Drainage Policy

For

City of Brownsville, Texas

Engineering Department

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Drainage Improvements Policy

1.1 Purpose

The purpose of this section is to outline the general requirements for the design of stormwater improvements and provide typical details for construction. These design guidelines are for use as minimum acceptable design criteria only and are not to be constructed as a waiver by the City of Brownsville of the right to require a more stringent or lenient design as conditions warrant for public safety. Design Engineers are responsible for initiating written requests for approval of any design concepts that differ from these standards, verifying additional requirements set forth by other departments of the City or other Government agencies, performing any necessary calculations or studies, and resolving any problems with appropriate departments or agencies. Our efforts in implementing these guidelines will allow us to maintain a high standard for improvements within public right of ways and reduce future maintenance cost to the residents of Brownsville.

The design guidelines presented on this document were prepared in an effort to facilitate the design, review and construction of proposed drainage infrastructure improvements. The methodologies appearing in the sections below are consistent with engineering practice and are intended to serve as guidance in the design of related infrastructure. Interpretation, implementation and Engineering judgment shall be the responsibility of the Engineer on record.

1.2 Drainage Improvements

All storm sewer mains extended or proposed to the City of Brownsville's storm water collection systems and watercourses shall be designed and constructed in accordance with the following requirements.

A. General Policy:

1. All Development within the City of Brownsville shall include planning, design and construction of storm drainage systems in accordance with this manual.

2. Drainage reports and drainage improvements shall be performed and designed by a Professional Engineer licensed to practice in the State of Texas and are subject to approval by the City Engineer.

3. All drainage studies and design plans shall be formulated and based upon ultimate, fully developed watershed or drainage area runoff conditions. In certain circumstances where regional detention is in place or a master plan has been adopted, a development

may plan to receive less than ultimate developed flow from upstream with the approval of the City Engineer.

4. Storm water must be carried to an adequate or acceptable outfall. An adequate outfall is one that does not create or increase flooding or erosion conditions downstream and is approved by the City Engineer.

5. Proposed stormwater discharge rates and velocities from a development shall not exceed the runoff from existing, pre-development conditions, unless a detailed study is prepared that demonstrates that no unacceptable adverse impacts will be created. Adverse impacts include: new or increased flooding of existing insurable (FEMA) structures, significant increases in flood elevations over existing roadways, unacceptable rises in FEMA base flood elevations, and new or increased stream bank erosion.

6. If a development drains into an improved channel or storm water drainage system designed under a previous drainage policy, then the hydraulic capacities of downstream facilities must be checked to verify that increased flows, caused by the new development, will not exceed the capacity of the existing system or cause increased downstream structure flooding. If there is not sufficient capacity to prevent increased downstream flooding, then detention or other acceptable measures must be adopted to accommodate the increase in runoff due to the proposed development.

7. Storm water runoff may be stored in detention and retention basins to mitigate potential downstream problems caused by a proposed development. Proposed detention or retention basins shall be analyzed both individually and as a part of the watershed system, to assure compatibility with one another and with the City's overall Drainage Master Plan for that watershed (if available). Storage of stormwater runoff, near to the points of rainfall occurrence, such as the use of ball fields, property line swales, parks, road embankments, borrow pits and on-site ponds is desirable and encouraged.

8. Alternatives to detention or retention, for mitigation of potential downstream problems caused by proposed development, include: acquisition of expanded drainage easements, ROW, or property owner agreements; downstream channel and/or roadway bridge/culvert improvements or stream bank erosion protection; and financial contributions to the City of Brownsville's Storm Water Utility Program for future improvements. These alternatives will be considered by the City Engineer, as presented by the developer, on a case-by-case basis.

9. Stream bank stabilization and protection shall be required to prevent erosion and sedimentation from creeks, streams, and channels.

10. Required Easements:

a. Drainage easements shall be required for both on-site and off-site public storm water drainage improvements, including standard engineered channels, storm drain systems, public detention/retention facilities and other stormwater controls.

b. Temporary drainage easements may be allowed off-site for temporary channels when future off-site development is anticipated to enclose the channel in conduit or follow an altered alignment. Temporary drainage easements will not be maintained by the City and will not terminate until permanent drainage improvements meeting City standards are installed and accepted. Temporary drainage easements will require written approval from the City Engineer and the City Attorney. Maintenance of a temporary drainage easement shall be maintained by the property owner(s) or a homeowners association if applicable.

c. Private drainage easements, not dedicated to the city, may be required for private storm water drainage improvements serving multiple lots or for storm water controls on a property. These improvements and easements will require a maintenance agreement with the City of Brownsville.

d. Access easements shall be provided for access to public storm water drainage improvements where necessary for maintenance.

e. Minimum width of easements required:

i. Storm Sewer:

≤ 30” Storm Sewer :: 20 foot Easement

36” - 72” Storm Sewer :: 25 foot Easement

> 72” or Box Culvert wider than 8 feet :: 30 foot Easement

ii. Drainage Channel: Maximum width of channel at the top plus 30 feet continuous along one side and 15 feet continuous along the opposite side

iii. Access: 20 feet

iv. Resacas & Lakes: Extending from a point on the bank 20-25 feet from the calculated high water elevation to the property line in the water or to the center of the body of water whichever is further. Dedication width to be verified by Brownsville Public Utilities Board and dedication to read “Resaca maintenance and transportation Easement

11. Required Right of Way:

a. All drainage improvements in residential developments shall be located within right of way and/or easements.

b. Floodplain right of way shall be provided on sites along natural or improved earthen drainage ways (other than standard engineered channels). Floodplain rights of way shall encompass all areas below a ground elevation one foot above the water surface elevation of the base flood. The right-of-way shall also include at least a minimum 20 foot wide maintenance strip along both sides of the channel to provide ingress and egress for maintenance of the banks, as determined and required by the City Engineer. The access shall be part of the floodplain right of way itself and not a separate easement. Floodplain rights of way are not routinely maintained by the City.

c. All proposed developments within the City of Brownsville and its (ETJ) shall comply with all local, county, state and federal regulations and all required permits or approvals shall be obtained by the developer.

d. The policy of the City Brownsville is to avoid substantial or significant transfer of storm water drainage runoff from one basin to another and to maintain historical drainage paths whenever possible. However, the transfer of storm water drainage from basin to basin may be necessary in certain instances and will be reviewed by the City Engineer on a case-by-case basis.

1.3 Design Storm Requirements

Storm Water Runoff

A. Rational Method
Peak flows may be estimated with use of the Rational Method for areas less than 100 acres.

$$Q = CiA$$

Where:

Q = flow (cubic feet/second)
i = intensity (inches/hour)
A = Area (acres)

Rainfall Intensity

B. Rainfall and Intensity: the table below shows the Intensity-Duration-Frequency coefficients for Cameron County that are to be used for Intensity Calculations:

Table 1-1 Intensity-Design-Duration Coefficients for Cameron County, Texas

TABLE 1-1 IDF Coefficients

Recurrence Intervals (years)	**IDF Coefficients**		
	e	**B**	**d**
2	0.859	78.96	14.80
5	0.850	99.98	14.84
10	0.844	114.90	15.78
25	0.840	136.01	16.64
50	0.837	155.32	17.19
100	0.835	180.34	18.60
Reference: United States Geological Survey (USGS) Scientific Investigation Report 2004-5041 "Atlas of Depth Frequency of Precipitation Annual Maximum for Texas" or the Latest updated EBD Spreadsheet for "Rainfall Intensity-Duration-Frequency Coefficients for Texas			

Intensity can be calculated by the relationship presented below:

$$i = \frac{B}{(t_c + d)^e}$$

Where:

i = intensity (inches/hour)

tc = time of concentration (minutes)

e, B, d = IDF Coefficients (reference Table 1-1)

Time of Concentration

C. Time of concentration may be estimated by considering the velocity associated with three typical flow regimes; overland/sheet flow, shallow concentrated flow and pipe or channel flow. Time of concentration shall be calculated for each applicable flow regime encountered. If the time of concentration exceeds 20 min in a five year event, you must use a 10 year event.

$$tc = \frac{L}{60V}$$

Where:

tc = travel time (minutes)

L = watercourse length (feet)

V = average flow velocity (feet/second)

Velocity Estimates:

D. Velocities for overland/sheet flow and shallow concentrated flow may be estimated with the following relationship.

$$V = K_u k S_p^{0.5}$$

Where:

$\mathbf{K_u}$ = 3.28
V = velocity (feet/second)
k = intercept coefficient
$\mathbf{S_P}$ = slope (%)

Table 1-2: Intercept Coefficients

Land Cover/Flow Regime	k
Forest with heavy ground litter; hay meadows (overland flow)	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overflow)	0.152
Short Grass pasture (overland flow)	0.213
Cultivated straight row (overland flow)	0.274
Nearly bare and untilled (overland flow); alluvial fans in western mountain regions	0.305
Grasses waterway (shallow concentrated flow)	0.457
Unpaved (shallow concentrated flow)	0.491
Paved area (shallow concentrated flow); small upland gullies	0.619

E. Manning's Equation shall be used to estimate average flow velocities in channels and conduits. Storm water runoff shall be calculated for fully developed conditions. Minimum inlet time of concentration shall be 10-minutes.

$$V = \left(\frac{1.49}{n}\right) R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Nomenclature:

V = velocity (feet/second)
n = Manning's roughness coefficient
R = Hydraulic radius (feet)
S = slope

The Manning's 'n' value or coefficient is a parameter that represents the "roughness" or resistance to flow that the water flowing in a channel will encounter. The more vegetation or obstructions to flow that occur, the higher the 'n' value. Refer to table 1-4 for Manning's Roughness Coefficient values.

