CITY OF LA MARQUE

CHAPTER 5

STORM WATER DRAINAGE DESIGN CRITERIA

CHAPTER 5 – STORM WATER DRAINAGE DESIGN

5.1 STORM WATER DRAINAGE DESIGN GENERAL

5.1.1 The following sections include criteria for the design of storm water drainage improvements for the City of La Marque and its Extraterritorial Jurisdiction (ETJ). Refer to each Drainage District Criteria Manual for complete methodologies, descriptions, tables and charts.

5.1.2 Drainage approval by the City of La Marque is required for all development within city limits and within its extraterritorial jurisdiction. All drainage facilities proposed within these limits are to adhere to these criteria.

5.1.3 Development within the City of La Marque or its extraterritorial jurisdiction will also require the approval of the applicable Drainage District. Galveston County Drainage District No. 1 and No. 2.

5.1.4 All outfall pipes, ditches, and structures that enter Drainage District Channels or Facilities shall be designed according to requirements of the applicable Drainage District. If there is a discrepancy in the drainage criteria requirements between the City and applicable Drainage District, the City Engineer shall determine which criteria to apply.

5.1.5 Development and drainage shall comply with all applicable City of La Marque Ordinances, including, but not limited to, the Floodplain Ordinance.

5.1.6 The goal for these criteria is to provide protection in a 100-year storm event. This is accomplished with the application of various drainage enhancements such as storm sewers, roadside ditches, open channels, detention, and overland (sheet) runoff. The combined system is intended to prevent structural flooding from extreme events up to a 100-year storm. In order to protect existing properties, water levels, due to runoff, shall not be increased upstream or downstream of a development due to the improvement.

A. Street Drainage: Street ponding of short duration in significant storms is anticipated and designed to contribute to the overall drainage capability of the system. Storm sewers and roadside ditch conduits are designed as a balance of capacity and economics. These conduits are designed to convey less intense, more frequent 5 year storms with the intent of allowing for traffic movement during these events. When rainfall events exceed the capacity of storm sewer system, the additional runoff is intended to be stored or conveyed overland in a manner that reduces the threat of flooding to structures.

B. Flood Control: The City of La Marque is a participant in the National Flood Insurance Program. The intent of the flood insurance program is to make insurance available at low cost by providing for measures that reduce the likelihood of structural flooding.

C. Relationship to the Permitting Process: Approval of storm drainage is a part of the review process for platting and permitting of the new development. All plans for plats and proposed new construction shall include drainage improvements in the plans submitted to the City Engineer.

5.2 DEFINITIONS

5.2.1 Conduit: Any open or closed device for conveying flowing water.

5.2.2 Drainage Area Map: Area map of watershed which is subdivided to show each area served by each subsystem.

5.2.3 GCDD No. 1: Galveston County Drainage District No. 1.

5.2.4 GCDD No. 2: Galveston County Drainage District No. 2.

5.2.5 FEMA: Federal Emergency Management Agency.

5.2.6 Hydraulic Grade Line: A line representing the pressure head available at any given point within the drainage system.

5.2.7 In-Fill Development: Development of open tracts of land in areas where the storm drainage infrastructure is already in place and takes advantage of the existing infrastructure as a drainage outlet.

5.2.8 Public Storm Sewers: Defined as sewers and appurtenances that provide drainage for a public right-of-way, or more than one private tract, and are located in public right-of-way or easement and officially accepted by the City for maintenance. Private storm sewer connections public storm sewers shall occur at a manhole or at the back of an inlet, as approved by the City. All private storm sewers shall be constructed in conformance with these standards.

5.2.9 Rational Formula: A method for calculating the peak runoff for a storm drain system.

5.2.10 Redevelopment: A change in land use that alters the impervious cover from one type of development of either the same type or another type, and takes advantage of the existing infrastructure in place as drainage outlet.

5.2.12 Sheet Flow: Overland storm runoff that is not conveyed in a defined conduit, and is typically in excess of the capacity of the conduit.

