or concentrated, discharge shall be conveyed off-site by creeks, channels or storm sewer systems. Easements shall be provided by the developer to the City for off-site drainage facilities, as well as for on-site facilities. All flows shall be discharged in a non-erosive manner, and shall meet the established regulations governing storm water quality.

The developer shall pay for the cost of all drainage improvements required, including any necessary off-site channels or storm sewers and acquisition of the required easements.

If it is anticipated that additional runoff caused by the development will overload any existing downstream drainage facility, whether natural or improved, and result in hazardous conditions, approval of the improvements for the proposed subdivision may be withheld until appropriate provision has been made to accommodate the problem. If existing capacity is not available downstream and property damage could occur, the owner or developer shall provide a drainage system or detention facility to mitigate the deficiency. In any case, a letter of acknowledgement shall be obtained from the downstream property owner indicating that the downstream property owner is aware of proposed drainage improvements impacting drainage on or to said owner's property.

For the purposes of establishing the responsibility of a developer as discussed in the preceding paragraphs, a recognized watercourse is defined as one of the major streams identified by name in the Storm Drainage Master Plan. These streams are shown on Figure 1 and identified below as:

#### Limits

Stream Name	Downstream	Upstream
Ten Mile Creek	East City Limits	West City Limits
Trib 3A10	Ten Mile Creek	Wintergreen
Trib 3A13	Ten Mile Creek	Danieldale
Trib 3A17	Ten Mile Creek	Danieldale
Trib 3A18	Ten Mile Creek	Danieldale
Trib 3A22	Ten Mile Creek	Bolton Boone
Trib 3A8	Ten Mile Creek	Parkerville Road
Spring Creek	Ten Mile Creek	Parkerville Road
Heath Creek	Ten Mile Creek	700' South of Silver Creek Road
Trib 3A15	Heath Creek	Eagle Drive
Trib 3A21	Heath Creek	Eagle Drive
Bee Branch	Ten Mile Creek	Duncanville Road, Belt Line
Stewart Branch	North City Limit	West City Limit

#### 2.2 Platting/Dedication of Easements for Drainage Facilities

Property developments containing Floodway Easements, Detention Easements, or Drainage Easements shall include on the face of the plat standard language addressing these easements as provided in the Appendix.

Placement of any fill or property development is prohibited in the 100-year floodplain (whether so designated by FEMA or as determined locally) except as allowed in accordance with FEMA regulations and the City of DeSoto ordinances.

Easements for drainage facilities shall be designated as follows:

#### A. Floodway Easements

Floodway Easements are to be used for open streams and channels, both natural and man-made. These easements will be maintained by the property owner or neighborhood association.

#### B. Drainage Easements

Drainage Easements shall be used for man-made storm drain systems and drainage structures. These easements shall be maintained by the property owner.

#### C. Detention Area Easements

Detention basins shall be maintained in Detention Area Easements. Detention basins shall be maintained by the property owner or neighborhood association.

#### D. Access Easement

All Floodway Easements, Detention Area Easements, and Drainage Easements shall include provisions for adequate access for maintenance such as dedicated and maintained Access Easements. These shall be sufficient to provide ingress and egress for maintenance. Access Easements are needed only when the area to be maintained does not border a public right-of-way.

#### 2.3 Drainage Facility Easements

The owner or developer shall provide all necessary drainage facility easements as defined above and as required for drainage structures, including storm drains, channels and streams. Easements shall be required in all upstream and downstream off-site locations where construction of drainage improvements is proposed or required.

Minimum drainage easement widths for storm drain pipe shall be as follows:

Storm Drain Diameter	Min. Easement Width
≤48"	15'
>48"	20'

Storm drains deeper than ten (10) feet as measured from flowline to ground surface shall add an additional two (2) feet easement width for each foot of depth greater than ten (10) feet.

Box culverts shall have a minimum easement width equal to the width of the culvert plus twenty (20) feet.

Drainage easement widths for open channels shall be at least twenty (20) feet wider than the top of the channel that contains the runoff from the design storm, fifteen (15) feet of which shall be on one side to serve as access for maintenance purposes. An easement at least twenty (20) feet wide shall also be provided for the required access ramp(s).

Drainage easements shall extend at least twenty-five (25) feet downstream of the outfall headwall. Drainage easements shall be provided where grading is required to establish positive slope from storm drainage system discharges to natural grade.

Drainage easements shall be dedicated to encompass the limits of the 100-year fully developed floodplain.

Off-site drainage easements shall be included in the record drawings submittal, prior to acceptance of the subdivision. These easements shall be shown on 24" x 36" sheets, to follow the signed and filed plat.

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Drainage easements are required to allow access for maintenance and repairs, and to prevent property owners from making modifications that would compromise the function of the system. However, the property owner is responsible for all necessary maintenance of the easement (excluding structures such as pipes, headwalls, etc.

#### 2.4 City Participation

The City of DeSoto may participate in drainage improvements in accordance with the <u>Subdivision Ordinance</u>. The City of DeSoto may participate in the cost of storm drain pipes larger than 72-inches, but only if the larger pipe is needed to convey runoff from off-site. The developer is responsible for all drainage related costs attributable to his development, even if the new development generates more runoff than a 72-inch pipe can convey. Such participation will be subject to the availability of funds.

#### 2.5 Development in Floodplains

It is the policy of the City of DeSoto to limit development or fill in the 100-year floodplain shown on the Storm Drainage Master Plan, which is based on a fully developed watershed. Development or fill within the limits of this fully developed floodplain will require engineering analysis that shows the development or fill causes no rise in the 100-year water surface elevation. Refer to the current floodplain management ordinance for further details.

#### 3 DRAINAGE DESIGN STANDARDS

#### 3.1 Design Storm Frequency

All drainage facilities shall be designed based on runoff from a 100-year storm event, assuming that the entire contributing drainage area is fully developed. The City of DeSoto Zoning District Map shall be used to identify the anticipated makeup of full development.

#### 3.2 Runoff Calculations

Design flow of storm water runoff is to be calculated using the Rational Method for storm drainage systems serving a drainage area less than two hundred (200) acres. This method will primarily be used for the design of storm drainage systems and small channels. Runoff from drainage areas larger than two hundred (200) acres will be determined using a unit hydrograph method.

#### 3.2.1 Rational Method

The Rational Method is based on the direct relationship between rainfall and runoff, and the method is expressed by the following equation:

#### Q = CIA

where:

Q = the storm flow at a given point in cubic feet per second (cfs)

C = a coefficient of runoff representing the ratio of rainfall to peak runoff. Typical values for C in the City of DeSoto may be found in Table 1 of this Manual.

I = the average intensity of rainfall in inches per hour for a period equal to the time of flow from the uppermost point of the drainage area to the point under consideration. The intensity-duration-frequency curve for use in the City of DeSoto may be found in Figure 2.

A = the area contributing to the point of design, in acres.

The size and shape of the watershed must be determined for each design point. The area of each watershed may be determined through the use of planimetric-topographic maps of the area, and supplemented by field surveys in areas where topographic data has changed or where the contour interval is insufficient to adequately determine the direction of flow. City of DeSoto topographic maps will be used to delineate off-site drainage areas. Drainage areas within the development will be delineated based on field-surveyed topo. The outline of the drainage area contributing to the system being designed and an outline of the sub-drainage area contributing to each inlet point shall be determined and shown on the drainage area map.

Drainage areas shall conform to the natural topography of the watershed contributing to the proposed storm drainage facilities. Where discharge toward off-site adjacent property is relocated, such relocation must be acknowledged by the downstream property owner or any other property owner who will be adversely affected. No diversion of drainage from one watershed to another shall be permitted without the express written approval of the City Engineer.

When calculating the quantity of storm water runoff, rainfall intensity will be determined from the rainfall intensity-duration-frequency curves, shown in the appendix of this Manual, as derived from National Weather Service Technical Memorandum Hydro 35.

Runoff coefficients, as shown in Table 1, shall be the minimum used, based on full development under current City of DeSoto zoning regulations. Larger coefficients may be used if considered appropriate to the project by the City Engineer. For small drainage areas, roadways, land uses other than those listed in Table 1, and miscellaneous land uses like parks, schools, planned developments, etc., where the

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designated runoff coefficient is not representative, a composite runoff coefficient shall be calculated, using 0.30 for pervious areas and 1.00 for impervious areas.

#### 3.2.1.1 Time of Concentration

The time of concentration 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 design point under consideration. The time of concentration to any point in a storm drainage system is a combination of the "inlet time" and the time of flow in the drain. The inlet time is the time for water to flow overland to the first storm drain inlet in the proposed drainage system.

The time attributable to overland flow may be calculated using the graphical method shown on Figure 3.

Shallow concentrated flow can occur on unpaved areas such as yards, parks, or other open space, on paved areas such as parking lots, or in street gutters. These three cases are represented in Figure 4 that can be used to determine the average flow velocity. This velocity can be used with the length of flow to determine the time of flow. The maximum allowable length of shallow concentrated flow is one thousand (1,000) feet. Beyond this distance, the velocity of flow should be calculated for the specific pipe or channel that conveys the flow.

For purposes of calculating inlet capacity, inlet times may be calculated as described above, but in no case shall the inlet time used be greater than the time shown in Table 1. Except in unusual cases, the inlet times shown in Table 1 should be used, as they will be shorter than the inlet time calculated as described above. Inlet locations shall be determined as described below.

#### 3.2.2 Unit Hydrograph Methods

Runoff from drainage areas larger than two hundred (200) acres will be determined using the Snyder Unit Hydrograph method. This method can be implemented by using the Corps of Engineers' HEC-1, HEC-HMS or NUDALLAS computer programs. Other software may be used only with the approval of the City Engineer.

The rainfall duration must be large enough to capture all excess rainfall as well as provide reasonable runoff volumes when performing storage analyses. Rainfall depths for greater than 60 minute durations shall be based on TP-40, and for less than 60 minute durations on HYDRO-35. Computation intervals shall be not greater than 15 minutes.

The effects of urbanization should be reflected in the precipitation loss rates. The Soil

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Conservation Service (SCS) curve number method may be used in this way. Suitable curve numbers for various urban land uses have been published in TR-55.

Routing, when appropriate, shall use the Modified Puls methodology. Reach lengths shorter than the computation interval should not incorporate routing.

#### 3.3 Street and Alley Capacities

Street and alley capacities shall be calculated as open channels using Manning's equation. Figure 5 provides a graphical solution for the capacity of triangular gutters, while Figure 6 may be used to determine the capacity of a gutter in a street with a parabolic crown. Streets must contain runoff from the 100-year storm between the curbs, or where no curbs exist, within the roadside ditches. Alleys shall be capable of conveying runoff from the 100-year storm within the limits of the paved surface. Combination curb and grate inlets shall be placed at those locations where the alley capacity is exceeded by runoff from the 100-year storm.

100-year discharge from alleys and driveways into streets shall not exceed five (5) cfs or the available street capacity, whichever is less.

Special attention is required at turns and intersections of alleys to determine whether super elevation or curbs are necessary to contain the required flow. Super elevation calculations will be required at all turns and bends in alleys where the velocity in the alley exceeds 3 feet per second. The minimum radius for the invert at alley turns (at bends, intersections or tees) will be thirty-five feet (35'). Figure 7 may be used for determination of alley capacity and velocity. Super elevation shall be calculated using the following formula:

 $\Delta y = V^2 W / gr$ 

where:

 $\Delta y = rise$  in water surface between theoretical centerline and outside edge of curve (ft)

V = mean velocity (fps)

W = alley width (ft)

g = acceleration due to gravity (32.2 ft/sec2)

r = radius of centerline curve

Alley turns and intersections shall be graded to provide no less than 0.2' of freeboard above super elevation as calculated above.

See Figure 8 for particular details related to turns in alleys. Note that curbs may be necessary at the outside of some turns in order to direct water around the turn. In such cases, no driveways will be permitted where such curbs are required.

#### 3.4 Valley Gutters

The use of valley gutters to convey storm water across a street intersection is subject to the following criteria:

- A. A major street (thoroughfare) shall not be crossed with a valley gutter.
- B. A collector street shall not be crossed with a valley gutter unless approved by the City Engineer.

#### 3.5 Flow in Gutters and Inlet Locations

Storm drain conduit and inlets shall begin at the point where the depth of flow based on the 100-year storm frequency reaches the height of the top of curb. Inlets are then to be located as necessary to maintain that maximum depth of flow. If, in the judgment of the City Engineer, the flow in the gutter would be excessive under these conditions, consideration should be given to extending the storm sewer to a point where the gutter flow can be intercepted by more reasonable inlet locations. Multiple inlets at a single location are permitted in extenuating circumstances, to a maximum of twenty (20) feet. Where possible, inlets should be placed upstream from an intersection to prevent large amounts of water from running through intersections.

Inlets should also be located on the lower traffic volume street at an intersection and in alleys where necessary to prevent water from entering these intersections in amounts that would cause the allowed street capacity to be exceeded. In the case of parking lots, the preferred practice will be to intercept the water before it enters the street gutter, subject to the limitations of Section 3.3. Inlets shall be placed at intersections such that the beginning of the inlet transition does not fall within the curb return radius.

Recessed curb inlets shall be used only on thoroughfares. Standard (non-recessed) curb inlets shall be used on all other streets.

Where water is conveyed from a street directly into an open channel, it shall be conveyed through an approved type of curb inlet or flume, and not through a curb cut.