SCS Unit Hydrograph

For areas greater than 100-acres, SCS Unit Hydrograph (Ty III rainfall distribution) methodology shall be utilized. In addition, applicable hydrologic software(s) may be utilized with approval from the City Engineer.

Street Flow

In an effort to maintain safe passage of vehicular and pedestrian traffic and to ensure properties are kept reasonably safe from flooding, the designer shall be responsible for determining the depth and width of stormwater runoff. Calculated ponding widths and depths shall be presented on storm sewer plan sheets.

The width of spread on a pavement section shall be contained to provide passage of vehicular traffic as specified in Table 1-3 below:

TABLE 1-3 Spread Limits for Roadways

FUNCTIONAL CLASSIFICATION	CLEAR LANES
Local	(a)
Collector	1-11 foot
Minor Arterial	2 - 11 foot (1 each way)
Principal Arterial	2- 11 foot (1 each way)

(a) No width requirement, depth not to exceed top of curb

In all cases, depth of flow shall be maintained at or below the top of the curb. For inlets located at sag points, the designer shall consider the effects resulting depths on existing and/or proposed adjacent grades.

Determination of Spread Widths

Flow in a gutter section can be calculated with adaptation of Manning's Equation.

$$Q = (\frac{K_u}{n}) S_x^{1.67} S_L^{0.5} T^{2.67}$$

Spread width can be determined by the formula

$$T = (\frac{Q_n}{K_u S_x^{1.67} S_L^{0.5}})^{0.375}$$

Where:
Ku = 0.56
n = Manning's roughness coefficient
Q = flow (cubic feet/ second)
T = Spread width (feet)
S_x = cross slope (foot/foot) S_L = longitudinal slope (foot/foot)

Depth of flow in a gutter section can be calculated by the formula

$$D = TS_x$$

WHERE:
D = depth of flow (feet)
T = spread width (feet)
S_x = cross slope (foot/foot)

Table 1-4: Manning's Roughness Coefficients (n)

TYPE OF LAND OR PAVEMENT	MANNING'S n
Concrete gutter, troweled finish	0.012
Asphalt Smooth Texture Rough Texture	 0.013 0.016
Concrete gutter-asphalt pavement Smooth Texture Rough Texture	 0.013 0.015
Concrete Pavement Float Finish Broom Finish	 0.014 0.016
Earth Channel maintained Bare Earth Straight and Uniform w/ short grass & few weeds	 0.025 0.035
Earth Channel NOT maintained Bare Earth Clean Bottom, Brush on sides	 0.028 0.050
Undeveloped Pasture short grass Pasture high grass Cultivated area w/ mature row crop Cultivated area w/ mature field crop Light brush & trees	 0.030 0.035 0.035 0.040 0.055

Runoff Coefficients:

F. Runoff Coefficients shall be determined for each drainage area. Weighted coefficients shall be determined with application of the Weighted Runoff Coefficient formula when multiple surfaces exist.

$$C_W = \frac{C_1A_1 + C_2A_2 + C_3A_3 + ... + C_nA_n}{A_{total}}$$

Nomenclature:

C_W = Weighted Runoff Coefficient

C_n = Runoff Coefficient n-th term

A_n = Area of n-th term (acres)

A_{total} = Total Area (acres)Table 1-5 (Values of C (Run-off Coefficient) In Formula Q = CIA) presents typical ranges for "C". Runoff coefficients utilized for 25-year and 50-year storm frequencies shall be adjusted by 10% and 20% respectively.

TABLE 1-5

VALUES OF (RUN-OFF COEFFICIENT) IN FORMULA Q=CIA

TYPE OF DRAINAGE AREA	RUNOFF COEFFICIENT
Business:	
Downtown areas	**0.70-0.95**
Neighborhood areas	**0.30-0.70**
Residential:	
Single-family areas	**0.30-0.50**
Multi-units, detached	**0.40-0.60**
Multi-units, attached	**0.60-0.75**
Suburban	**0.35-0.40**
Apartment dwelling areas	**0.30-0.70**
Industrial:	
Light areas	**0.30-0.80**
Heavy areas	**0.60-0.90**

Parks, cemeteries	**0.10-0.25**
Playgrounds	**0.30-0.40**
Railroad yards	**0.30-0.40**
Unimproved areas:	
Sand or sandy loam soil, 0-3%	**0.15-0.20**
Sand or sandy loam soil, 3-5%	**0.20-0.25**
Black or loessial soil, 0-3%	**0.18-0.25**
Black or loessial soil, 3-5%	**0.25-0.30**
Black or loessial soil, > 5%	**0.70-0.80**
Deep sand area	**0.05-0.15**
Steep grassed slopes	**0.7**
Lawns:	
Sandy soil, flat 2%	**0.05-0.10**
Sandy soil, average 2-7%	**0.10-0.15**
Sandy soil, steep 7%	**0.15-0.20**

Heavy soil, flat 2%	**0.13-0.17**
Heavy soil, average 2-7%	**0.18-0.22**
Heavy soil, steep 7%	**0.25-0.35**
Streets:	
Asphaltic	**0.85-0.95**
Concrete	**0.90-0.95**
Brick	**0.70-0.85**
Drives and walks	**0.75-0.95**
Roofs	**0.75-0.95**

Link: http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm

Inlet Design Considerations

Curb and grate inlets shall be used to facilitate the drainage of pavement sections and open areas. Placement of inlets shall consider the safety of pedestrian, vehicular and bicycle traffic. Inlets shall be placed at low points and at intervals necessary to meet maximum permissible spread limits and inlet capacities. In any case, inlet spacing shall not exceed 600-feet, with a maximum surface run of 300-feet from crest to sag of the roadway profile. In the event a longitudinal roadway profile exceeds 300-feet from crest to sag, inlets shall be spaced at a maximum of 300-feet. Flows shall be intercepted upstream of street intersections where practical. Any exemptions to these requirements may be considered by the City Engineer.

Runoff across roadway intersections consisting of a minor or principal arterial street is prohibited. For inlets on grade, by-pass flows shall be limited to 10% of previously intercepted flows. When curb inlet extensions are required, no more than two extensions shall be used in conjunction with a primary inlet. Inlet hydraulics shall be presented on plan sheets. The use of inlets other than curb-opening or grate inlets shall require approval from the City Engineer.

Inlet Capacity

Capacities for inlets may be determined by the following equations.

Curb Opening Inlets on Grade

$$L_T = K_u Q^{0.42} S_L^{0.3} \left(\frac{1}{nS_x}\right)^{0.6}$$

WHERE:

L_T = curb opening length for 100% interception (feet)
K_u = 0.6
Q = flow in gutter (cubic feet/second)
S_L = longitudinal slope (foot/foot)
n = Manning's roughness coefficient
S_x = cross slope (foot/foot)

For curb inlets utilizing a depressed curb opening, the following equation is used.

$$L_T = K_u Q^{0.42} S_L^{0.3} \left(\frac{1}{nS_e}\right)^{0.6}$$

In this case the cross slope, SX is replaced by an equivalent cross slope, Se that accounts for the depressed gutter section. The equivalent cross slope is calculated by

$$S_e = S_x + S'_w E_o$$

WHERE:
S_e = Equivalent cross slope (foot/foot)
S_x = Pavement cross slope (foot/foot)
S'_w = gutter cross slope; gutter depression/gutter width (foot/foot)
E_o = Ratio of flow in depressed section to total gutter flow upstream of inlet

Curb Opening Inlets- Sag Location

Curb Opening inlets operate under weir or orifice flow conditions. Capacity of a curb opening inlet under weir conditions can be estimated by the following relationship.

$$Q_I = C_w(L + 1.8W)d^{1.5}$$

WHERE:

C_w = weir coefficient

Suggested value = 2.3 for depressed inlets

Suggested value = 3.0 without depression

L = length of curb opening (feet)
W = lateral width of depression (feet)
If L > 12 ft., then W = 0 and C_w = 3.0 ft.
d = depth at curb measured from normal cross slope (feet)

This formula is applicable for depths less than the curb opening plus the depth of the depression

$$d \leq h + \frac{a}{12}$$

WHERE:
h = curb opening height (feet)
a = depth of depression (inches)

$$Q_I = C_o hL(2gd_o)^{0.5}$$

Or

$$Q_I = C_o A_g[2g(d_1 - \frac{h}{2})]^{0.5}$$

WHERE:
C_o = 0.67 (orifice coefficient)
d_o = head on center of orifice throat (feet)
L = length of orifice opening (feet)
A_g = clear area of opening (square feet)
d_1 = depth at lip of curb opening (feet)
h= height of curb opening orifice (feet)

For curb opening inlet other than vertical face use

$$D_o = d_1 - (\frac{h}{2})sin\Theta$$

h= orifice throat width (feet)
Do = effective head on center of orifice throat (feet)

Grate Inlets in Sag Locations

As weir flow:

$$Q_I = C_W P d^{1.5}$$

WHERE:

P = perimeter of the grate (feet) disregarding curbside
d = average depth across grate (feet)
Cw = 3.0

As an orifice,

$$Q_I = C_o A_g (2gd)^{0.5}$$

WHERE:

Co = 0.67 (orifice coefficient)
Ag = clear opening area of grate (square feet)
g = 32.2 (feet/second/second)
Grate inlet design shall incorporate a 50 % factor to account for clogging.