Curb inlets and drop inlets can be used to divert runoff to the storm sewer system. Selection of the type of inlet depends on the location and conditions, and is at the discretion of the design engineer, subject to approval by the City Engineer.

Combination inlets (curb and grate) may be used in alleys, but may not be used in streets. The flowline of the alley must transition to direct flow into the inlet. Because of the tendency for clogging, combination inlets at low points shall be designed as curb

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inlets, neglecting any grate inlet capacity. Capacity of grate inlets on grade is a function of the number, size and orientation of the grate openings, in addition to the depth of flow in the gutter. Calculation of the capacity of combination inlets must be based on these factors, and may be as provided by grate inlet manufacturers.

Positive overflow shall be provided at all low points. Positive overflow shall refer to a means for safely conveying excess flow overland when underground storm drainage systems do not function properly or their capacity is exceeded. Such overflow shall be in a public right-of-way or dedicated easement. Calculations may be required to demonstrate the capacity of the overflow provisions. Minimum finish floor elevations adjacent to such overflows shall be no less than 12" above the overland flow water surface elevation.

#### 3.6 Inlet Sizing

Under normal conditions, the minimum curb inlet size shall be four (4) feet. Standard inlet sizes will be in increments of two (2) feet to a maximum of twenty (20) feet. The minimum criteria for the sizing of curb inlets is as follows:

	Length of Inlet Opening
Street Grade	per cfs in Gutter Flow
Sags	0.6 feet
Less than 2%	1.2 feet
2% to 4%	1.5 feet
Greater than 4%	1.8 feet

#### 3.7 Hydraulic Design of Closed Conduits

After completing the computations of the quantity of storm runoff entering each inlet, the size and gradient of pipe required to carry the design storm are to be determined. All hydraulic gradient calculations are required to begin at the outfall of the system. The following is the criteria for the starting elevation of the hydraulic gradient:

- A. The 100-year water surface elevation in a creek, stream, or other open channel is to be calculated for the time of the peak pipe discharge in the same storm and that elevation used for beginning the hydraulic gradient.
- B. When a proposed storm sewer is connected to an existing storm sewer system, the hydraulic gradient for the proposed storm sewer should start at the elevation of the existing storm sewer's hydraulic gradient.

All closed conduits shall be hydraulically designed for full flow through the use of

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Manning's equation (below or from Figure 9):

$$Q = 1.486 AR^{2/3} S_f^{1/2}$$

where:

Q = flow (cfs)

A = cross sectional area of conduit or channel (sq. ft.)

V = velocity of flow in conduit (fps)

n = roughness coefficient of the conduit or channel

R = hydraulic radius, the area of flow divided by the wetted perimeter. (R = A/P)

Sf = friction slope (ft./ft.)
P = wetted perimeter

The hydraulic grade line (HGL) shall be designed to be at least two (2) feet below the top of curb elevation. Where this is not possible, the hydraulic gradient shall be at least  $1.5 \text{ V}^2/2g$  below the gutter line, where V is the velocity in the lateral. Once the HGL is set, the depth and slope of the pipe may be determined. The pipe shall be located so that the inside top of the pipe is at or below the HGL and at or above the minimum slope shown in Table 3. In some situations, generally at the upstream end of a pipe system, the inside top of the pipe may be above the HGL, which results in partial flow. In such cases, the pipe capacity and velocity shall be calculated at normal depth, neglecting minor losses. The HGL shall be shown in the profile on the plans for all storm drain lines, including inlet leads.

Closed drainage system conduit shall be reinforced concrete pipe (RCP), high density polyethylene pipe (HDPE), or reinforced concrete box sections. HDPE pipe will not be permitted within public right-of-way. The minimum slope of a pipe or box section should be capable of producing a velocity of at least 2.5 feet per second when flowing full. Table 3 gives the minimum slopes for storm drain pipes based on this criterion.

From the time storm water first enters the storm drainage system at the upstream inlet until it discharges at the outlet, it will encounter a variety of structures such as inlets, manholes, junctions, bends, and enlargements that will cause minor head losses. In general, these minor losses can be expressed as a function of velocity head. Figure 10 shows the various cases and the method of computing the associated minor head loss. The minimum head loss permitted shall be 0.1'. In other words, "head gains" will not be recognized. The minimum storm sewer pipe diameter shall be 18-inches. Pipe sizes shall not decrease in the downstream direction.

The junction of in-line pipes of different diameters shall be made such that the crowns (inside tops or soffits) are at the same elevation. When lateral pipes connect to trunk mains, they shall be connected with the center of the lateral matching the center of the trunk main.

Where a storm sewer system discharges into a lake, the outside top of the pipe shall be set below the normal pool of the lake. The impact on tailwater from fluctuations in the lake level should be considered in designing the pipe system. Where storm sewers discharge into channels or streams, adequate measures must be taken to control erosion using concrete headwalls, rock riprap, and/or other means as necessary.

Storm drain junction boxes are needed for access to underground storm sewers for inspection and cleanout. Junction boxes should be located at junctions with other storm drain main lines, and at abrupt changes in alignment or grade. For pipes larger than 24-inches, junction boxes or other access points shall be located at intervals not to exceed eight hundred (800) feet. They shall be located at intervals not to exceed four hundred (400) feet for pipes 24-inches in diameter or smaller. Generally, square junction boxes will be required. However, round manholes may be used where no more than two pipes enter or exit the manhole and where neither of the pipes are greater than 24" in diameter.

A junction box with appropriate frame and lid should be provided for the following storm drain sizes. When the storm drain pipe diameter is 24-inches or less, a four (4) foot square junction box (or round manhole as restricted above), should be provided. When the storm drain pipe diameter is greater than 24-inches up to 42-inches, a five (5) foot junction box should be provided. When the storm drain pipe is greater than 42-inches or is a box culvert, a minimum six (6) foot square junction box or a specially designed junction box should be provided.

The invert of the junction box should be rounded to match the inverts of the pipes entering the junction box in order to reduce eddying and resultant head losses. The invert should be rounded to a minimum depth equal to the design flow depth. At junctions with other storm drain main lines, the maximum interior angle of intersection of pipes in the junction box shall be ninety degrees (90°).

Storm sewers will typically be located in the center of the roadway. Storm sewers should be straight between junction boxes where possible. Where curves are necessary to conform to street layout, the radius of curvature should not be less than one hundred (100) feet. Short radius bends at junction boxes should rarely be necessary because pipe alignments usually follow street alignments. The minimum radius of curvature should not be less than the pipe manufacturer's recommendation, which must be provided as documentation. Head losses must be calculated for bends and curves as shown on Fig. 12.

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A headwall shall be constructed at the outfall of any storm drainage system. If the outlet velocity exceeds the maximum permissible velocity for the channel (see Table 4), erosion protection or energy dissipation is required. Erosion protection shall consist of concrete and/or gabion channel improvements, or an apron of grouted rock riprap between the storm sewer headwall and the channel. The apron shall be a length equal to 8 times the diameter of the discharge pipe. The width of the apron shall vary from a width of three times the diameter of the discharge pipe at the discharge point to a width equal to the diameter plus half the length of the apron or the width of the channel, whichever is greater. Other methods may be used to calculate apron dimensions if approved by the City Engineer.

#### 3.8 Open Channels

As shown on the Drainage Master Plan, concrete drainage channels are discouraged in the City of DeSoto. Concrete-lined channels are prohibited on all recognized watercourses, as defined in this Manual.

If the outlet velocity of an improved channel discharging into an existing channel exceeds the maximum permissible velocity for the existing channel, erosion protection is required. This protection shall consist of a channel reach of rock riprap or other energy dissipation measures between the end of the improved channel and the existing channel. The dimensions and median stone diameter of the energy dissipation reach shall be specified as required to protect the channel from erosion.

Freeboard is the height of the improved channel above the designed water surface. Minimum freeboard shall be one (1) foot, and additional freeboard must be provided to accommodate super elevation or other factors causing a rise in the water surface. Super elevation of the water surface must be determined at horizontal curves in order to properly specify freeboard. The minimum radius of curvature shall be not less than three times the top width for improved channels in a sub-critical flow regime, unless detailed calculations indicate a smaller radius can be used without causing excessive velocities, shear stresses, or waves on the outside of the channel.

For waterways included in the Flood Insurance Study (FIS), flood elevations shall be determined by the same methodology as used in the FIS, unless other methods are approved by the City Engineer. Should other methods be approved, such as HEC-RAS, the results of the modeling must be compared with and reconciled with the FIS results. For any computer model used, the techniques specified in the most recent version of the appropriate user's manual should be followed. The hydraulic effects of flood plain encroachments shall be evaluated over a full range of frequencies from the 10-year through 500-year storm event.

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The composite roughness coefficient should account for the sediment and debris that could accumulate in the channel. The roughness coefficients given in this Manual are minimum and should be increased at the discretion of the design engineer to account for expected conditions. If the possibility exists that high bed loads or debris can accumulate in the channel, the 'n' factor should be adjusted or other measures taken to ensure that flow shifts from super-critical to sub-critical will not cause flooding.

All channels shall be designed to operate in sub-critical conditions except at hydraulic jumps, such as at culverts, bridges and drop structures, and shall be designed for stable flow (Froude number less than 0.90). All instances of super-critical flow, or places where flow passes through critical depth, shall be lined to prevent scour and erosion. Channels shall be designed to convey the 100-year storm, assuming fully developed watershed conditions, with one (1) foot of freeboard to the top of channel bank. Maximum allowable channel velocities shall be as shown in Table 4; however, good engineering judgment may indicate that lower velocities are necessary in specific situations. Drop structures, if needed to provide grade control and maintain sub-critical flow, must be constructed of reinforced concrete lining or gabion structures.

The roughness values and maximum velocities given in Table 4 should be used as a guide. Actual conditions may warrant use of alternate values. Any deviation from the values presented in Table 4 shall be approved by the City Engineer before being used for design. Documentation of 'n' values may be required by the City Engineer for conditions not listed in Table 4.

#### 3.9 Roadside Ditches

Roadside ditches, where permitted, shall be designed to convey runoff from a 100-year storm. All roadside ditches shall be protected with sod, back sloping, and/or other bank protection designed and constructed to control erosion. Any earthen slopes shall have proper vegetative cover and shall be no steeper than three horizontal to one vertical (3:1).

#### 3.10 Culverts

A culvert is used to convey surface runoff through roadway embankments. Culverts shall be designed to convey the 100-year storm without overtopping the roadway.

The culvert length shall be chosen to provide minimum three horizontal to one vertical embankment slopes. The culvert flowline shall be aligned with the channel bottom and the skew angle of the stream. The culvert skew shall not exceed forty-five degrees (45°) as measured from a line perpendicular to the roadway centerline without the approval of the City Engineer.

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The allowable headwater is the depth of water that can be ponded at the upstream end of the culvert. The headwater shall be based on the design storm, and shall not increase the flood hazard of adjacent property. A minimum of one (1) foot of freeboard is required between the 100-year headwater, based on fully developed conditions, and either the top of curb or edge of pavement.

Depending on the type of hydraulic operation, a culvert may function either under inlet control or outlet control. Inlet control exists when the barrel capacity exceeds the culvert inlet capacity and the tailwater is not high enough to control culvert operation. Headwater depth and entrance conditions control the culvert capacity. Outlet control exists when the culvert inlet capacity exceeds the barrel capacity, or the tailwater elevation is high enough to create a backwater condition through the culvert. The tailwater elevation and the slope, length and roughness of the culvert determine the culvert capacity. Both types of operation must be considered, and the culvert capacity will be based on the type of operation that yields the higher headwater of the two. Inlet control must not be assumed without the prior approval of the City Engineer.

Nomographs for the solution of inlet and outlet control problems for several types of culverts are included as Figures 11 thru 16. Various computerized solutions are also available, such as HYDRAIN and HY8. The City Engineer may require submittal of documentation on any such program used. If the culvert is being analyzed as part of a stream or waterway, which is being modeled using a water surface profile program such as HEC-2 or HEC-RAS, then the water surface profile model being used may be used to analyze the culvert.

The tailwater shall be determined for the design discharge, based on the hydraulic conditions of the downstream channel. Open channel flow methods should be used for this analysis.

A headwall or wingwalls and apron shall be constructed at both ends of all culverts except driveway culverts. For small culverts (30" in diameter or less), a sloped end section or a sloped headwall may be specified. Current TxDOT specifications shall be used for end treatments. Headwalls are not required for driveway culverts less than or equal to 30" diameter.

If the outlet velocity exceeds the maximum permissible velocity for the channel (see Table 4), the exit velocity may be mitigated with either channel improvements for erosion protection or energy dissipation. Erosion protection may consist of an apron of rock riprap between the storm sewer headwall and the channel. The apron length, width, and median stone diameter shall be specified as required to protect the channel from erosion.

The minimum velocity in the culvert barrel shall be 2.5 feet per second in a 5-year storm. Maximum allowable velocity in the culvert is 15 feet per second in a 100-year storm. However, downstream conditions will generally impose more stringent limits.

The minimum culvert diameter shall be eighteen (18) inches. Culvert material shall be limited to reinforced concrete unless approval is obtained from the City Engineer for alternate materials.

#### 3.11 Bridges

Bridges shall be designed to span the entire stream or channel without restricting flow. To the extent possible, bridges will span streams and channels at a ninety-degree (90°) angle.

Flow hydraulics through the bridge shall be modeled using HEC-2 or HEC-RAS. Bridges shall be designed so that the lowest point of the bridge, the low chord, will be a minimum of two (2) feet above the 100-year water surface elevation, assuming fully developed upstream conditions.

#### 3.12 Detention Facilities

Detention shall be provided such that runoff from all sites equal to or greater than one (1) acre shall not exceed pre-development peak levels. Commercial and industrial sites less than one acre are encouraged to provide detention. In addition, storm water runoff attributable to new development must not exceed the capacity of the downstream drainage system until it reaches a recognized watercourse, as defined in Section 2.1 and depicted on Figure 1. If no downstream drainage system exists, increased storm water runoff must not adversely affect adjoining property. In cases where the proposed runoff would exceed the capacity of downstream facilities, detention will be required.

Permanent impoundments of water shall be constructed in such a way that negative effects on aesthetics, function, flooding, health, and safety are minimized. Such improvements shall be allowed at the discretion of the City Engineer. The Developer shall be responsible for all necessary permitting required by the TCEQ for impounding public water. The City Engineer may require calculations and/or other documentation that no negative impact is created.

All storage facilities serving drainage areas greater than fifty (50) acres shall be designed and analyzed using reservoir routing of an inflow hydrograph. The software program or computational method must be approved by the City Engineer. The analysis should consist of comparing the design flows at a point or points downstream of the proposed storage site with and without storage. Design calculations shall show the effects of the detention facility in each of the 5-, 25-, 50-, and 100-year storm events. This may require

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the use of multi-stage control structures. The detention facility shall be designed to provide the required detention for all of the above-listed frequencies.

Detention storage facilities serving drainage areas smaller than fifty (50) acres may use the Modified Rational Method for storage calculations. Sample calculations using this method are shown in the Appendix. All calculations must be provided to the City Engineer for review and approval.

Detention facility embankments shall be designed to provide a minimum freeboard of one (1) foot above the 100-year storm water elevation. Certain impoundments are subject to State of Texas regulations.

The potential for the impact of sedimentation on the detention facility should be evaluated. A means of access for maintenance of the facility shall be provided.

The outlet control structures for storage facilities typically include a principal outlet and an emergency overflow. The principal outlet functions to restrict the outflow and cause the runoff to use the available storage volume. The principal outlet shall be designed to accommodate the multiple frequency storms listed above while maintaining the minimum freeboard of one (1) foot. The emergency overflow shall be paved and provide positive overflow.

The outlet control structure may be drop inlets, pipes, culverts, weirs, or orifices. Checks should be made to determine if the outlet structure is controlled by weir or orifice flow. The tailwater on the structure could significantly affect its capacity. The engineer should carefully evaluate the tailwater depth. For detention facilities in a series, the lower facility should not cause inundation of the upper outlet control structure. The calculation of the hydraulic capacity for outlet control structures is based on the type of structure used. See a standard hydraulic text.

All Texas Commission on Environmental Quality's (TCEQ) requirements for impoundment and dam safety shall apply. These requirements relate to both the size and the hazard classification of the embankment. Copies of all materials submitted to TCEQ for permitting, along with the TCEQ permits, must be submitted to the City Engineer.

#### 4 STORM WATER QUALITY DESIGN STANDARDS

The City of DeSoto has been issued a storm water discharge permit from the Texas Commission of Environmental Quality (TCEQ) and is required under the Clean Water Act to implement a storm water management program with an overall goal of improving water quality of receiving water bodies and reducing the discharge of pollutants to the

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maximum extent practicable. In compliance with the City's TCEQ storm water permit and in an effort to improve the storm water quality of our local water resources, the City of DeSoto has established the following criteria for land development projects and construction sites. It is the responsibility of the Developer, Owner and Contractor to ensure they are in compliance with the most current state or federal storm water regulations including the Clean Water Act, EPA National Pollutant Discharge Elimination System, and TCEQ Texas Pollutant Discharge Elimination System.

#### 4.1 Land Development Post-Construction Runoff Controls

Post-construction runoff controls shall be used to minimize increases in storm water runoff rates and volumes, soil and stream channel erosion, sediment transport and the discharge of pollutants to the City's municipal separate storm sewer system. The City of DeSoto has adopted these standards for the purpose of protecting local water resources from degradation and to protect the general health, safety and welfare of the public residing in affected watersheds.

All new development and re-development projects, one acre or larger, or less than one acre if part of a larger common plan of development or sale, shall implement Best Management Practices (BMP's) to minimize water quality impacts from development after construction is complete (post-construction). Examples of various long-term post-construction BMPs are provided below.

- Floodplain and channel buffers
- Storm water treatment ponds and wetlands
- Grassed swales and channels
- Detention and retention facilities
- Energy dissipators and velocity control structures
- Infiltration trenches
- Rain gardens
- Green roofs
- Open spaces
- Native landscaping and
- Porous parking surfaces
- Storm water re-use and rainwater harvesting
- Tree preservation and tree planting
- Storm water treatment systems

It is the responsibility of the design engineer to verify the adequacy of the post-construction BMP for mitigating the runoff effects from the proposed project. Guidelines for the selection and design of post-construction BMPs may be found in the North Central Texas Council of Government's (NCTCOG) integrated Storm Water

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Management (iSWM) Technical Manual, Site Development Controls. These BMPs are acceptable for design of storm water controls within this section, however the design of detention facilities shall be as defined in the City's Drainage Design Manual.

It is recommended that the owner, developer and/or design engineer consult with the City Engineer prior to design of any post-construction BMPs to discuss and evaluate the intended BMP performance criteria (e.g. water quality, channel protection, runoff volume reduction, etc.) and related long term maintenance requirements. All post-construction BMP's shall be submitted to the City Engineer for review and approval prior to construction of the proposed project.

All post-construction BMPs shall have an enforceable long term operation and maintenance agreement to ensure the system functions as designed. This agreement will include any and all maintenance easements as required to access and inspect the storm water practices, and to perform routine maintenance as necessary to ensure proper functioning of the storm water practice. Unless otherwise agreed upon by the City of DeSoto, the long term operation and maintenance of any post-construction BMPs shall be the responsibility of the property owner.

#### 4.2 Construction Site Storm Water Pollution Prevention

All construction activity, regardless of size, shall have storm water pollution prevention BMP's installed prior to any land disturbing activities to prevent the discharge of pollutants to the City's municipal separate storm sewer system. It is the responsibility of owners, developers and contractors to maintain compliance with the (TCEQ) storm water construction permit TXR150000. All storm water BMP's shall be provided, constructed and maintained per the City of DeSoto's standards and details, or in the absence of an applicable City detail, the standards set forth in the NCTCOG iSWM Technical Manual, Construction Controls.

The developer or owner is responsible for providing the City Engineer with a copy of the TCEQ Construction Site Notice for projects between 1 and 5 acres or the TCEQ Notice of Intent (NOI) for projects larger than 5 acres prior to any land disturbing activities. Reference the TCEQ general permit TXR150000 for further information.

It is the intent of the City of DeSoto that sediment from construction sites be contained on the site. Sediment ponds shall be provided for construction sites as required by the TCEQ TPDES Construction Permit. Accordingly, Storm Water Pollution Prevention Plans (SWPPP) shall address two stages. Stage I refers to the initial grading and infrastructure construction phase of the development. Sediment ponds, boundary silt fence or other approved mass grading erosion and sediment controls shall be in installed before construction may commence. Inlet protection devices shall be installed

until streets and alleys have been paved. Immediately after paving, an erosion control blanket (or other erosion control method as approved by the City Engineer) shall be installed adjacent to paved surfaces such as alleys, streets, flumes, etc., in addition to the placement of silt fence along the downslope boundaries of the site. No construction is permitted until Stage 1 erosion controls are installed and the City has received a copy of the NOI or Construction Site Notice.

Stage 2 refers to the period of time after acceptance of the development by the City and prior to completion of homes or other buildings. During this stage, an erosion control blanket (or other erosion control method as approved by the City Engineer) shall be placed adjacent to all streets and alleys and at the project perimeter to contain sediment within the block and prevent transport to the pavement. The maintenance of this perimeter erosion control system becomes the builder's responsibility once a building permit is issued. The developer is then responsible for the perimeter erosion controls until the development or phase is 95% built out.

#### 5 CONSTRUCTION PLAN REQUIREMENTS

All construction plans prepared for construction of public works or private development drainage facilities shall be sealed by a Professional Engineer who is registered in the State of Texas and is experienced in civil engineering work.

Plans shall include the following information in addition to those items included on the checklist in the Appendix of this Manual.

#### 5.1 Drainage Area Maps

Generally, a map having a scale of one (1) inch equals one hundred (100) feet is suitable unless dealing with large off-site drainage areas. Off-site drainage areas may be shown at a smaller scale. The City Engineer may require a larger scale if necessary to depict the necessary information in a readable format. The drainage area map shall show the boundary of all drainage areas contributing runoff into the proposed system. The area shall be further divided into sub-areas to determine flow concentration points or inlet locations. Drainage area maps shall show streets, zoning, zoning boundaries, existing ground on one (1) or two (2) foot contours (show proposed contours within the limits of the site) and a hydrologic summary table showing drainage area calculations for both existing and proposed conditions. The Drainage Design Standards section of this document provides maximum inlet times in Table 1. The Time of Concentration (Tc) path shall be shown on the drawing along with detailed calculations indicating how the total Tc was determined.

Direction of flow within streets, alleys, natural and man-made drainage ways, and at all system intersections shall be clearly shown on the drainage area map or paving plans. This includes sags, crests and corners. All existing and proposed drainage facilities shall be clearly shown and differentiated on the drainage area map. All existing structures and improvements, such as streets, parking lots, buildings, etc. shall be shown on the drainage area map.

The means provided for accommodating any increase in runoff due to the development shall be clearly depicted, along with the means for handling runoff that is conveyed to or through the site from upstream.

The appendix includes sample calculation forms that depict the information required and the format in which it is to be displayed. While the format shown is not required, use of such format will expedite review by the City of DeSoto. Additional information not included on the sample forms may be necessary to adequately address the particular conditions of a given project. Calculations shall be provided showing the capacity of all inlets, pipes and other drainage structures. All calculations must be shown on the construction plans.

#### 5.2 Grading Plans

Grading and drainage plans shall be prepared for all proposed developments, and shall show in detail the proposed grading and the proposed drainage patterns. Existing and proposed contours at one (1) foot intervals shall be shown on all commercial and industrial developments. Grading plans for residential developments shall show existing contours at one (1) foot intervals, and shall depict proposed grading by the use of spot elevations and flow arrows. Spot elevations shall be shown at the top of the curb adjacent to each lot line, and adjacent to each building corner as well as the upper end of each swale. The grading plan shall clearly show swales, ditches and other means of conveying storm water runoff across the proposed site. Finish floor elevations shall be shown, and flow arrows used to indicate flow patterns.

In residential developments, storm water may not cross more than one lot before being discharged to a street, alley, channel or other public storm drainage facility. In all other developments, concentrated storm water may not be discharged to an adjacent property (other than a recognized watercourse) except in a dedicated easement and an approved storm drainage system. Runoff from adjacent lots or properties must be collected and conveyed in an easement rather than across lots.

Positive overflow shall be provided at sump or low point inlets. Minimum finish floor elevations adjacent to such overflows shall be no less than 12" above the overland flow water surface elevation, with positive drainage provided away from the building.

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Minimum finish floor elevations shall be set at least two (2) feet above the 100-year base flood elevation of any adjacent stream for which base flood elevations have been set as depicted on the most current Flood Insurance Rate Map.

#### 5.3 Storm Drainage Plans

Storm drain plans shall include the following in addition to all items specified in the plan checklist:

- Plan and profile sheets at a scale not greater than 1"=50' horizontally, and 1"=5' vertically. The storm drainage system shall be shown on separate sheets from the paving plans.
- Detailed geometry to facilitate construction, including stations at all junctions, structures, pipe size changes, inlets, and all changes in direction, including PC's, PT's, and Pl's, along with complete curve data.
- Surface flow arrows shall be shown at all intersections and high points.
- Storm drain pipes shall generally be located in the center of the roadway.
- Junction boxes shall be constructed at all pipe intersections except inlet lead lines.
- Junction boxes or manholes shall be spaced a maximum of 400' apart for pipe 24-inches or smaller in diameter, and a maximum of 800' apart for pipe 27-inches or greater in diameter.
- Storm drain pipe shall be reinforced concrete pipe (RCP) in all public right-of-ways. Other pipe materials may only be used with the approval of the City Engineer.
- Where multiple inlet leads intersect the main at the same or similar station, a junction box shall be constructed.
- All property lines, right-of-way lines, and easements shall be shown, and the storm drain facilities tied to these as appropriate.
- All existing and proposed utilities shall be shown in the plan view, and in the profile view where such information is available.
- Profiles shall include existing ground line at the center of the proposed storm drain, proposed ground line at the center of the proposed storm drain, 100-year hydraulic grade line (HGL) with HGL elevations at each junction, end of pipe, and pipe size change. Pipe flowline elevations shall be shown at fifty (50) foot intervals along the pipe. The size, length and slope of each pipe shall be shown, along with the runoff to be conveyed (Q required), the capacity of the pipe at full flow (Q provided), and the velocity at Q<sub>100</sub>.
- The hydraulic grade line shown shall include all minor losses at appurtenances.
- The starting (downstream) elevation of the hydraulic grade line shall be based on downstream conditions. Determination of this starting elevation must be documented.