2.0 Drainage Report Requirements

Requirements: Drainage Report to be submitted to city (and Cameron County Drainage District #1, TxDOT, if applicable) with preliminary plans for review.

The following information shall be required as part of the drainage report for new developments:

1) Cover Sheet
    a) Firm's Name, Title, Prepared by, Date, & Engineering Seal
2) Index
3) Summary of Project
    a) Engineering Seal
    b) Project Location description (City/ETJ)
    c) Flood Plain (FEMA info)
    d) Soil Conditions: Map symbol, Soil Name, Group and Unified Class
    e) Existing and proposed drainage conditions
    f) Pre Development 10-Yr CFS
    g) After Development 50-Yr CFS or as required by municipality
    h) Proposed Use
    i) Flow Direction and Outfall Location

j) Outfall location and owner
k) Increase Q (CFS) rate
l) Detention Volume (cf and AC-ft)

4) Vicinity map showing location of project
5) Location of proposed site with respect to the latest FEMA Floodplain map
6) USGS Topo Map with location of proposed site
7) Summary of Soil Conditions and Soil Classifications
8) Summary of Existing Drainage Conditions
9) Summary of Proposed Drainage Conditions
10) Summary of detention requirements based on the 2, 10, 25, and 50 year storm events
11) Attachments
    a) Exhibit A - Drainage Area Map
        i) All contributing areas
        ii) Contours and spot elevations
        iii) Right-of-Way, property lines
        iv) Direction of flow
        v) Existing and Proposed storm sewer systems and outfalls
        vi) Design assumptions
    b) Exhibit B - FEMA Floodplain Map with respect to project location
    c) Exhibit C - USGS Topo Map with respect to project location
    d) Exhibit D - Soils Survey Map
    e) Exhibit E - Existing Drainage Features Map
        i) Drainage channels
        ii) Streams
        iii) Flood control improvements
        iv) Other facilities
    f) Exhibit F - Storm Water Pollution Prevention Plan (SWPPP)
    g) Exhibit G - Drainage Calculations
        i) Runoff, detention and hydraulic summary
        ii) Time of concentration (Tc) estimates
        iii) Runoff coefficient (c) assumptions
        iv) Storage volume calculations (Modified Rational Method)
        v) Pipe and inlet capacities
        vi) Detention pond dimensions
        vii) Hydraulic Grade Line (HGL)
    h) Exhibit H - Storm Sewer Plan and Profile Plan
        i) Right-of-Way/property lines
        ii) Storm sewer alignment

iii) Direction of flow
iv) High points
v) Identification of existing and proposed storm sewer
vi) Identification of existing and proposed storm sewer inlets, manholes and junctions
vii) Applicable details (other than standard)
viii) Profile
ix) Pipe length, size, class, and slope
x) Identification of inlets, manholes, junction boxes
xi) Flow lines at structures, outfalls; 100-foot intervals along storm sewer length
xii) Finished grade/natural ground
xiii) Utility crossings, conflicts
xiv) Hydraulic Grade Line (10-year)
xv) Top of curb elevations
xvi) Manhole rim elevations
xvii) Trench protection limits

i) Exhibit I - Bridge/Culvert Layout
   i) Plan and Profile
   ii) Hydraulic calculations
   iii) Applicable details

j) Exhibit J - Channels and Detention Basin
   i) Grading Plan
   ii) Earthwork Calculations
   iii) Typical Sections
   iv) Hydraulic calculations
   v) Design water surface elevations
   vi) Maintenance access
   vii) Applicable details

3.0 Storm Water Detention Design

1. General Policy
    a. Storm water runoff increases resulting from development shall be mitigated on-site for the 2, 10, 25, 50 -year meteorological events. The Modified Rational Method is to be used for determination of storm water storage requirements for developments less than 100 acres. Reference Table 3-1 for the Modified Rational Method calculation example.

Table 3-1 Modified Rational Method

(A)	(B)	(C)	(D)	(E)	(F)	(G)
Duration	Intensity	Qin	Qout	Vin	Vout	Storage
(min)	(in/hr)	(cfs)	(cfs)	(cf)	(cf)	(cf)

(A) – Duration in minutes

(B) – Intensity for respective duration

(C) – Developed conditions peak discharge

(D) – Developed conditions runoff volume

(E) – Pre-developed peak discharge

(F) – Pre-developed conditions runoff volume

(G) – Storage required (Vin – Vout)

b. Storm water runoff shall be released from the detention area into a receiving system at a maximum pre-development rate of 10-year frequency storm events.
c. On-site detention facilities shall be placed in dedicated areas unless otherwise approved by the City Engineer.
d. Maintenance of on-site detention areas shall be maintained by the property owner(s) or a homeowners association if applicable.
e. Provide adequate trash racks to prevent clogging of the outlet
f. Where possible, provide the installation of simple, reliable, and operator-free equipment for regulating outflow.

g. When fill is used to change the grade or elevation of a development, 70% of the material volume shall be added to the required detention by a 50 year storm. (i.e. if the required volume of the pond is 100,000 c.f., and the fill used for the development is 30,000 c.f. then 21,000 c.f. will be added to the volume of the pond for a grand total of 121,000 c.f.)

4.0 Storm Sewer Design

A. General Policy

1. Storm sewer systems shall be designed to convey runoff from a 10-year frequency storm event and checked for a 50 year frequency storm event where the surface elevation shall be a maximum of 12'' above the lowest top of curb elevation.
2. Storm drainage designs shall include provisions to account for off-site drainage patterns affected by any proposed improvements.
3. Storm sewer systems shall utilize rubber-gasket, Class IV reinforced concrete pipe (RCP) with a minimum size of 24 inches; other smaller pipes must be approved by the City Engineer.
4. Manholes or junction boxes shall be utilized at all changes in pipe size and direction in both horizontal and vertical planes. Manhole spacing shall be maintained as presented in Table 4-1.

Table 4-1 Suggested Manhole Spacing (1)

PIPE SIZE (INCHES)	MAXIMUM SPACING (feet)
24	300
27 to 36	375
42 to 54	450
60 and greater	900
Reference: onlinemanuals.txdot.gov	

5. Pipes shall be matched at soffits when practical. In instances where radial alignment is required, pipe joints shall not be deflected beyond manufacturer's suggested tolerances. Pipe slopes shall be designed to provide a minimum velocity of 3-feet per second and a maximum velocity of 12-feet per second. Table 4-2 on the next page presents the minimum slopes necessary to achieve the minimum velocity.

Table 4-2: Minimum Pipe Slopes

Diameter (inches)	Slope (foot/foot)	Slope (%)
24	0.00174	0.174
27	0.00148	0.148
30	0.00129	0.129
33	0.00114	0.114
36	0.00101	0.101
42	0.00082	0.082
48	0.00069	0.069
54	0.00059	0.059
60	0.00051	0.051
66	0.00045	0.045
72	0.00040	0.040
Based on Manning's Equation; v = 3 fps, n = 0.013		

6. All proposed outfalls shall provide a concrete sloped-end treatment approved by the City Engineer. Velocity dissipations shall be used when outlet velocities exceed the suggested maximum.

7. Minimum depth of cover for all storm sewer pipes shall be 3-feet from finished grade to the crown of the pipe. Depth of cover not meeting this requirement shall require structural calculations as approved by the City Engineer.

8. Trench protection shall be required for storm sewer system installations in accordance with Occupational Safety and Health Administration Trenching and Excavation Safety.

9. The maximum length of gutter flow before runoff is intercepted by an underground storm sewer system is 600’ from the high point to an inlet measured along the gutter.

10. Minimum gutter elevation to be at Base Flood Elevation (BFE).

11. Construction of pipe drains into City facilities shall require the pipe to be bedded and backfilled with suitable material to prevent settlement and wash outs. The downstream end of the pipe shall be no higher than one (1) foot above the flowline, and the pipe shall be oriented downstream in the channel. Concrete-rip-rap, or other suitable erosion prevention material, may be required.

12. Open ditch connections to existing channels are prohibited.

13. Culverts shall be bedded and backfilled with suitable material to prevent settlement and wash outs. Concrete rip-rap or other suitable erosion prevention material may be required.

14. Rubber Gasketed pipe requirements, minimum pipe size 24”

15. HDPE or Corrugated Metal is not acceptable, unless approved by the City Engineer.

4.1 Hydraulic Grade Line Analysis

A hydraulic grade line (HGL) analysis is required for all proposed storm sewer system improvements.

The analysis shall include determination and presentation of the 10-year HGL. The HGL shall be shown on all storm sewer profile plans. The hydraulic grade line shall be maintained at or below the throat of the inlet. Computations shall include determination of major and minor losses.