- Indicate the size and type of inlet, top of curb elevation, flowline elevation, and lead line size and slope. All inlet laterals shall be shown in profile in the plans and shall show the HGL.
- All storm drain pipe connections shall match at the crowns of the pipe. Laterals shall connect to the main such that the center of the lateral matches the center of the main.
- Specify and provide details for required backfill and embedment, using NCTCOG backfill requirements.
- Identify erosion protection measures for storm drain outfall structures, where required.
- Identify benchmarks, including at least one City of DeSoto benchmark.
- Inlet leads shall connect to the main at a thirty-degree (30°) angle or greater (no connections greater than sixty degrees (60°) shall be permitted without a junction box. No connections greater than ninety degree (90°) will be permitted.
- Applicable City of DeSoto Standard Construction details shall be included in the construction plans. Modifications to these standard details may be made only with the approval of the City Engineer.

#### 5.4 Channel Plans

- Plan and profile sheets at a scale not greater than 1"=50' horizontally, and 1"=5' vertically.
- Detailed geometry to facilitate construction, including stations at all junctions, structures, and all changes in direction, including PC's, PT's, and PI's, along with complete curve data.
- All property lines, right-of-way lines, and easements shall be shown, and the channel facilities tied to these as appropriate.
- All existing and proposed utilities shall be shown in the plan view, and in the profile view where such information is available.
- Profiles shall include existing ground line at the center of the proposed channel, proposed ground line at the center of the proposed channel, proposed right and left top of bank, 100-year water surface elevation, and flowline elevations at each structure, grade change, etc., as well as at 50-foot intervals along the channel.
- The runoff to be conveyed (Q required), the capacity of the channel at full flow (Q provided), and the velocity at Q<sub>100</sub> shall be shown.
- Identify erosion protection measures for storm drain outfall structures.
- A typical section(s) shall be depicted on the plans, showing bottom width, side slopes, lining (if applicable), depth, etc.
- Earthen channels shall have side slopes no steeper than 4:1.
- Actual cross sections shall be shown at no less than 100-foot intervals.
- Specify compaction requirements where fill must be placed.

#### 5.5 Detention/Retention Facilities

- Show all hydrologic, routing, storage and outlet calculations. The Modified Rational method may be used for drainage areas less than fifty (50) acres. For larger drainage areas, a unit hydrograph method that employs reservoir routing calculations must be used.
- Provide detailed plans showing all aspects of the outlet structure(s), along with hydraulic calculations of the outlet(s).
- Grading plans must be provided for the facility. The bottom slope shall be a minimum 2% towards the outlet structure, and a concrete pilot channel shall be provided through the pond for low flows.
- Show downstream conditions and provide information that shows the effect of the discharge on downstream properties and/or structures.
- Show adequate erosion control measures at outlet structure(s).
- Show normal pool elevation, 5-year, 25-year, 50-year and 100-year pool elevations, and overflow facilities.
- Show existing and proposed contours to depict slopes of embankments. The maximum slope of embankments shall be 4:1.
- Show emergency overflow provisions.

#### 5.6 Storm Water Pollution Prevention Plans

- Storm Water Pollution Prevention Plans shall be prepared and sealed by a registered professional engineer. The engineer shall attest that the SWPPP fully complies with the requirements of this manual and with TCEQ requirements.
- Contours or other indication of flow direction shall be shown on the plan.
- Show the location of all structural sediment control measures.
- Erosion and sediment control calculations must be shown on the SWPPP.
- Stabilization measures must be identified.
- Maintenance and inspection procedures must be outlined.
- Project sequencing and/or phasing must be identified.
- Both construction (Stage 1) and post-construction (Stage 2) conditions shall be shown.

#### **6 SUBMITTAL REQUIREMENTS**

Any information that is submitted to the City Engineer's office for approval shall be accompanied by a completed copy of the checklist found in the Appendix of this Manual. The checklist is intended as an aid to those submitting drainage information for review. A completed checklist will minimize the need for additional information to complete a proper technical review by the City. The items shown on the checklist should be considered minimum requirements for plan submittal.

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#### 7 REGULATORY ISSUES

#### 7.1 U.S. Army Corps of Engineers 404 Permits

The U.S. Army Corps of Engineers (USACE) has been directed by Congress under Section 404 of the Clean Water Act (33 USC 1344) to regulate activities impacting all waters of the United States, including wetlands. The USACE has developed a permitting process to ensure compliance with the Clean Water Act. Developers will be expected to ensure that all requirements of the Clean Water Act are met. The City of DeSoto assumes no responsibility for the compliance of the Developer with this or any other Federal regulations.

However, the Developer should be aware that under current regulations, most of the streams within the City of DeSoto are likely to be considered jurisdictional waters by the USACE. As a result, permitting will likely be required for any projects impacting these streams by fill, excavation, utility crossings or roadway crossings. In many cases, these permits carry significant compensatory mitigation requirements to offset losses of jurisdictional waters and their associated habitat.

#### 7.2 National Flood Insurance Program

The City of DeSoto is a participant in the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA). Copies of the Flood Insurance Rate Maps (FIRM) are available from the City, for a fee, depicting the 100-year floodplain developed for insurance rating purposes. Floodplain management in the City of DeSoto is under the direction of the City Engineer, who also functions as the Floodplain Administrator. Refer to the Floodplain Management Ordinance for further information.

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#### **FIGURES**

Figure 1 - Recognized Watercourses

Figure 2 - Rainfall Intensity Values

Figure 3 - Overland Time of Flow

Figure 4 - Shallow Concentrated Flow Velocity

Figure 5 - Capacity of Triangular Gutters

Figure 6 - Gutter Flow in Street Sections with Parabolic Crowns

Figure 7 - Capacity of Alley Sections

Figure 8 - Alley Paving at a Turn

Figure 9 - Manning's Formula for Flow in Storm Sewers

Figure 10 - Minor Head Losses (2 pages)

Figure 11 - Headwater Depth for Concrete Pipe Culverts with Inlet Control

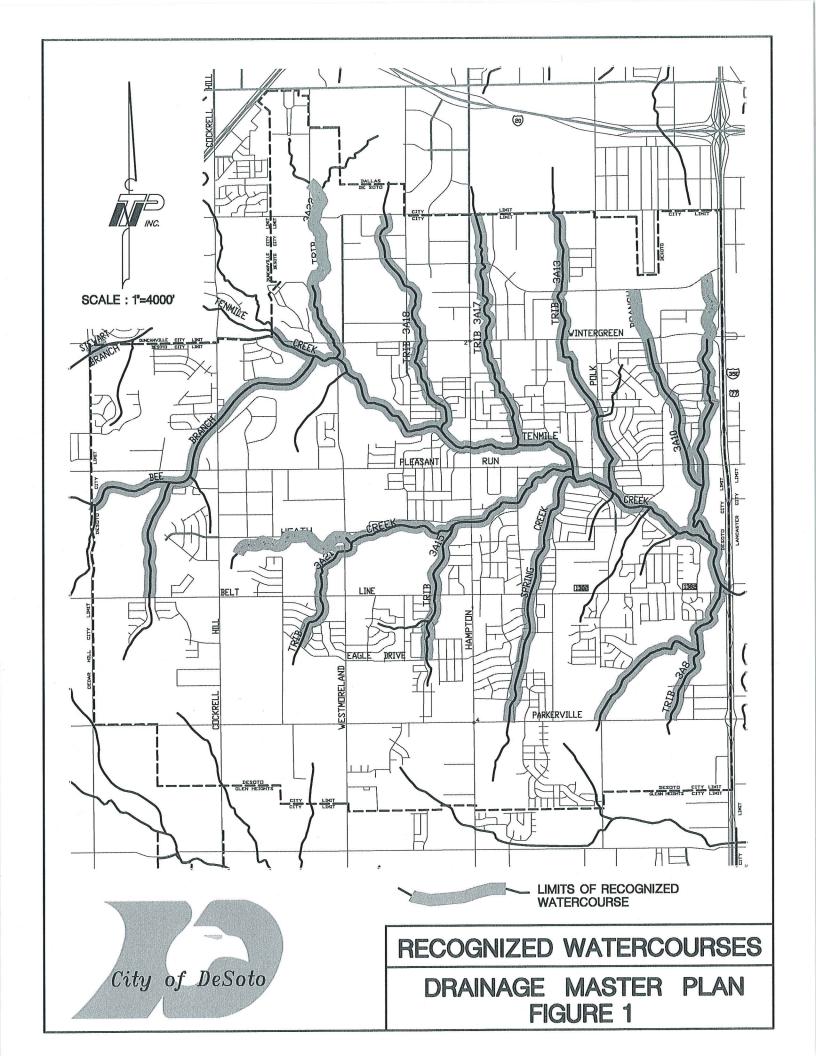
Figure 12 - Headwater Depth for C.M. Pipe Culverts with Inlet Control

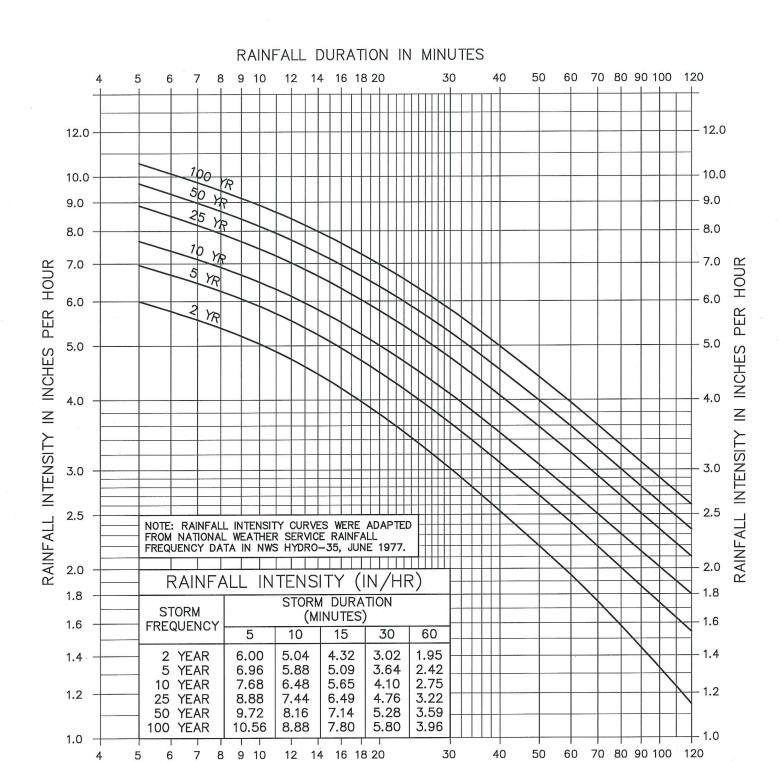
Figure 13 - Headwater Depth for Box Culverts with Inlet Control

Figure 14 - Head for Concrete Pipe Culverts Flowing Full (n=0.012)

Figure 15 - Head for Standard C.M. Pipe Culverts Flowing Full (n=0.024)

Figure 16 - Head for Concrete Box Culverts Flowing Full (n=0.012)

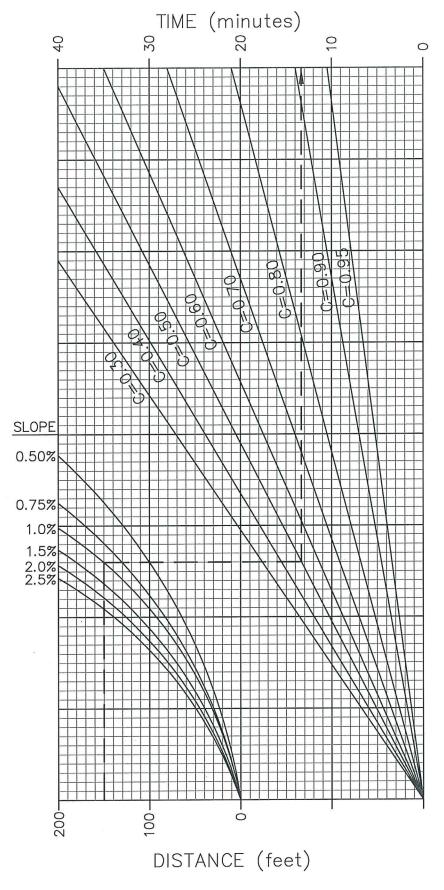




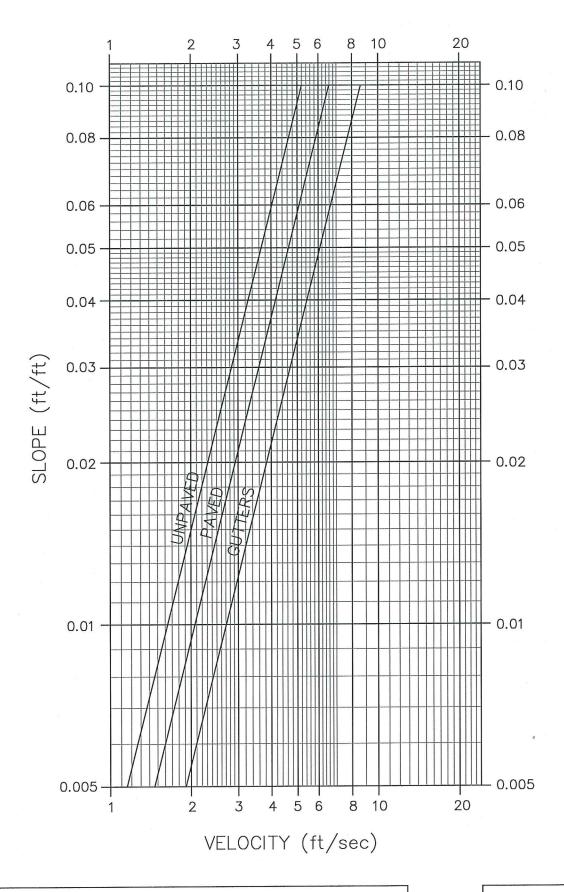
RAINFALL DURATION IN MINUTES

CITY OF DESOTO RAINFALL INTENSITY VALUES

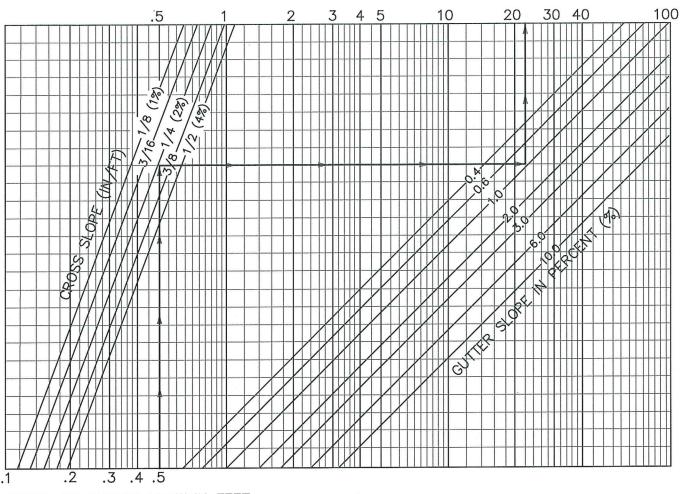
FIGURE 2



EXAMPLE: 150 feet at 1.0%, C = 0.50; Time = 13 Minutes Overland Flow



## GUTTER CAPACITY IN C.F.S.



DEPTH OF GUTTER FLOW IN FEET



(Roughness Coefficient n = .0175)

## **EXAMPLE**

Known:

Gutter Slope = 1.0%

Pavement Cross Slope = 1/4"/1' Depth of Gutter Flow = 0.5'

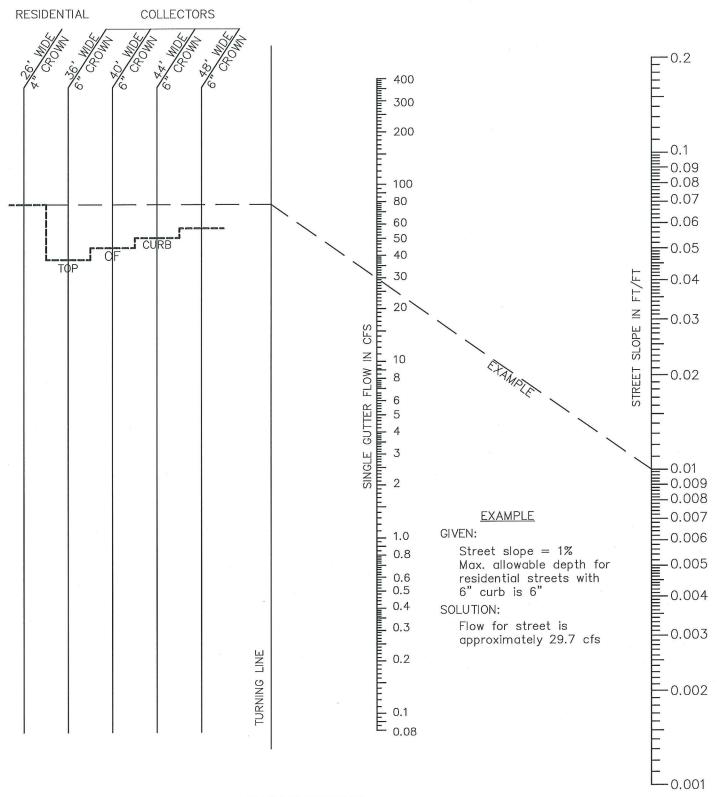
Find:

**Gutter Capacity** 

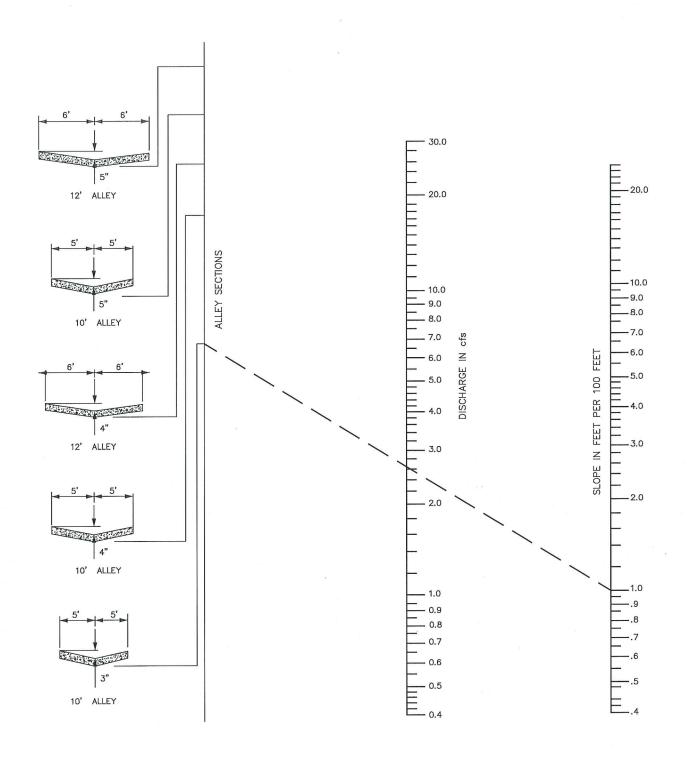
Solution:

Enter Graph at 0.5'

Intersect Cross Slope = 1/4"/1' Intersect Gutter Slope = 1.0% Read Gutter Capacity = 22 c.f.s.



NOTE: THIS NOMOGRAPH REPRESENTS FLOW FOR BOTH GUTTERS. WITH NO CURB SPLIT.



#### NOTE:

- All Alley Capacities are to Paving Edge
- The Capacities obtained from this Nomograph are based on a Straight Horizontal Alignment. Curved Alignments may result in Reduced Capacity.

## EXAMPLE

## KNOWN:

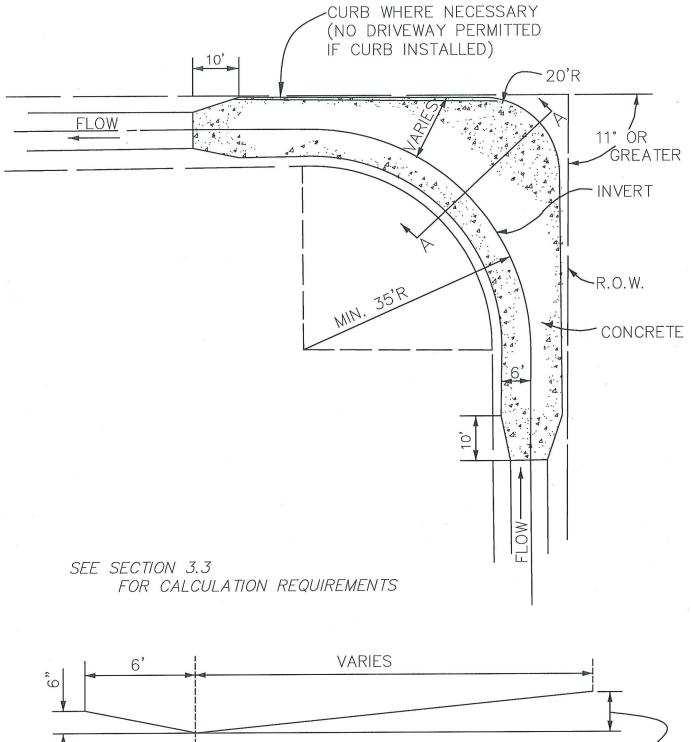
Alley width = 10'
Alley depression = 3"
Gutter slope = 1.0%
"n" = 0.0175

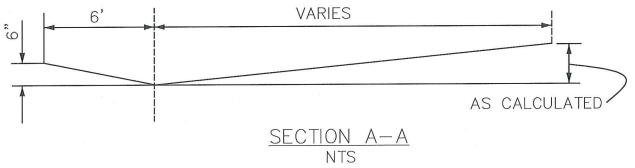
FIND:

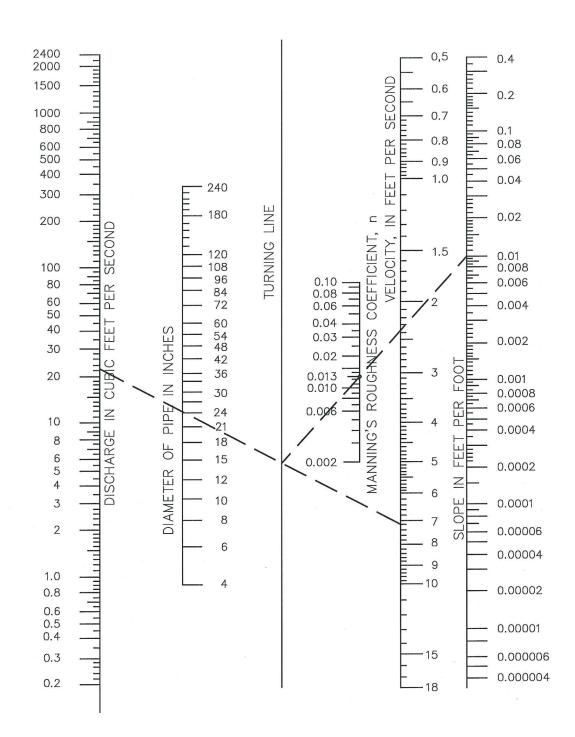
Gutter Flow (Q)

#### SOLUTION:

Connect the 10' alley section with slope = 1.0%. Read Q = 2.6 c.f.s.







# EXAMPLE

KNOWN:

"n" = 0.013

Slope(s) = 1.0%

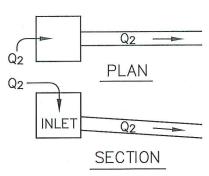
Pipe Diameter = 24"

Connect Slope thru "n" Turning Line,

Connect to Pipe Size V=7.2Q = 22.6

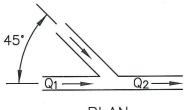
FIND:

Capacity (Q) Velocity (V)



$$H_{j} = 1.5 \frac{V_{2}^{2}}{2g}$$

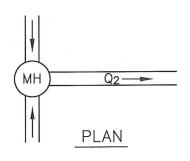
INLET AT BEGINNING OF LINE



$$H_{j} = \frac{V_{2}^{2}}{2g} - \frac{0.75 V_{1}^{2}}{2g}$$

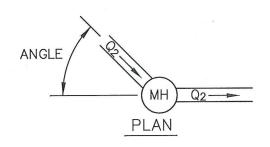
PLAN

45° WYE CONNECTION



$$H_{j} = \frac{V_{2}^{2}}{2g}$$

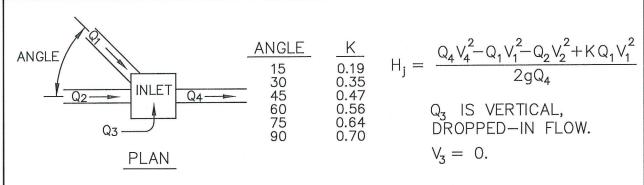
INCOMING OPPOSING FLOWS AT MANHOLE



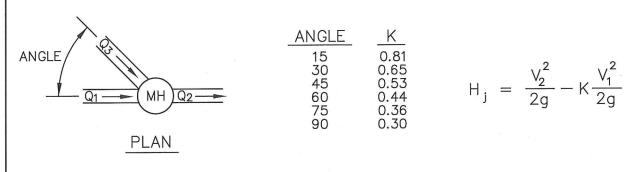
ANGLE	_K_
0	0.15
15	0.19
30	0.35
45	0.47
60	0.56
75	0.64
90	0.70