Starting water surface elevations shall be calculated from the best available data. The designer shall document all assumptions. For starting water surface elevations where an outfall is provided at a channel, a backwater analysis shall be utilized where no water surface data is available. Similarly, starting water surface elevations at ties to existing storm sewer systems shall utilize best available data and shall be reviewed and approved by the City Engineer.

4.2 Major Losses

Losses due to friction may be calculated by the relationship:

$$H_f = S_f L$$

WHERE:

Hf = loss due to friction (feet)

Sf = friction slope (feet)

L = length of conduit (feet)

Slope friction may be calculated by:

$$S_{f} = (Qn/K_Q D^{2.67})^2$$

WHERE:

S_f = friction slope (feet/feet)

Q = flow (cubic feet/ second)

n = Manning roughness coefficient

K_Q = 0.46

D = pipe diameter (feet)

Manning's roughness coefficient may be assumed as 0.013 for concrete pipe.

4.3 Minor Losses

Minor losses result from flow disturbances at junctions such as inlets, manholes or junction boxes. Minor losses may be calculated with application of the formula.

$$H_m = K (V^2/2g)$$

WHERE:

H_m = Minor losses (feet)

K = Constant of proportionality

V = Velocity (feet/second)

g = gravitational acceleration constant (32.2 feet/second/second)

$$K = K_O C_D C_d C_Q C_p C_B$$

K = adjusted loss coefficient

K_O = initial head loss coefficient based on relative access hole size

C_D = correction factor for pipe diameter (pressure flow only)

C_d = correction factor for flow depth

C_Q = correction factor for relative depth

C_p = correction factor for plunging flow

C_B = correction factor for benching

$$Ko = 0.1(b/D_O)\,(1\text{-}\sin\theta) + 1.4\,(b/D_O)^{0.15}\,\sin\theta$$

WHERE:

Θ = angle between pipes (degrees)

B= manhole/junction diameter (feet)

D_O = diameter of outlet pipe

$$C_D = (D_O/D_I)^3$$

D_O = diameter of outlet pipe

D_I = diameter of incoming pipe

Applicable if the ratio of the depth in junction to outlet pipe diameter is greater than 3.2 ($depth/D_O$) and pipe is flowing under pressure.

$$C_d = 0.5\ (d_{mh}/D_O)^{0.6}$$

WHERE:

$\mathbf{d_{mh}}$ **=** depth in $_{mh}$/junction

$\mathbf{D_O}$ **=** diameter of outlet pipe

This formula is applicable when $d_{mh}/D_O < 3.2$ and free surface flow or low pressure. Depth in the access hole is estimated as HGL at the upstream end of the outlet pipe.

$$C_Q = (1\text{-}2\ \sin\theta)\ (1\text{-}Q_I/Q_O)^{0.75} + 1$$

WHERE:

$\mathbf{C_Q}$ = relative flow correction factor

θ = angle between pipes

$\mathbf{Q_I}$ = flow in incoming pipe

$\mathbf{Q_O}$ = flow in outgoing pipe

The formula above is used only when 3 or more pipes enter the structure at approximately the same elevation.

4.4 Plunging Flow

$$C_p = 1 + 0.2\ (h/D_O)\ (h\text{-}d_{mh}/D_O)$$

WHERE:

$\mathbf{C_p}$ = Plunging flow correction factor

h = elevation difference between the invert of plunging flow pipe to center of outflow pipe

D_O = outlet pipe diameter

d_{mh} = depth of water in manhole relative to outlet pipe invert

The above equation is applicable if $h>d_{mh}$ and if the plunging flow is at a higher elevation and inflow and outflow pipes are at the bottom of the manhole/junction. This correction factor is also applied at curb and grate inlets functioning as junctions.

4.5 Benching

The following correction factor is applied to address benching configurations for either submerged or unsubmerged conditions.

TABLE 4-3 BENCH CORRECTION FACTOR, C_B

Bench Type	C_B SUBMERGED[1]	C_B UNSUBMERGED[2]
Flat or Depressed Floor	1.00	1.00
Half Bench	0.95	0.15
Full Bench	0.75	0.07
(1) Pressure flow $d_{mh}/D_O \geq 3.2$ (2) Free surface flow $d_{mh}/D_O \leq 1.0$		
Reference: FHWA, Urban Sewerage Design Manual HEC-22 (2001)		

4.6 Exit Losses

Exit losses shall be accounted for at all outfalls.

$$H_E = 1.0\left(\frac{V_O^{\,2}}{2g} - \frac{V_r^{\,2}}{2g}\right)$$

WHERE:

$\mathbf{V_O}$ = average velocity at outlet (feet/second)

$\mathbf{V_r}$ = velocity of receiving stream (feet/second)

All hydrologic and hydraulic design computations may be completed with the aid of design software approved by the City Engineer.

4.7 Pipe Bending

Manhole structures are commonly used to change direction of concrete pipe sewers, however restricting such changes to manhole structures can not always be practical or feasible.

1. Deflected Straight Pipe:

$$R = \frac{L}{2(tan(1/2)*\frac{\Delta}{N})}$$

where:

R = Radius of curvature, feet

L = Average laid length of pipe sections measured along the centerline, feet

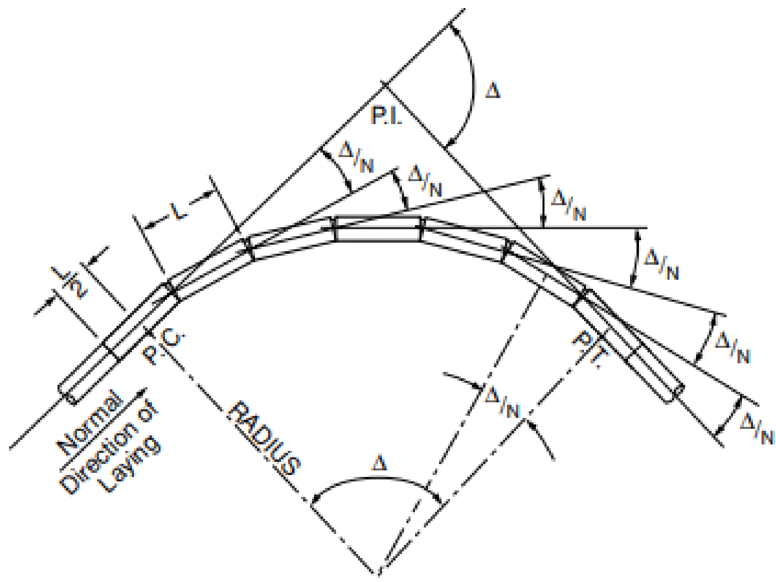
Δ = Total deflection angle of curve, degrees

N = Number of pipe with pulled joints

$\frac{\Delta}{N}$ = Total deflection of each pipe, degrees

*The radius of curvature which may be obtained by this method is a function of the deflection angle per joint and the length of the pipe sections. Thus, longer lengths of pipe will provide a longer radius for the same pull than would be obtained with shorter lengths.

Curved Alignment Using Deflected Straight Pipe



2. Radius Pipe:

$$tan(\frac{\Delta}{N}) = \frac{L}{R+(D/2)+t}$$

WHERE:

Δ = Total deflection angle of curve, degrees

N = Number of radius pipe

L = The standard pipe length being used, feet

R = Radius of curvature, feet

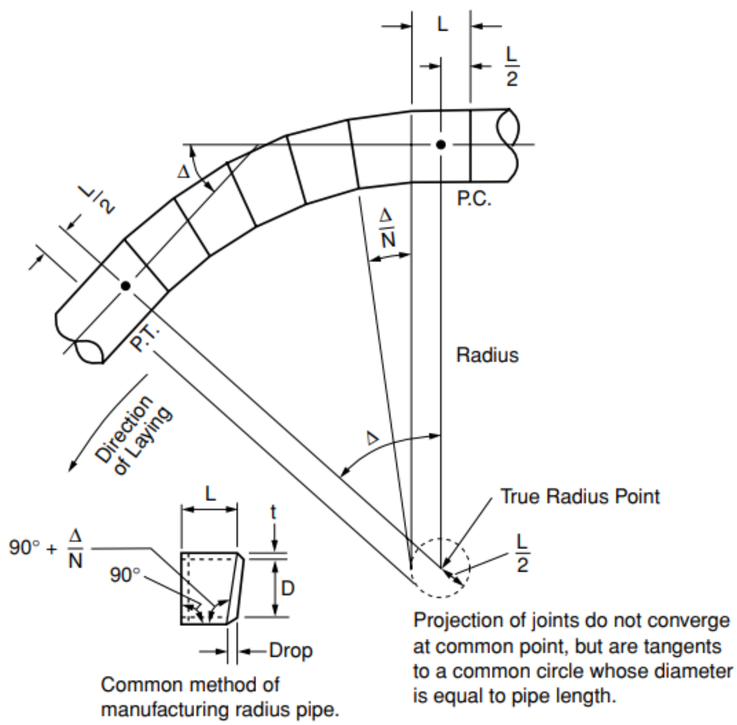
D = Inside diameter of the pipe, feet

t = Wall thickness of the pipe, feet

3. The required drop to provide the deflection angle:

$$Drop\ (inches) = 12(D + 2t)tan\frac{\Delta}{N}$$

Curved Alignment Using Radius Pipe



For more information regarding bends in pipes, refer to concrete pipe design manual
Link: https://www.concretepipe.org/wp-content/uploads/2014/09/cp-manual.pdf