$$H_j = K \frac{V_2^2}{2g} .$$

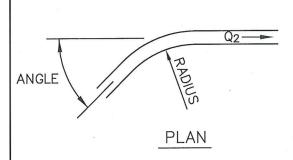
CHANGE IN DIRECTION AT MANHOLE



# INLET WITH MULTIPLE ENTERING FLOWS



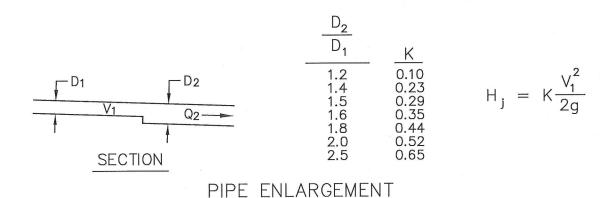
# MANHOLE WITH LATERAL



	- 1	K	
ANGLE	RADI	US (#	DIA's)
	_1_	2-8	8-20
90	0.50	0.45	0.40
60	0.43	0.38	0.34
45	0.35	0.32	0.28
22½	0.20	0.18	0.16

$$H_{j} = K \frac{V_{2}^{2}}{2g}$$

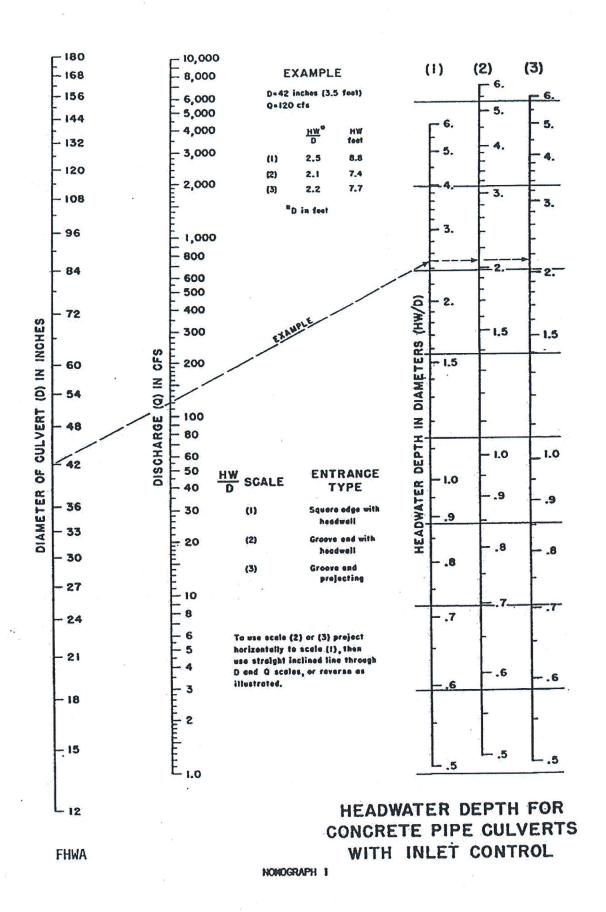
# CONDUIT ON CURVE

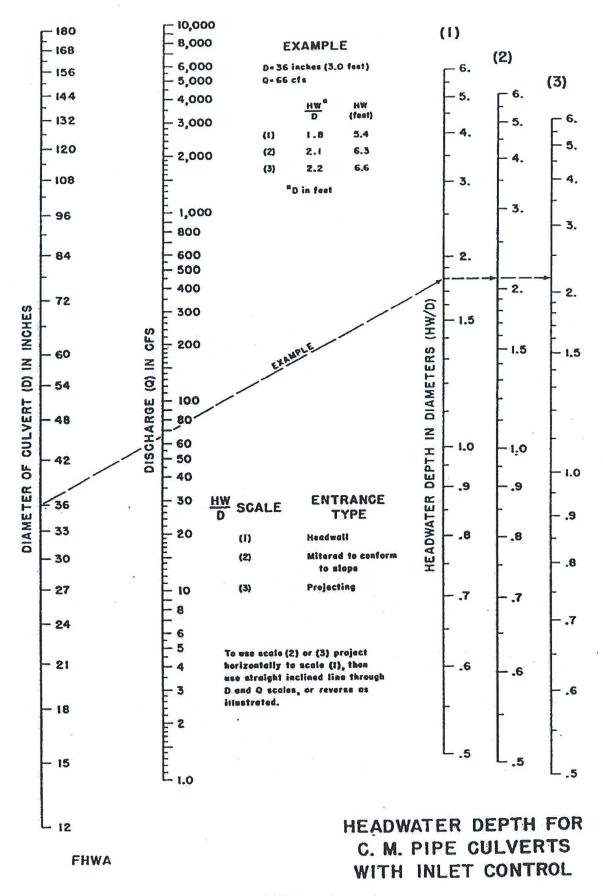


MINOR HEAD LOSSES

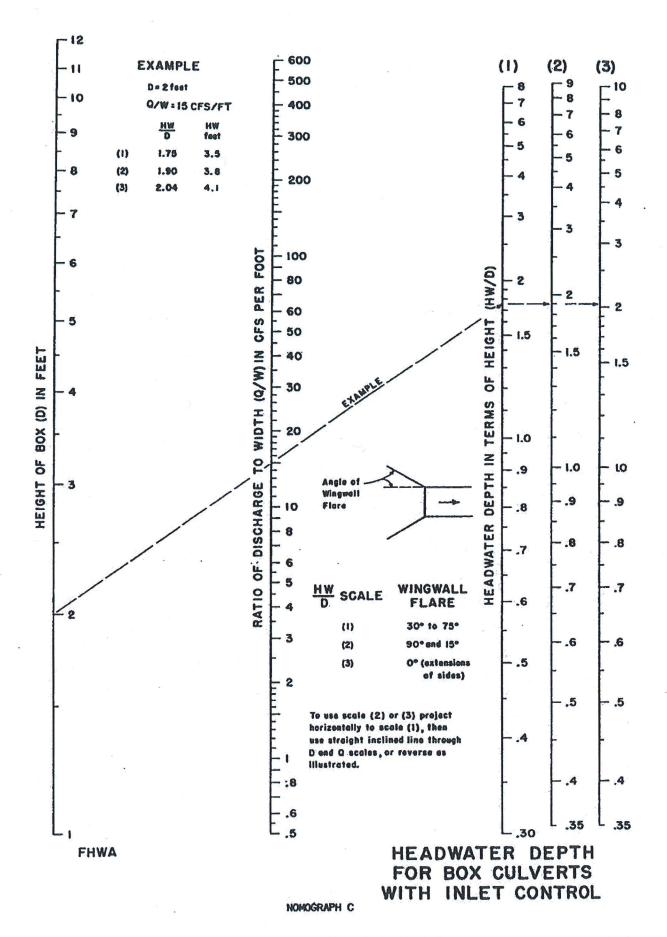
(2 OF 2)

FIGURE 10



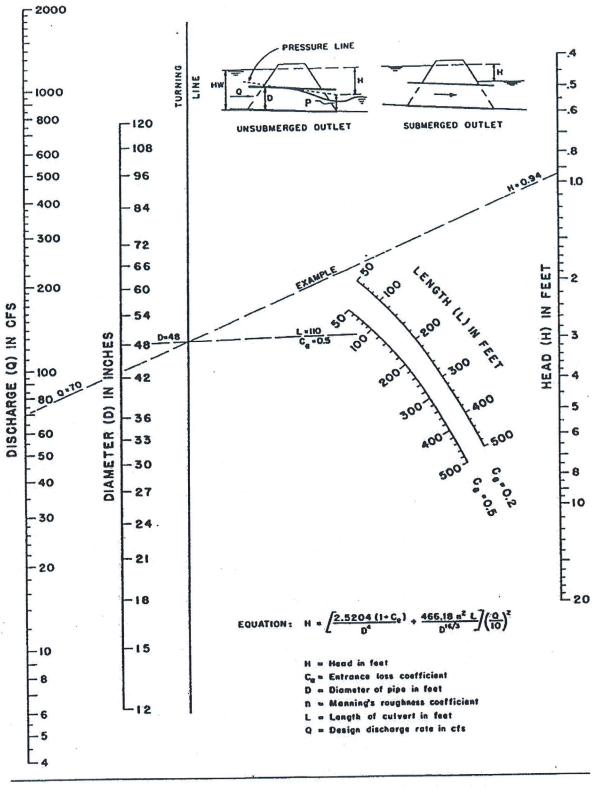


NONOGRAPH J



BRIDGE DIVISION HYDRAULIC MANUAL
4 - 23

12-85



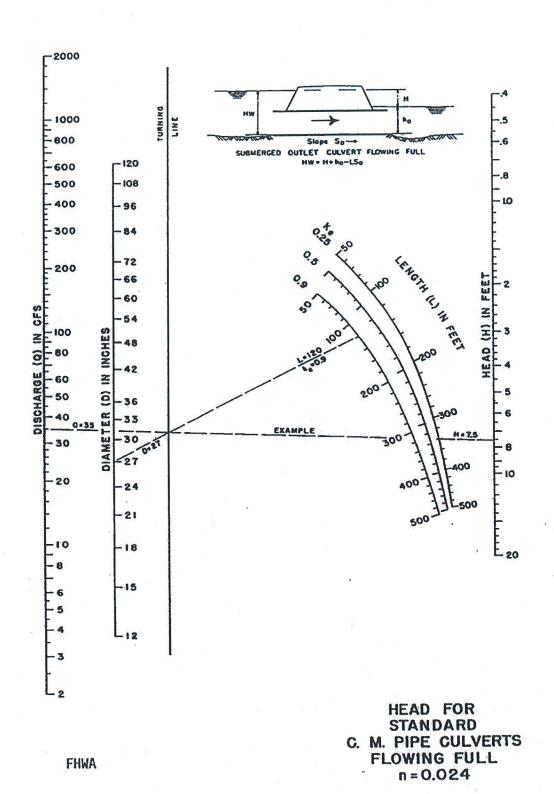
FHWA

HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n=0.012

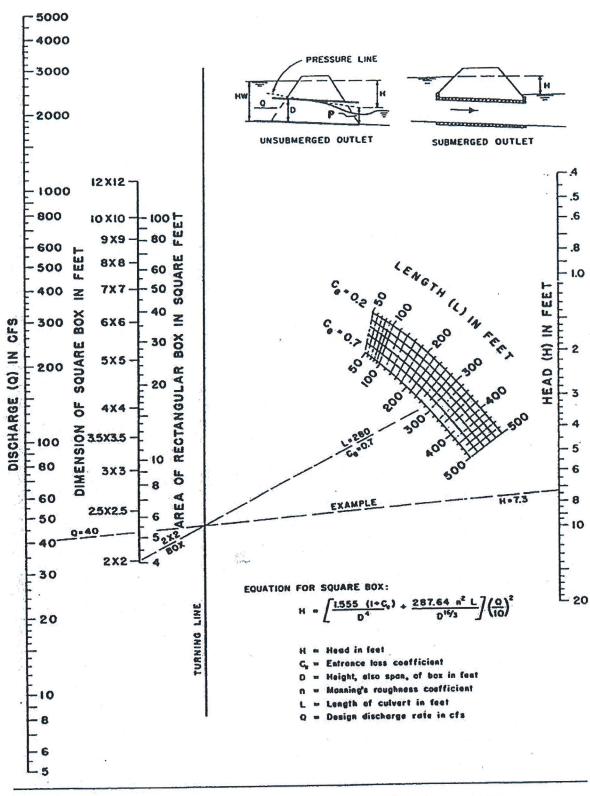
NOMOGRAPH K

BRIDGE DIVISION HYDRAULIC MANUAL
4 - 39

12-85



NONOGRAPH L



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

FHWA

NONOGRAPH D

## **TABLES**

TABLE 1		
RUNOFF COEFFIC	CIENTS	
	Runoff	Maximum
	Coefficient	Inlet Time
Zoning District Name	<u>"C"</u>	<u>in Minutes*</u>
Undeveloped Land	0.30	Variable
Agricultural	Variable	Variable
Single Family-Estate	0.35	20
Single Family – 20	0.40	15
Single Family – 15	0.50	15
Single Family – 12	0.55	15
Single Family – 10	0.55	15
Single Family – 9	0.60	15
Single Family – 8	0.60	15
Two Family	0.60	15
Single Family Attached	0.75	15
Multiple Family – 18	0.70	10
Mobile Home	0.55	15
Office – 1	0.65	10
Office – 2	0.85	10
Neighborhood Service	0.80	10
General Retail	0.85	10
Commercial – 1	0.85	10
Commercial – 2	0.85	10
Industrial Park	0.85	10
Light Industrial	0.90	10

## Miscellaneous Land Uses

Land Use	Runoff Coefficient "C"
Planned Development	Variable
Church	Variable
School	Variable
Park	Variable

<sup>\*</sup> Note: Inlet time is not necessarily Time of Concentration. See Section 3.2.1.1 for more information. Inlet time shall be calculated, but shall not exceed the values listed above.

TABLE 2	
MANNING'S ROUGHNESS COEFFICIENT	S "n" FOR STORM DRAINS
Materials of Construction	Manning's Coefficient
Monolithic Concrete Structure	0.015
Concrete Pipe	
Good alignment, smooth joints	0.013
Fair alignment, ordinary joints	0.015
Poor alignment, poor joints	0.017
High Density Polyethylene Pipe (HDPE)	0.012

	TABLE 3	
MINIMU	M GRADES FOR STORM	DRAINS
Pipe Size (inches)	Concrete Pipe <u>Slope Ft./Ft.</u> ( <u>n = 0.013</u> )	High Density Polyethylene Pipe <u>Slope Ft./Ft</u> (n = 0.012)
18	0.00177	0.00151
21	0.00144	0.00123
24	0.00121	0.00103
27	0.00103	0.00088
30	0.00090	0.00076
33	0.00079	0.00067
36	0.00070	0.00060
39	0.00063	0.00054
42	0.00057	0.00049
45	0.00052	0.00044
48	0.00048	0.00041
54	0.00041	0.00035
60	0.00036	0.00030
66	0.00031	0.00027
72	0.00028	0.00024
78	0.00025	0.00021

TABLE 4 CHANNEL ROUGHNESS AND N	I A YIMII IM	VELOCITY					
Channel Description	"n"	Maximum Velocity (fps)					
Mowed bermuda grass, clay soil	0.035	8					
Mowed bermuda grass, sand/silt soil	0.035	6					
Bare earth, stiff clay 0.025 4							
Bare earth, sandy loam	0.020	2					
Ungrouted rock rip-rap, D <sub>50</sub> =12"	0.040	12					
Grouted rock rip-rap, D <sub>50</sub> =12"	0.035	14					
Smooth-finished concrete	0.015	18					
Gabions, min. 1' thick	0.030	14					

	TABLE 5			
ROUGHNESS COEFF	FICIENTS FOR	OPEN CHAI	NNELS	
	Roug	hness Coeff	ficient	
				Maximum
Channel Description	Minimum	Normal	Maximum	Velocity
MINOR NATURAL STREAMS				
Moderately Well-Defined Channel				
Grass and Weeds, Little Brush	0.025	0.030	0.033	88
Dense Weeds, Little Brush	0.030	0.035	0.040	8
Weeds, Light Brush on Banks	0.030	0.035	0.040	8
Weeds, Heavy Brush on Banks	0.035	0.050	0.060	8
Weeds, Dense Willows on Banks	0.040	0.060	0.060	. 8
Irregular Channel with Pools and Meanders				
Grass and Weeds, Little Brush	0.030	0.036	0.042	8
Dense Weeds, Little Brush	0.036	0.042	0.048	8
Weeds, Light Brush on Banks	0.036	0.042	0.042	8
Weeds, Heavy Brush on Banks	0.042	0.060	0.072	8
Weeds, Dense Willows on Banks	0.048	0.072	0.085	8
Flood Plain, Pasture				
Short Grass, No Brush	0.025	0.030	0.035	8
Tall Grass, No Brush	0.030	0.035	0.050	8
Flood Plain, Cultivated				
No Crops	0.025	0.030	0.035	
Mature Crops	0.030	0.040	0.050	
Flood Plain, Uncleared		>		
Heavy Weeds, Light brush	0.035	0.050	0.070	8
Medium to Dense Brush	0.070	0.100	0.160	8
Trees with Flood Stage below Branches	0.080	0.100	0.120	8
MAJOR NATURAL STREAMS				
The roughness coefficient is less than that fo less effective resistance.	r minor streams	of similar de	escription becau	use banks offe
Moderately Well-Defined Channel	0.025		0.060	8
Irregular Channel	0.035		0.100	8
UNLINED VEGETATED CHANNELS	2 0			
Mowed Grass, Clay Soil	0.025	0.030	0.035	8
Mowed Grass, Sandy Soil	0.025	0.030	0.035	6
UNLINED NON-VEGETATED CHANNELS				
Clean Gravel Section	0.022	0.025	0.030	8
Shale	0.025	0.030	0.035	10
Smooth Rock	0.025	0.030	0.035	15
LINED CHANNELS	7.020			
Smooth Finished Concrete	0.013	0.015	0.020	15
Rip-rap (Rubble)	0.030	0.040	0.050	10
PAVEMENTS	1 3.000	0.070	2.300	
Concrete Pavement	0.015	0.017	0.020	
Asphalt Pavement	0.015	0.015	0.017	

#### **APPENDIX**

## MODIFIED RATIONAL METHOD DENTENTION BASIN DESIGN EXAMPLE

GIVEN:

A 25-acre site, currently agricultural use, is to be developed for retail

use. The entire site is the drainage area of the proposed detention

basin.

DETERMINE:

The maximum release rate and required detention storage, detention

basin size and shape, and outlet structure configuration for the 5-, 25-,

50-, and 100-year events.

### SOLUTION:

Step 1. Determine peak runoff rate prior to site development. This is the maximum release rate from site after development.

Step 2. Determine inflow for storms of various durations in order to determine maximum volume required with release rate determined in Step 1.

NOTE:

Incrementally increase durations to determine maximum required volume. The duration with a peak inflow less than maximum release rate, or where required storage is less than storage for the prior duration, is the last increment.

## Present Conditions Q = CIA

C = 0.30

Tc = 20 min.

 $I_{100} = 7.0 \text{ in./hr.}$ 

 $Q_{100} = 0.30 \text{ X } 7.0 \text{ X } 25 = 52.5 \text{ cfs (Maximum release rate)}$ 

## Future Conditions (Retail)

C = 0.85

Tc = 15 min.  $I_{100}$  = 7.8 in./hr.

 $Q_{100} = 0.85 \times 7.8 \times 25 = 165.8 \text{ cfs}$ 

 $Q_p = C \times I \times A$ Check various duration storms:  $Q_p = 0.85 \times 7.8 \times 25 = 165.8 \text{ cfs}$ 15 min. I = 7.820 min. I = 7.0 $Q_p = 0.85 \times 7.0 \times 25 = 148.8 \text{ cfs}$  $Q_p = 0.85 \times 5.8 \times 25 = 123.3 cfs$ 30 min. 1 = 5.8 $Q_p = 0.85 \times 5.0 \times 25 = 106.3 \text{ cfs}$ 40 min. I = 5.0 $Q_p = 0.85 \times 4.4 \times 25 = 93.5 \text{ cfs}$ 50 min. 1 = 4.4 $Q_p = 0.85 \times 4.0 \times 25 = 85.0 \text{ cfs}$ 60 min. I = 4.0 $Q_p = 0.85 \times 3.7 \times 25 = 76.5 \text{ cfs}$ 70 min. I = 3.7 $Q_p = 0.85 \times 3.4 \times 25 = 70.1 \text{ cfs}$ 80 min. 1 = 3.4

Maximum Storage Volume is determined by deducting the volume of runoff released during the time of inflow from the total inflow for each duration.

Inflow = Storm duration x respective peak discharge x 60 sec./min.

Outflow = Half of the respective inflow duration x control release discharge x 60 sec./min.

15 min. Storm	Inflow Outflow Storage	15 x 165.8 x 60 sec./min 0.5 x 30 x 52.5 x 60 sec./min	= 149,220 cf = 47,250 cf 101,970 cf
20 min. Storm	Inflow Outflow Storage	20 x 148.8 x 60 sec./min 0.5 x 35 x 52.5 x 60 sec./min	= 178,560 cf = 55,125 cf 123,435 cf
30 min. Storm	Inflow Outflow Storage	30 x 123.3 x 60 sec./min 0.5 x 45 x 52.5 x 60 sec./min	= 221,940 cf = 70,875 cf 151,065 cf
40 min. Storm	Inflow Outflow Storage	40 x 106.3 x 60 sec./min 0.5 x 55 x 52.5 x 60 sec./min	= 255,120 cf = 86,625 cf 168,495 cf
50 min. Storm	Inflow Outflow Storage	50 x 93.5 x 60 sec./min 0.5 x 65 x 52.5 x 60 sec./min	= 280,500 cf = <u>102,375</u> cf 178,125 cf

60 min. Storm	Inflow Outflow Storage	60 x 85.0 x 60 sec./min 0.5 x 75 x 52.5 x 60 sec./min	= 306,000 cf = <u>118,125</u> cf 187,875 cf
70 min. Storm	Inflow Outflow Storage	70 x 76.5 x 60 sec./min 0.5 x 85 x 52.5 x 60 sec./min	= 321,300 cf = <u>133,875</u> cf 187,425 cf
80 min. Storm	Inflow Outflow Storage	80 x 70.1 x 60 sec./min 0.5 x 95 x 52.5 x 60 sec./min	= 336,480 cf = <u>149,625</u> cf 186,855 cf

Maximum volume required is 187,875 cf at the 60 minutes storm duration for the 100-year storm.

### Step 3.

Size the basin to contain the required volume for the 100-year storm while maintaining minimum slope and freeboard requirements.

## Step 4.

Using the selected geometry of the basin as determined above and the storage volumes required for each storm event, determine the maximum depth in the basin for each storm. To design the outlet structure for the required multiple frequencies, the calculations shown above may be repeated for each frequency in tabular form as shown below. For each storm event, the highest storage value calculated, along with the selected basin size and shape, determines the maximum depth for each event. This depth is the head used in outlet structure design.

## Step 5.

A trial outlet structure is selected, and may be a weir, an orifice (pipe), a V-notch weir, or a combination of outlets.

The outlet structure is designed using the head calculated above, to provide a peak discharge that is no greater than 2% above existing (undeveloped) peak runoff for each of the 5-, 25-, 50-, and 100-year storm events.

Several iterations may be necessary to balance discharge from the outlet structure, pond geometry and head. If the discharge is significantly different (either higher or lower) than the discharge assumed in Step 2, the actual operation of the pond will not correspond to the calculations. Discharge for any given event may not exceed the

allowable discharge determined in Step 1 by more than 2% nor may actual discharge be more than 10% below the allowable discharge.

Sample calculations are provided in the following pages.

DeSoto Detention Sample Calcs

1. Determine allowable discharge for each storn event

Proposed					7.14		
					6.49		
	2	25	0.85	15	5.09	108.	
						_	
	100	22	0.3	8	2.00	52.5	
sting	50	25	0.3	20	6.40	48.0	Discharge
Exis	25	22	0.3	20	5.80	43.5	Allowable
	5	25	0.3	20	4.50	33.8	
		4	ပ	τo	_	ø	

100 25 0.85 15 7.80 165.8

2. Determine required storage for each storm event

Z. Deleil	Z. Determine required storage for each storing event	stolage for	ממחו אוחוו	מאפוו					9				
100-yr	Duration	Intensity	Peak Q	Inflow	Outflow	Storage	50-yr	Duration	Intensity	Peak Q	Inflow	Outflow	Storage
	(min)	(in/hr)	(cfs)	ਹਿ	<u>G</u>	ල්		(min)	(in/hr)	(cts)	ල්	ਹੁ	ලි
	15	7.8	165.8	149220	47250	101970		15	7.1	150.9	135810	43200	92610
	20	7.0	148.8	178560	55125	123435		20	6.4	136.0	163200	50400	112800
	30	5.8	123.3	221940	70875	151065		30	5.3	112.6	202680	64800	137880
	40	5.0	106.3	255120	86625	168495		40	4.5	92.6	229440	79200	150240
	20	4.4	93.5	280500	102375	178125		20	4.0	85.0	255000	93600	161400
	09	4.0	85.0	306000	118125	187875		09	3.6	76.5	275400	108000	167400
	02	3.6	76.5	321300	133875	187425		20	3.3	70.1	294420	122400	172020
	8	3.3	70.1	336480	149625	186855		80	3.0	63.8	306240	136800	169440
25-yr	Duration	Intensity	Peak Q	Inflow	Outflow	Storage	5-yr	Duration	Intensity	Peak Q	Inflow	Outflow	Storage
	(min)	(in/hr)	(cts)	(cd)	<u>ਰ</u>	(cf)		(min)	(in/hr)	(cts)	ਹੁ	<u>G</u>	(c)
	15	6.5	138.1	124290	39150	85140		15	5.1	108.4	97560	30375	67185
	20	5.8	123.3	147960	45675	102285		20	4.5	92.6	114720	35438	79283
	30	4.8	102.0	183600	58725	124875		90	3.6	76.5	137700	45563	92138
	40	4.1	87.1	209040	71775	137265	•2	40	3.1	62.9	158160	55688	102473
	20	3.6	76.5	229500	84825	144675		20	2.7	57.4	172200	65813	106388
	8	3.2	68.0	244800	97875	146925		09	2.4	51.0	183600	75938	107663
	20	2.9	61.6	258720	110925	147795		20	2.2	46.8	196560	86063	110498
	80	2.7	57.4	275520	123975	151545		8	2.0	42.5	204000	96188	107813

Determine pond geometry based on 100-year storage requirements and develop stage/storage relationships.
 Max. storage required = 187875
 Max. depth = 4"

	S		189308	177176	165209	153404	141760	130276	118950	107781	99296	85905	75196	64637	54228	43965	33848	23876	18959	14113	9339	4635	0
	side slope	Depth	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	9.0	0.4	0.2	0.0
	m with 4:1	Area	60784	59996	59213	58436	57663	56896	56134	55377	54625	53878	53136	52399	51668	50941	50220	49504	48793	48087	47386	46691	46000
	225' botto	Width	262.0	260.4	258.8	257.2	255.6	254.0	252.4	250.8	249.2	247.6	246.0	244.4	242.8	241.2	239.6	238.0	236.4	234.8	233.2	231.6	230.0
.4	$try = 180^{\circ} x$	Length	232.0	230.4	228.8	227.2	225.6	224.0	222.4	220.8	219.2	217.6	216.0	214.4	212.8	211.2	209.6	208.0	206.4	204.8	203.2	201.6	200.0
Max. depth = 4	Pond geometry = 180' x 225' bottom with 4:1 side slopes	Elevation	104.0	103.8	103.6	103.4	103.2	103.0	102.8	102.6	102.4	102.2	102.0	101.8	101.6	101.4	101.2	101.0	100.8	100.6	100.4	100.2	100.0

4. Given pond geometry, determine depth for each storm storage requirements.

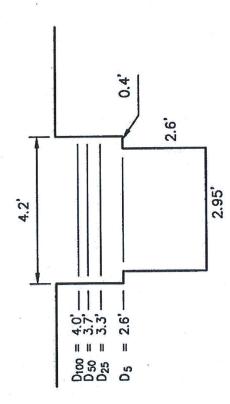
Depth	2.6	3.3	3.7	4.0
Storage	106388	146925	172020	187875
	5-yr	25-yr	50-yr	100-yr

5. Select trial outlet structure

		Could include a multi-stage weir, a triangular weir, pipes or combinations of these	r combinations	of these	
Step weir	For a mult	For a multi-stage weir, the flow over a snarp-crested weir is found as follows:	IS TOUTION AS TOUR	OWS.	
•	Q = C*L*hA(3/2)	(Z:E)V	2	22	22
	# O	3.3	3.3	3.3	3.3
	<u>ت</u> "	(Measured weir length)	2.95	3.75	3.75
		Length (adjusted for end contractions)	2.43	3.61	3.53
	11	head, above weir crest	2.6	0.7	1.
	11		33.6	40.6	47.1
	Q Req'd.		33.8	43.5	48.0

3.3 3.75 3.47 1.4 52.6

Each flow must match within a reasonable tolerance, since the required storage is determined from this outflow. This process must generally be iterative to reconcile all the parameters for each of the four storm events. Changes in the outflow assumption affect the storage required, thus the pond geometry, thus the head. In this sample, a step weir will control all flows to below or within 2% above the target flows. Other options include multiple pipes at varying elevations, V-notch weirs or combinations.