5.0 Clearance

1. Submitted plans shall include the following for existing and proposed storm drain systems:
    a. Horizontal alignment of the storm drain system in plan view; and
    b. Vertical alignment of the storm drain system in profile view.
2. Plans and drawings shall:
    a. Label all storm drain lines "SD”;
    b. Label all storm drain lines with size (diameter for circular pipes, span by rise for box culverts, etc.) and material;
    c. Label clearance distances on the plan and profile when minimum clearances are not met; and
    d. Show storm drain lines that are 24-inches and larger as double-lined to render actual internal dimension(s) of the storm drain.
3. Conflict boxes
    a. Case 1: Sanitary sewer conflict

i. Casing shall be utilized when a sanitary line runs through a storm manhole. The casing is to be 20’ in length and centered at the manhole location.

b. Case 2: Utility conflict

i. Casing shall be utilized when a water line runs through a storm manhole. The casing is to be 20’ in length and centered at the manhole location.

c. Case 3: Sanitary sewer or waterline conflict

i. A sanitary sewer or water line may be allowed to pass through the bottom of a manhole or catch basin, but it must be placed in an appropriate size casing and sufficient concrete shall be added so as to provide a 6” minimum cover around the sanitary sewer/water line. Refer to Figure 1 for more details.

4. The following clearance requirements apply to all fixed infrastructure and utilities. Fixed infrastructure and utilities include, but are not limited to:
   a. Water and wastewater mains and service lines;
   b. Gas lines; and
   c. Dry utility services.
5. Clearances shall be measured from the outside edge of the other utility or infrastructure to the outside edge of the storm drain, manhole, inlet, or other appurtenance.
6. The minimum horizontal clearance shall be 60 inches (5 ft) for storm drain, inlet, or other appurtenance. The minimum horizontal clearance shall be 36 inches (3 ft) for storm drain manholes.
7. For storm drains smaller than 42 inches with a depth of cover of 6 feet or less, the minimum vertical clearance will be 12 inches above the storm drain and 18 inches below the storm drain or Manufactures Specifications.
8. For storm drains 42 inches or larger or with a depth of cover greater than 6 feet, the minimum vertical clearance will be 18 inches above the storm drain and 24 inches below the storm drain or Manufactures Specifications.
9. When vertical clearance is less than values described above, the crossing utility shall utilize an encasement pipe, or other manufactures specified stabilization, unless otherwise allowed by the owner of the crossing utility or City Engineer.
10. Storm drain laterals and trunk lines shall:
    a. Not be built under structures or within 5 feet of building foundations; and
    b. Be offset from public sidewalks by a minimum of 2 feet from the edge of pipe to the edge of public sidewalk but may cross under public sidewalks as necessary.

Figure 1: Sanitary Sewer or Water Line Conflict

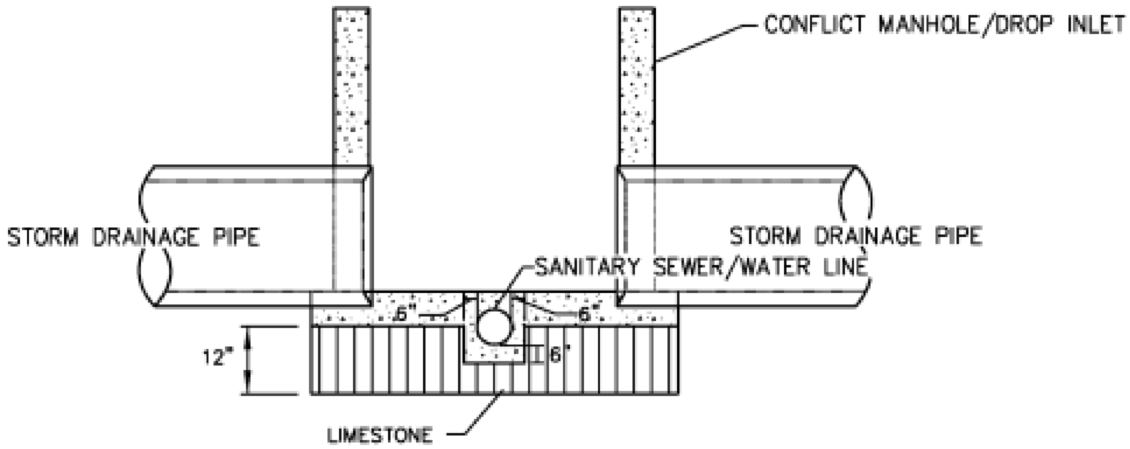
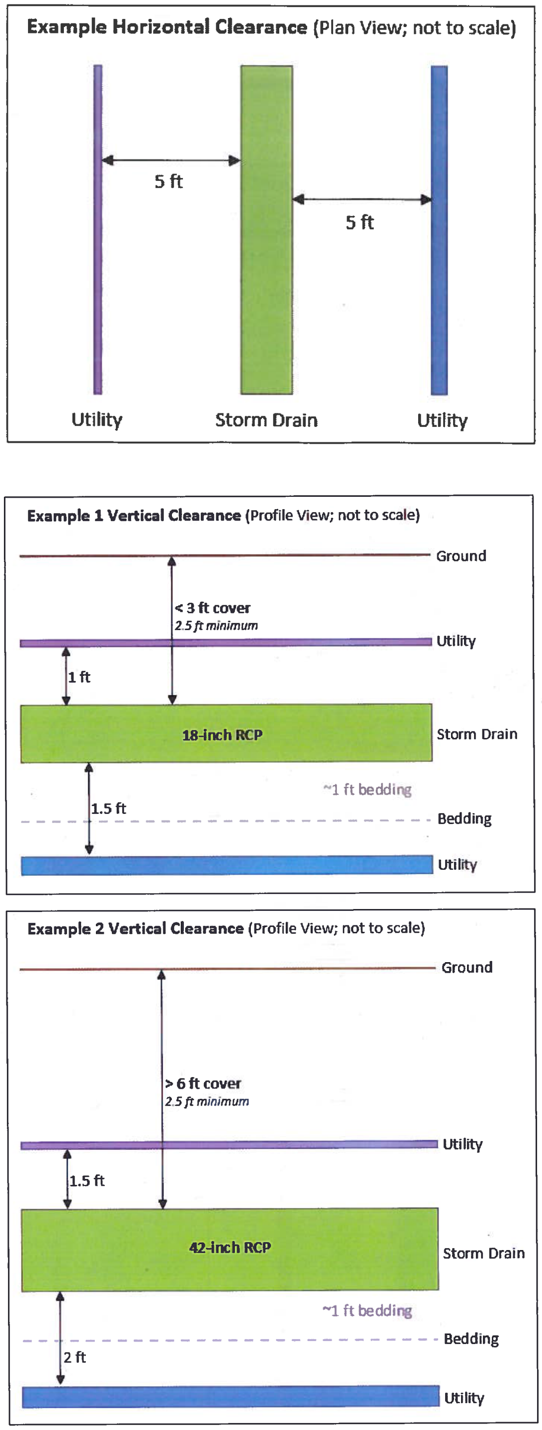


Figure 2: Examples of Horizontal and Vertical Clearance from Utilities



6.0 Culvert Design

The criteria contained in culvert design applies only to those culverts to be placed in public right-of-way and those culverts within private property drainage easements whose headwater depth might cause unacceptable inundation of public right-of-way. The purpose of a culvert is to provide a means of passing a design storm discharge beneath a roadway or similar structure without causing excessive backwater or over-topping of the structure as well as preventing the creation of excessive downstream velocities. The design location and application of a culvert will depend on the available depth for installation, inlet and outlet conditions, general topography, upstream and downstream land use, development layout, flow rates and the level of protection that might be attainable. The Brownsville Engineering and Public Works Department will review proposed culverts on a case-by-case basis and determine the feasibility or the creation of an adverse situation based on the circumstances.

6.1 Culvert Methodology

To prevent adjacent soil from sloughing into the culvert waterway opening and prevent movement of a culvert due to hydraulic pressures, headwalls, endwalls, concrete spillways, dissipators and canastas shall be applied on culverts in order to control the erosion and scour that results from excessive velocities and turbulence. Headwalls and endwalls with or without wingwalls and aprons shall be constructed of reinforced concrete, and in accordance with engineering drawings as required by the physical conditions of the particular installation.

The entrance geometry of a culvert is a controlling factor in the amount of flow that a culvert may pass. The design of culverts shall involve the consideration of energy head losses that may occur at the entrance. Entrance head losses may be determined by the following equation:

$$h_e = C_e(v_2^2 - v_1^2)/2g$$

Where:

- h_e = Entrance Head Loss (ft)
- v_2 = velocity of flow in culvert (ft/s)
- v_1 = velocity of flow approaching culvert (ft/s)
- C_e = entrance loss coefficient as shown in Table 6-1 (dimensionless)
- g = acceleration due to gravity, 32.2 (ft/s2)

Table 6-1 Entrance Loss Coefficients

Type of Structure and Design of Entrance	Coefficient C_e
Pipe, Concrete	
Projecting from fill, socket end (groove end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall & wingwalls: socket end of pipe (groove end)	0.2
Headwall or headwall & wingwalls: square edge	0.5
Headwall or headwall & wingwall: rounded (radius=1/12D)	0.2
Mitered to conform to slope	0.7
End-section conforming to fill slope	0.5
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls): square-edged on 3 edges	0.5
Headwall parallel to embankment (no wingwalls): rounded on 3 edges to radius of 1/12 barrel dimension	0.2
Wingwalls at 30° to 75° to barrel: square-edged at crown	0.4
Wingwalls at 30° to 75° to barrel: crown edge rounded to radius of 1/12 barrel dimension	0.2
Wingwalls at 10° to 25° to barrel: square-edged at crown	0.5
Wingwalls parallel (extension of sides): square-edged at crown	0.7

6.2 Headwall types

Several types of headwall entrances may be used for culverts. The approach velocity is the determining factor in the type of headwall or entrance structure chosen. Typical headwall types and conditions are as follows:

A. Parallel Headwall – constructed parallel with the roadway above and provides stability against embankment erosion. They should be used in locations where the approach velocities in the channel are below 6 feet per second, and headwater pools are permitted.
B. Flared Wingwalls – help to further retain and protect the embankment by acting as a funnel or guide for the flow. They should be used where the approach velocities in the channel are between 6 and 12 feet per second, along with the addition of a concrete apron.
C. Parallel Wingwalls – oriented parallel with the direction of flow through the culvert and are normally used to reduce the wingwall length required to protect the embankment. Parallel wingwalls will typically adversely affect the hydraulic operation of the culvert and should only be used on special non-hydraulic adaptations of culverts where drainage is a minor factor. Headwall designs based on the dimensions and reinforcement requirements of Texas Department of Transportation (TxDOT) design standards will be suitable for construction as long as the remaining requirements (such as velocity limits) of this section are also satisfied.
D. Skewed Wingwalls – similar to flared wingwalls, except the wingwalls are skewed toward the direction of flow relative to the orientation of the culvert. They should be used where the approaching flow is not parallel with the culvert.

6.3 Debris Fins

For culvert structures which consist of more than one box culvert, debris fins may be required by the City Engineer where the possibility of debris flow exists. The thickness of the extended wall shall be designed to meet structural requirements as well as limit interference with the flow capacity of the culvert. The debris fin shall be the same height as the wall at the structure and shall slope away from the culvert such that the length of the debris fin is one and one-half (1.5) times the height of the wall of the culvert.

6.4 Safety-End-Treatments

A safety end treatment is a concrete structure at the end of culverts or storm water pipes installed under roadways. SETs provide a method of mitigating a less safe condition without interfering with the hydraulic function of a culvert. Extensive testing has proven vehicles that leave the roadway will safely cross the end treatment instead of crashing into the end of an otherwise exposed culvert or drain pipe. For isolated instances where the culvert installation does not fit one of the categories below, the City Engineer shall specify the culvert end treatment to be used. The end treatments shall consist of one of the following:

A. For circular or arched culverts less than or equal to 24 inches in diameter, where the vertical distance from the roadway edge to the stream flowline of the channel is less than 3 feet, the ends of the culvert shall be sloped with the embankment at a slope not greater than 7 feet horizontal to 1 foot vertical, or
B. For circular or arched culverts which do not meet the criteria above or cannot be sloped as required, and for box culverts, metal beam guard fence shall be installed in accordance with TxDOT Standards, or
C. Culverts may also use pipe runners or metal gratings designed after TxDOT standards. To use pipe runners or metal gratings as safety end treatments in lieu of metal beam guard fences, the end of the top of the culvert barrel must be at least 12 feet from the edge of the nearest uncurbed traffic lane.

6.5 Selection of Culvert Size & Flow Classification

Inlet control and outlet control are the two ways a flow in a culvert is controlled. With Inlet Control, the discharge rate is independent of the length of pipe, the slope, or the roughness of the pipe wall. The discharge is dependent only upon the depth of the headwater elevation above the invert at the entrance, the pipe size and the entrance geometry. With Outlet Control, the discharge rate is affected by all hydraulic factors upstream of the outlet. These factors are headwater elevation, entrance geometry, pipe size, wall roughness, barrel length and slope. Tailwater elevation will be a factor if the tailwater depth is greater than the critical depth. Sufficient information shall be submitted so that the City Engineer is able to complete a thorough review of the design calculations.

6.6 Multiple Barrel Boxes

Culverts consisting of more than one box are useful in wide channels where the constriction or concentration of flow must be kept to a minimum. Alternatively, low roadway embankments offering limited cover may require a series of small openings. In addition, the situation may require separating the boxes to maintain flood flow distribution. As a general recommendation, where a culvert consists of more than one barrel, shapes of uniform geometry and roughness characteristics should be used to maintain uniform flow distribution. Locations where debris flow may obstruct the culvert entrance may be better served with a clear span bridge.

Certain situations warrant placing boxes at various elevations. Placing one box at the natural stream flowline and placing additional boxes slightly higher is good practice for the following reasons:

1. the configuration does not require widening the natural channel
2. the side boxes provide overflow (flood) relief when needed but do not silt up or collect debris when dry
3. The minimal stream modification supports environmental preservation.

6.7 Design Criteria

To prevent scour and erosion damage to the structure, stream bed, and embankment, outlet protection must be utilized on culverts. Endwalls and associated structures should provide an efficient flow transition from potentially higher velocity pipe flow to the less concentrated stream or ditch flow.

Structures that attempt to decrease the erosive qualities of exiting flow include riprap, aprons, endwalls and wingwalls. The minimum outlet protection used will involve either riprap or an apron and will be based on the discharge velocity.

A. For outlet velocities below 6 feet per second, riprap protection consisting of a 4-inch minimum thickness of concrete or alternate approved material will be required. The length shall be as computed using the equation shown below, and the rip-rap width should cover at least two pipe diameters on each side of the outlet.
B. Aprons – For outlet velocities above 6 feet per second, a minimum 6-inch thick reinforced concrete apron structure with a toe-wall will be required. The minimum length of the apron in the culvert design, or the length determined from the following equation, whichever is greater:

$$L = \frac{(VD)}{5}$$

Where:

- L = Length of Apron (ft)
- V = Discharge Velocity (ft/s)
- D = Height of Box Culvert or Diameter of Pipe Culvert (ft)

C. Endwalls – The endwall size should be sufficient to support the culvert end, and act as a retaining wall for the surrounding soils if necessary. To avoid scour behind the endwall, the face should extend as high as the expected tailwater depth, and the endwall face width should preferably be wider than the low-water downstream channel. Also, at a minimum, the endwall should extend into the stream bed below the invert to a depth below the frost line. This type of installation may also require downstream streambed protection in the form of concrete riprap.
D. Wingwalls – Wingwalls can be used as retaining walls, and/or to contain erosive eddy currents at higher tailwater depths. If high tailwater depths are expected, the installation of an apron is also required to reduce the hazard of undercutting the wingwalls. The wingwall length shall match the designed apron, while the orientation of the wingwalls is generally determined by site conditions.

Where discharge velocities exceed 12 feet per second and the hydraulic characteristics of the culvert cannot be modified to reduce the discharge velocities, energy dissipators shall be used to control downstream erosion.

7.0 Sediment & Erosion Control

Permanent and temporary construction erosion and sediment control is the practice of preventing or reducing the movement of sediment from a site during/after construction through the implementation of man-made structures, land management techniques, or natural processes.

7.1 Design Criteria

Sediment Controls	
Control	***Primary Purpose***
Active Treatment System	Remove pollutants and suspended soil, including fine clay particles, through filtration and/or chemical-aided flocculation
Depressed Grade Sediment Trap	Detain and settle suspended soil from small areas within rights-of-way
Dewatering Controls	Remove suspended soil from water that is pumped out of low points onsite

Inlet Protection	Intercept sediment at curb and area inlets as a secondary defense in sequence with other controls
Organic Filter Berm	Slow and filter runoff to retain sediment
Organic Filter Tubes	Slow and filter runoff to retain sediment
Passive Treatment System	Improve performance of other controls by adding flocculation agents to stormwater
Pipe Inlet Protection	Detain stormwater for sedimentation and filtration before it enters a closed conveyance system
Sediment Basin	Detain stormwater in a pond with a controlled outflow to allow for sedimentation
Silt Fence	Slow and filter runoff to retain sediment
Stabilized Construction Exit	Reduce offsite sediment tracking from trucks and construction equipment
Stone Outlet Sediment Trap	Intercept and filter small, concentrated flows in swales and other defined waterways
Triangular Sediment Filter Dike	Slow and filter runoff to retain sediment
Turbidity Barrier	Detain and settle suspended soil where work is occurring in or adjacent to a water body
Vegetated Filter Strips and Buffers	Slow sheet flow from small areas to allow for sedimentation
Wheel Cleaning Systems	Reduce offsite sediment tracking from trucks and construction equipment