SAMPLE OUTLET STRUCTURE

## **CONSTRUCTION PLAN CHECKLIST**

The items indicated below shall be shown on all construction plans where appropriate. This checklist should be considered a guide, and may not include all required elements of a complete set of construction plans. A completed copy of this checklist shall be submitted to the City Engineer with all submitted construction plans. Provide an explanation for all information not provided or not applicable.

PROVIDED	NOT <u>PROVIDED</u>	NOT APPLICABLE	DESCRIPTION
DRAINAGE	AREA MAP	s	
			Drainage area map depicting contours and drainage areas for all runoff either from or through the site Show proposed contours on project site Existing and proposed storm drains and inlets Sub-area delineations for each design point, alley, street and off-site area Current zoning shown on drainage area calculation table Design points of concentration or collection labeled Drainage areas and flow rate calculations (both existing and proposed) Flow direction arrows shown at all street crests, sags, alleys and intersections Pipe hydraulic calculations Street and alley capacity calculations Inlet calculations Ditch and channel hydraulic calculations Other hydraulic calculations Calculations address off-site runoff (existing and proposed) both to and from the site Engineer's seal and certification (see below)
STORM DR	AINAGE PL	ANS	Plan and profile of all proposed storm drain systems at 1" = 50' or larger Stationing along centerline of pipe Curve data Pipe size, length, grade and material for each pipe segment in profile Station and offset to block corners Station and offset to inlets, culverts and other special structures Junction box provided at all junctions of trunk lines
			Junction box or manhole provided at max. 400' spacing (pipe ≤ 24")  Junction box provided at max. 800' spacing (pipe≥ 27")  Minimum Class III RCP pipe specified  Inlets provided where street or alley capacity is exceeded  Property lines, right-of-way lines and easements

		Edward Van Company	Existing and proposed ground elevations on profiles
PROVIDED	NOT PROVIDED	NOT APPLICABLE	DESCRIPTION
			100-year hydraulic grade lines, velocities, Q required and Q provided
			Size of inlet shown on plan view, lateral size, street station, flowline elevation and top-of-curb elevation
			Future streets and grades, where applicable
		-	100-year HGL with elevations at each appurtenance
-			Outlet erosion/sedimentation protection provided 100-year hydraulic grade line at outfalls
	8		Profiles for all laterals
			Headwalls shown at all discharge points Existing and proposed utilities shown
			Benchmarks shown on each sheet
			Alley capacity calculations provided
			Curb provided along alleys within 10 feet of inlet Flow line elevations and pipe slope shown in profile
			Off-site easements provided, where applicable
2		-	Off-site letters of acknowledgement, where applicable Standard City details used or waived
			otandard Oity detaile doed of warved
<b>Grading P</b>	lans		E : C = c = (d) = c = (d) = c = (d)
			Existing contours shown (1' contour interval)  Proposed contours shown (1' contour interval) for
			commercial and industrial developments
			Proposed spot elevations and flow arrows shown for residential developments, including top of curb elevations
			and at each building corner
	-		Flow arrows on lots, streets and alleys
			Minimum finish floor elevations adjacent to streams, channels and low point inlets shown
			Overflow swales provided at all low point inlets
Channel P	lane		
			Plan & profile showing horizontal and vertical alignment of
			channel with centerline stationing and curve data  Profile including proposed flowline, top of bank on each
	I		side, existing ground line at center of proposed
			channel, 100-year water surface
			Channel capacity and velocity shown Channel design based on subcritical flow
			Erosion protection (temporary and permanent) shown
	-		Property lines, easements and right-of-way shown Existing and proposed utilities
			Typical section(s) with min. 4:1 side slopes
			Actual sections at 100' intervals
			Benchmarks shown on each sheet USACE 404 permit application (copy attached)
			FEMA CLOMR application (copy attached)

PROVIDED	NOT PROVIDED	NOT APPLICABLE	DESCRIPTION
Storm Wat	er Pollutio	n Preventio	n Plans (SWPPP)
			Erosion control measures comply with NCTCOG BMP's Notice of Intent (NOI) (copy attached) Sealed by Professional Engineer Location of construction structural control measures shown Sequencing and/or phasing identified Maintenance and inspection procedures outlined Stabilization measures identified Post-construction measures shown
Detention/	Retention	<u> </u>	Dam hazard classification certification provided
			USACE 404 permit application (copy attached) TNRCC Permit to Appropriate Public Water application (copy attached) Routing, storage, outlet calculations shown /models provided Outlet structure details provided Emergency overflow provided Discharge limited to pre-development flows for 5-, 10-, 25- and100-year storms Normal pool, 100-year water surface shown (on plan and section views) Embankment details and specifications provided Benchmarks shown on each sheet Soil boring logs shown Required 1' freeboard provided Typical cross section of detention/retention pond
prepared the requirement this study is	nis drainage ts of the C s suitable fo	e study in co ity of DeSoto or determinin	stered professional engineer in the State of Texas, have ompliance with the latest published policy, criteria, and by have verified that the topographic information used in a drainage areas; and have determined that this plan of ugh proper planning, design, and construction methods.

The above certification shall be affixed to the Drainage Area Map.

# FLOODWAY EASEMENT STATEMENT

This plat is approved by the City Engineer of the City of DeSoto and accepted by the Owner, subject to the following conditions which shall be binding upon the Owner, his heirs, grantees, successors, and assigns:
The existing watercourses, creek or creeks described as Floodway Easement traversing along Block, within the limits of this addition, will remain as an open channel at all times and will be maintained by the individual owners (or neighborhood association) of the lot or lots that are traversed by or adjacent to the drainage courses in Block The City of DeSoto will not be responsible for the maintenance and operation of said watercourses, creek or creeks or for any damage to private property or person that results from the flow of water along said creek, or for the control of erosion in the Floodway Easement.
No obstruction to the natural flow of stormwater run-off shall be permitted by filling or by construction of any type of dam, building, bridge, fence, walkway or any other structure within the Floodway Easements, as hereinafter defined in Block, unless approved by the City Engineer. Provided, however, it is understood that in the event it becomes necessary for the City of DeSoto to erect any type of drainage structure in order to improve the storm drainage that may be occasioned by the streets and alleys in or adjacent to the subdivision, then in such event, the City of DeSoto shall have the right to enter upon the Floodway Easement at any point or points, to erect, construct and maintain any drainage facility deemed necessary for drainage purposes. Each property owner (or neighborhood association) shall keep the Floodway Easements traversing or adjacent to his property clean and free of debris, silt and any substance which would result in unsanitary conditions, and the City of DeSoto shall have the right of ingress and egress for the purpose of inspection and supervision of maintenance work by the property owner (or neighborhood association) to alleviate any undesirable conditions which may occur.
The natural drainage channels and watercourses through Block, as in the case of all natural channels, are subject to stormwater overflow and natural bank erosion to an extent which cannot be definitely defined. The City of DeSoto shall not be held liable for any damages of any nature resulting from the occurrence of these natural phenomena, nor resulting from the failure of any structure of structures, within the Floodway Easement.
The natural drainage channel crossing each lot is shown by the Floodway Easement line(s) shown on the plat.
Building areas outside the Floodway Easement line should be filled to a minimum elevation of The minimum floor elevations on houses built within this subdivision shall be as shown on this plat.

Floodway Marker monuments shall be installed, delineating the proposed Floodway Easement line(s), prior to filing of plat, along all rear or side lot lines that are adjacent to the creek. The surveyor shall provide signed and sealed documentation that the Floodway Marker monuments have been installed prior to obtaining the signature of the City Engineer.

## DRAINAGE EASEMENT STATEMENT

This plat is approved by the City Engineer of the City of DeSoto and accepted by the Owner, subject to the following conditions which shall be binding upon the Owner, his heirs, grantees, successors, and assigns:

The proposed storm drain facilities within the limits of this addition will be constructed within the drainage easements shown on the plat. The City of DeSoto will not be responsible for any damage to private property or person that results from the flow of water in or along said storm drain facilities, or for the control of erosion in the Drainage Easement.

No obstruction to the natural flow of stormwater run-off shall be permitted by filling or by construction of any type of dam, building, bridge, fence, walkway or any other structure within the Drainage Easements, as hereinafter defined in Block \_\_\_\_\_\_, unless approved by the City Engineer. Provided, however, it is understood that in the event it becomes necessary for the City of DeSoto to erect any type of drainage structure in order to improve the storm drainage that may be occasioned by the streets and alleys in or adjacent to the subdivision, then in such event, the City of DeSoto shall have the right to enter upon the Drainage Easement at any point or points, to erect, construct and maintain any drainage facility deemed necessary for drainage purposes. Each property owner (or neighborhood association) shall keep the Drainage Easements traversing or adjacent to his property clean and free of debris, silt and any substance which would result in unsanitary conditions, and the City of DeSoto shall have the right of ingress and egress for the purpose of inspection and supervision of maintenance work by the property owner (or neighborhood association) to alleviate any undesirable conditions which may occur.

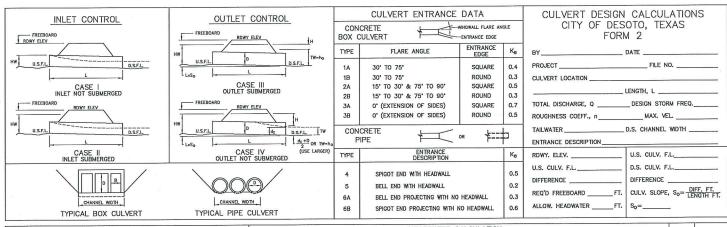
The storm drain facilities through Block \_\_\_\_\_\_, as in the case of all drainage facilities, are subject to stormwater overflow to an extent which cannot be definitely defined. The City of DeSoto shall not be held liable for any damages of any nature resulting from the occurrence of these natural phenomena, nor resulting from the failure of any structure or structures, within the Drainage Easement.

The Drainage Easement crossing each lot is shown by the Drainage Easement line(s) shown on the plat.

#### **DETENTION AREA EASEMENT**

This plat is approved by the City Engineer of the City of DeSoto and accepted by the Owner, subject to the following conditions which shall be binding upon the Owner, his heirs, grantees, successors, and assigns: The proposed detention area(s) along Block \_\_\_\_\_, within the limits of this addition, will remain as detention areas to the line and grade shown on the plans at all times and will be maintained by the individual owners (or neighborhood association) of the lot or lots that are traversed by or adjacent to the detention areas in Block The City of DeSoto will not be responsible for the maintenance and operation of said detention areas or for any damage or injury to private property or person that results from he flow of water along, into or out of said detention areas, or for the control of erosion. No obstruction to the natural flow of stormwater run-off shall be permitted by filling or by construction of any type of dam, building, bridge, fence, walkway or any other structure within the designated detention areas, as hereinafter defined in Block unless approved by the City Engineer. Provided, however, it is understood that in the event it becomes necessary for the City of DeSoto to erect any typed of drainage structure in order to improve the storm drainage that may be occasioned by the streets and alleys in or adjacent to the subdivisions, then in such event, the City of DeSoto shall have the right to enter upon the detention areas at any point or points, to erect, construct and maintain any drainage facility deemed necessary for drainage purposes. Each property owner (or neighborhood association) shall keep the detention areas traversing or adjacent to his property clean and free of debris, silt and any substance, which would result in unsanitary conditions or blockage of the drainage. The City of DeSoto shall have the right of ingress and egress for the purpose of inspection and supervision of maintenance work by the property owner, or to alleviate any undesirable conditions which may occur. The detention area in Block \_\_\_\_\_, as in the case of all detention areas, is subject to storm water overflow to an extent which cannot be clearly defined. The City of DeSoto shall not be held liable for any damages of any nature resulting from the occurrence of these natural phenomena, nor resulting from the failure of any structure or structures, within the detention areas or the subdivision storm drainage system. The detention areas serving the plat are shown by the detention area easement line(s)

as shown on the plat.



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TRIAL		DEPTH D.	RANGE R.			POSSIBL	E CULVER	RT SIZES			INL	ET CONTR	OL '							OUTLET C							GREATER CONTROLLING	SELECTED
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CITY OF DESOTO, TEXAS
HYDRAULIC COMPUTATIONS

DRAINAGE MASTER PLAN FORM 1