Erosion Controls	
Control	***Primary Purpose***
Check Dam	Slow flow to prevent erosion of swales and drainage ditches while also providing minor detention and sediment removal
Diversion Dike	Route flows around slopes and disturbed areas
Erosion Control Blankets	Protect disturbed soil and slopes from erosion using a degradable, rolled erosion control product; also provides limited protection as a perimeter control
Interceptor Swale	Route flows around slopes and disturbed areas
Mulching	Protect disturbed soil with a layer of straw, wood chips, compost or other organic material
Pipe Slope Drain	Route overland flow on a slope into a pipe to protect the slope
Soil Surface Treatments	Protect disturbed soil from wind erosion (dust control) while also providing some protection from water erosion, depending on the treatment method
Turf Reinforcement Mats	Protect disturbed soil on steep slopes and in channels from erosion using a nondegradable, rolled erosion control product
Vegetation	Prevent erosion by providing a natural cover through hydro-mulching, seeding or sod placement
Velocity Dissipation Devices	Protect soil from erosion at points where concentrated flows are discharged

Source: iSWMTM Technical Manual: Site Development Controls, April 2010 (Revised September 2014)

Link: https://iswm.nctcog.org/Documents/technical_manual/Construction_Controls_10-2019.pdf

7.2 Dumpster Leachate

Do not place dumpsters near or on storm drains. It is recommended that all storm drains be marked to prevent accidental dumping. Leachate, trash, and debris from the dumpsters flow untreated to our stormwater drainage system and directly to our local creeks, rivers, ponds, resecas and lakes. These pollutants have the potential to destroy sensitive ecosystems, harm aquatic life and habitats, and pollute recreational sites and the drinking water supplies in Brownsville and the surrounding communities. Therefore, the following trash enclosure sewer connection standards shall apply:

1. Enclosure slabs shall slope inward at no more than one percent to collect any effluent in the enclosure.
2. Tallow containers shall be separated from waste and recycling containers by a barrier, with at least 12 inches of space from other containers. Tallow containers shall not be allowed to spill or drain to the sanitary sewer drain.
3. Trash enclosures shall have a water connection in or nearby to provide for cleaning inside the enclosure area. If inside, the connection shall be located such that it cannot be damaged by enclosure bins.
4. Wastewater discharges or potential discharges to the parking lot, street or storm drain system are illicit discharges and a violation of the City Municipal Code.
5. Enclosure drains shall be traffic rated and located so they are not under container wheels or in the path of service vehicles.
6. Developments with the potential to generate the following types of waste shall flow through a grease trap connecting to a stormwater system, as defined in this section, with a minimum capacity of 35 gallons per minute (70 pounds):
    a. Automotive fluid waste, including gas stations, auto repairs, oil change centers and facilities with similar wastes.
    b. Food waste, including restaurants, food preparation businesses, facilities with large kitchens, multifamily units of five or more units and facilities with similar wastes.
    c. Commercial or industrial waste, including any commercial or industrial businesses that use significant quantities of solvents, lubricating greases, oils or similar wastes.

7. It will be the responsibility of the property owner to properly dispose of any other contaminants that are not filtered prior to discharge into the City's stormwater system.

8.0 Floodplain Development

The City of Brownsville consists of floodplains, each based on different hydrologic assumptions:

The "FEMA Floodplains" are based on the most current version of the Flood Insurance Study and Flood Insurance Rate Maps (FIRM), as delineated by FEMA. They are developed based on existing conditions and land use at the time of the study.

FEMA Floodplains are designated according to varying levels of flood risk. The floodplain designations that will be most commonly involved with the development of projects within the City of Brownville are as follows: Zone A (areas with 1% annual chance of inundation developed without analyses, no base flood elevation shown), Zone AE (areas with 1% annual chance of inundation developed without analyses, no base flood elevation shown), and Zone AO (areas with a 1% annual chance of flood from sheet flow).

These procedures are available to change and/or correct an existing FEMA Floodplain. These include a Letter of Map Amendment (LOMA), Electronic Letter of Map Amendments (eLOMA), Letter of Map Change (LOMC), Letter of Map Revision (LOMR), Letter of Map Revision on Fill (LOMR-F), and a Physical Map Revision (PMR). These are defined as follows:

A. LOMA – is an official amendment to an effective FIRM that may be issued when a property owner provides additional technical information from a licensed land surveyor or engineer, such as ground elevation relative to the BFE, SFHA, and the building. Lenders may waive the flood insurance requirement if the LOMA documents that a building is on ground above mapped floodplain. Used to remove a specific area or property from a FEMA designated floodplain.

B. eLOMA – is a web based application to submit simple LOMAs to FEMA

C. LOMC – a letter which reflects an official revision to an effective NFIP map.

D. LOMA (Out as Shown) – If a structure is identified as flood prone, but the flood map shows the structure outside of the floodplain, the LOMA (Out as Shown) process may assist a homeowner in removing the mandatory purchase requirement for flood insurance.

E. LOMR – is an official revision to an effective FIRM that may be issued to change flood insurance risk zones, special flood hazard areas and floodway boundary delineations, BFEs and/or other map features. Lenders may waive the insurance requirements if the approved map revision shows buildings to be outside of the SFHA.Used to modify an effective FIRM. Completed after construction of physical measures that affect the hydrologic or hydraulic characteristics of an area. A LOMR is required when development is proposed in Zone A in order to establish a base flood elevation (BFE).

F. LOMR-F – is an official revision to an effective FIRM that is issued to document FEMA's determination that a structure or parcel of land has been elevated by fill above the BFE, and therefore is no longer in the SFHA. Lenders may waive the insurance requirement if the LOMR-F shows that a building on fill is above the BFE.

G. PMR – may be issued for major floodplain changes that require engineering analysis, such as bridges, culverts, channel changes, flood control measures, and large fills that change BFE or Floodway. Physical map revisions are also issued when a new study updates or improves the FIRM.

It is possible to exclude a single structure from the floodplain by placing it on a fill with sufficient freeboard above the base flood elevation. This procedure is referred to as a Letter of Map Revision – Fill (LOMR-F). LOMR-Fs shall not be allowed within playa overflow conveyance areas. A Conditional Letter of Map Revision (CLOMR) may be required at the discretion of the City Engineer prior to construction of proposed development within a floodway. If a Developer wishes to officially modify a City Floodplain, sufficient information shall be provided to the City such that the floodplains in the MDP can be updated appropriately.

8.1 Floodplain Development Requirements

Floodplain alteration shall be allowed if all of the following criteria are met:

A. Hydrologic and hydraulic analyses shall include flows generated for existing conditions and future fully developed conditions for the 2-, 10-, 25-, and 50-year storm events.
B. Alterations shall be complete to the standard of FEMA guidelines.
C. Any alteration to the floodplain areas shall not cause any additional expense in any current or future public improvements, including maintenance.
D. For the performance of any grading activities on site, a Floodplain Development Permit shall be required.
E. Development within a designated floodway is not permitted without FEMA CLOMR approval and proof of no downstream impact.
F. A LOMR shall be required when proposed development occurs within a FEMA Zone A Floodplain, or when proposed development in a Zone AE Floodplain results in a change in Base Flood Elevation. Upon completion of construction, the LOMR shall be submitted to the City Engineer for approval prior to submission to FEMA. Once the City Engineer

has signed the required acknowledgement form, it is the responsibility of the Developer to submit the LOMR to FEMA. The Developer shall provide the City Engineer with proof of submission of the LOMR to FEMA. Final acceptance of the development is contingent upon proof of LOMR submission to FEMA. The LOMR process is completed once construction of the proposed development is complete and the LOMR becomes effective with FEMA.

G. A LOMR-F is acceptable if approved by the City Engineer for a single lot development, or as an interim condition for a multi-phase development. In all other cases, final acceptance of the development is contingent upon proof of LOMR submission to FEMA.

H. A CLOMR may be required at the discretion of the City Engineer. This will typically be required in situations where there is a risk of significant change to the floodplain, and it is unclear how much the proposed development will affect water surface elevations. The CLOMR shall be submitted to the City Engineer for approval prior to submission to FEMA. Once the City Engineer has signed the required acknowledgement form, it is the responsibility of the Developer to submit the CLOMR to FEMA. The Developer shall provide the City Engineer with proof of submission of the CLOMR to FEMA. When required, the CLOMR process shall be completed prior to commencement of construction of the proposed development.

The Developer shall be required to submit the results of the existing conditions analyses and supporting hydrologic and hydraulic data to the City Engineer. The appropriate FEMA application forms, if required, shall also be submitted to the City concurrent with the Floodplain Development Permit submittal. If the City Engineer accepts the analyses, the existing conditions data, model and application forms will need to be submitted to FEMA by the Developer to update the FIS and FIRMs, if the City determines that a LOMR is necessary.

8.2 Floodplain Management

The objectives of floodplain management are to adopt effective floodplain regulations, improve local land use practices and regulations in flood prone areas, reduce losses from flooding, minimize adverse water quality impacts, and foster the creation/preservation of greenbelts, with associated societal, water quality, wildlife and other ecological benefits in urban areas. To accomplish all this one must create a program where they promote the natural and beneficial uses of the floodplain. These uses of the floodplain hold political, social, and economical value. Although hydrologic data are critical to the development of a floodplain management program, a successful program is largely dependent on a series of policy, planning, and design decisions. These area-wide decisions provide the setting for floodplain usage and, when combined with hydrologic considerations and augmented by administrative and other implementation devices, constitute a floodplain management program. The program must give high priority to both flood danger and public programs, such as urban renewal, open space, etc.

8.3 Floodplain Management Strategies and Tools

FEMA has developed a variety of floodplain management strategies and tools, as summarized in Table 8-1. Other strategies and tools may also be used.

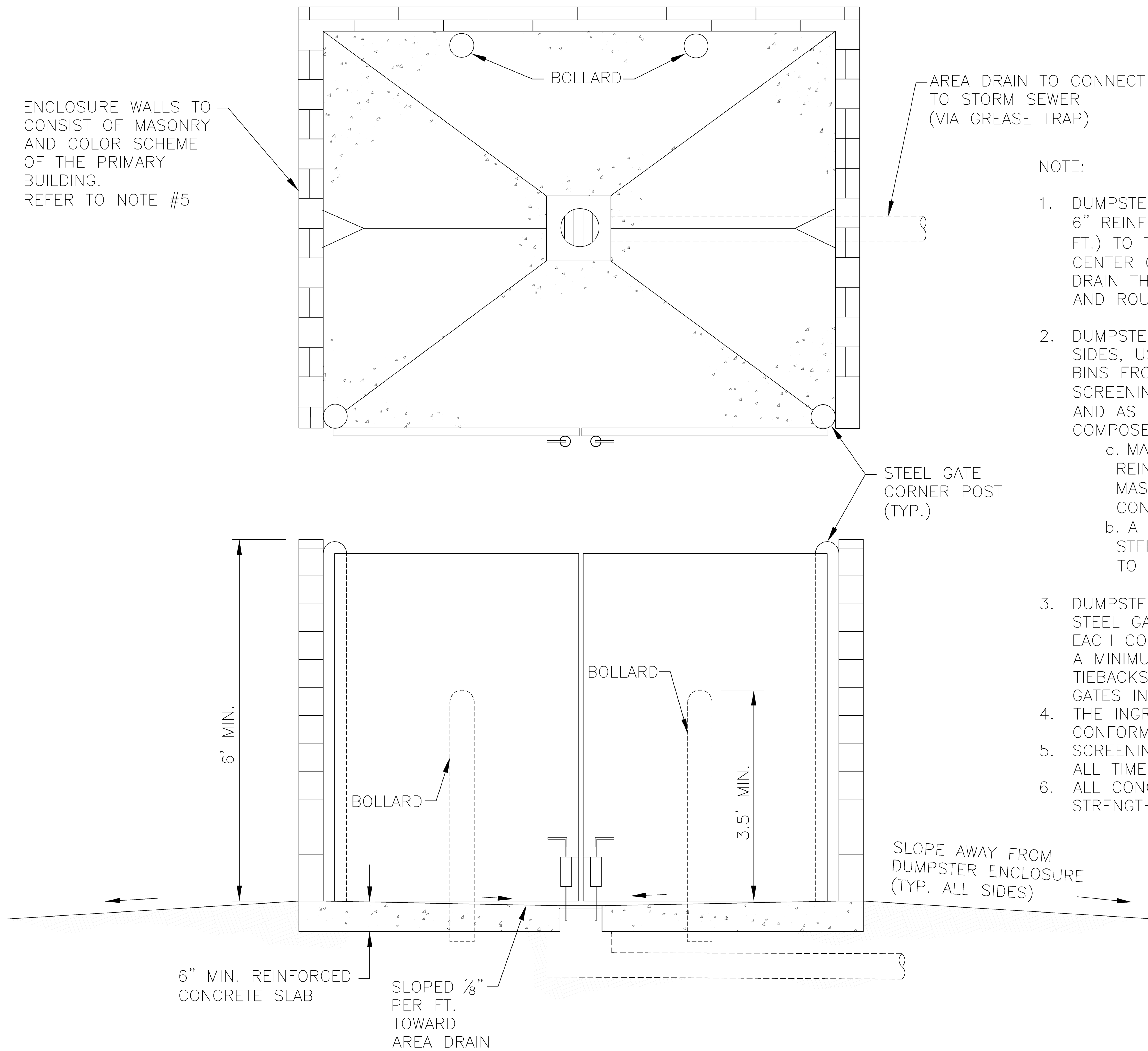
Table 8-1 Floodplain management strategies and tools

Strategy	Brief Description
Reduce Exposure to Floods	Reduce exposure to floods and disruptions by employing floodplain regulations and local regulations. The latter includes zoning, subdivision regulations, building codes, sanitary and well codes, and disclosure to property buyers
Development Policies	Development policies that include design and location of utility services, land acquisition, redevelopment, and permanent evacuation (purchase of properties).
Disaster Preparedness	Disaster preparedness is an important tool for safeguarding lives and property, and disaster assistance will reduce the impact to citizens from flooding.
Flood Proofing	Flood proofing of buildings is a technique that is wise and prudent where existing buildings are subject to flooding. Flood proofing can help a proposed project achieve a better benefit-cost ratio.
Flood Forecasting	Flood forecasting and early warning systems are important means to reduce flood losses, safeguard health, protect against loss of life and generally provide an opportunity for people to prepare for a flood event before it strikes.
Flood Modification	The use of methods to modify the severity of the flood is a floodplain management tool. These include regional detention, channelization, minimizing directly connected impervious areas, and on-site detention.
Modification of Flood Impacts	The impact of flooding can be mitigated (or modified) through education, flood insurance, tax adjustments, emergency measures, and a good post-flood recovery plan that can be initiated immediately following a flood.

9.0 Compliance with NPDES Program & Clean Water Act Permitting Requirements

New development and redevelopment that will result in disturbance of five or more acres of land must comply with the United States Environmental Protection Agency ("USEPA") National Pollution Discharge Elimination System ("NPDES") General Permits for Storm Water Discharges from Construction Activities in Region 6. Rules covering the requirements of the General Permit are published at 63 Federal Register 36489, July 6, 1998, and are available at the USEPA Region 6 website (www.epa.gov/earthlr6/gen/w/formsw.htm.) Individuals who intend to obtain coverage under the General Permit for Construction Activities must submit a Notice of Intent ("NOI") to the USEPA Region VI office in Dallas, Texas in accordance with the General Permit. The content of the NOI shall comply with the requirements of the NPDES General Permit for Storm Water Discharges from Construction Sites in Region 6, as published at 63 Federal Register 36489.

In addition to compliance with the NPDES program, it may be necessary to obtain a permit from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. (33 U.S.C. §1344). Certain activities are covered by the Nationwide Permit Program ("NWP"). NWP's, which may be applicable in the development of subdivisions, include NWP 39, 41 and 43, among others. Applicability of NWP 39 and 43 is limited in areas within the 100-year Floodplain by General Condition 26. See, 65 Fed. Reg. 12818, March 9, 2000. (New NWP provisions were effective June 7, 2000.) Copies of all materials submitted to the District Engineer under an NWP or an application for an individual permit must be simultaneously provided to Cameron County Drainage District No. 1.



NOTE:

1. DUMPSTER BINS SHALL BE LOCATED ON A MINIMUM 6" REINFORCED CONCRETE SLAB, SLOPED (1/8" PER FT.) TO THE CENTER POINT OF THE SLAB. THE CENTER OF THE SLAB SHALL CONTAIN AN INTERNAL DRAIN THAT IS CONNECTED TO A WASTEWATER LINE AND ROUTED TROUGH A GREASE TRAP.
2. DUMPSTER BINS SHALL BE SCREENED ON FOUR SIDES, USING AN ENCLOSURE THAT SCREENS THE BINS FROM VIEW AT THE PROPERTY LINES. SCREENING SHALL BE A MINIMUM OF 6' IN HEIGHT AND AS TALL AS THE CONTAINER, AND SHALL BE COMPOSED OF:
   a. MASONRY (BRICK, STONE, STUCCO, REINFORCED CONCRETE, OR OTHER SIMILAR MASONRY MATERIALS) AND COLOR SCHEMES CONSISTENT WITH THE PRIMARY BUILDING.
   b. A MINIMUM OF TWO (2) CONCRETE FILLED 6" STEEL BOLLARDS ADJACENT TO THE REAR WALL TO EXTEND A MINIMUM OF 18' BELOW GRAD
3. DUMPSTER ENCLOSURES SHALL HAVE SPRING LOADED STEEL GATES WITH HINGED ON THE OUTSIDE OF EACH CORNER POST TO ALLOW THE GATES TO OPEN A MINIMUM OF 110 DEGREES. WHEN IN USE, TIEBACKS SHALL BE USED TO SECURE THE STEEL GATES IN THE OPEN POSITION.
4. THE INGRESS, EGRESS, AND APPROACH SHALL CONFORM TO FIRE LANE REQUIREMENTS.
5. SCREENING SHALL BE MAINTAINED BY THE OWNER AT ALL TIMES.
6. ALL CONCRETE SHALL HAVE A MINIMUM COMPRESSION STRENGTH OF 3000 PSI.

DUMPSTER ENCLOSURE WITH INTERNAL DRAIN

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