5.3 DESIGN REQUIREMENTS

5.3.1 Storm Sewer Easements – the following minimum easements are required when facilities are not located within public street rights-of-way:

A. When not adjacent to public street rights-of-way, the minimum width shall be twenty feet (20') with the storm sewer centered in an exclusive easement.

B. For storm sewers greater than eight feet (8') and less than or equal to twelve feet (12') in diameter or width, the minimum width of an exclusive easement shall be twenty-five feet (25').

C. For storm sewer greater than twelve feet (12') in diameter or width, the minimum width of an exclusive easement shall be determined by the City Engineer.

D. For storm sewers whose depth to flow line is greater than fifteen feet (15'), add five feet (5') to the 20 feet (20') minimum easement width.

E. For all easements specified, a minimum distance of five feet (5') must be maintained from the easement line to the outside edge of the storm sewer.

F. Where approvals are granted for a special use or combination easement located along side lot or back lot, the minimum width shall be twenty-five feet (25'). The easement width shall meet or exceed all other easement requirements.

G. For specifically approved storm sewers located in an exclusive easement adjacent to public rights-of-way, the minimum easement width shall be ten feet (10'). The easement width shall meet or exceed all other easement requirements.

5.3.2 All projects shall be tied to National Geodetic Survey (NGS) Datum Adjustment which matches the Federal Emergency Management Agency (FEMA) rate maps or the most current NGVD which matches the FEMA rate maps. At least two references to bench marks relating to the FEMA rate maps must be identified. Equations may be used to translate other datum adjustments to the required adjustment.

5.3.3 Plan sets will include a drainage area map which shall contain all storm sewer drainage calculations.

5.3.4 All drainage systems for curb and gutter pavements shall be underground closed conduits; individual residential lot drainage is exempt. Drainage systems for pavements without curb and gutter shall be roadside open-ditch sections.

5.3.5 Plan sets shall include the 5 year Hydraulic Grade Line for storm sewers and roadside ditches on the plan and profile sheets.

5.3.6 The quantity of storm water runoff (peak discharge) shall be determined for each inlet, pipe, roadside ditch, channel, bridge, culvert, outfall, or other designated design point by using the following criteria:

A. Determination of Runoff:

Design storm Events - All drainage improvements shall be designed for the following storm frequencies:

Roadside Ditches	5 years
Storm Sewers	5 years
Open Drainage Channels serving less than 100 acres	25 years
	25 years
Secondary Arterials	100-years
Bridges	100-years
Creeks/Channels	100-years
Detention Facilities	

B. Intensity-Duration Curves: TxDOT Manual provides intensity-duration values to be used for storm sewer and roadside ditch design in the City of La Marque. These intensities are derived from the formula:

$$I = \frac{b}{(d+t_c)^e}$$

Values are as listed below:

Rainfall Intensity-Duration-Frequency Coefficient for Galveston County						
Coefficient	**3-year**	**5-year**		**25-year**	**50-year**	**100-year**
e (in)	0.782	0.739		0.727	0.704	0.69
b	77	66		85	88	85
d (mins)	11.9	7.6		7.6	7.6	7.8

C. The Rational Method shall be used for determining the peak flow rate in the sizing of all local drainage improvements with drainage areas less than 100 acres.

D. Coefficients for the Rational Method:

a. Run-Off Coefficient: The following values for the run-off coefficient "C" in the Rational Method formula will vary based on the land use. Land use types and "C" values which are to be used in La Marque are as follows:

Land Use Type	Run-Off Coefficient
Raw Undeveloped Acres	0.20

Improved Undeveloped Acres (i.e. mowed filled, regraded, etc.)	0.30
Park Land	0.20
Residential:	
Single Family Lots greater than 0.75 acre	0.35
Single Family Lots 0.25 acre to 0.75 acre	0.45
Single Family Lots less than 0.25 acre	0.55
Townhomes/Patio Homes	0.65
Commercial	0.80
Multifamily	0.80
Industrial	
50% impervious	0.65
75% impervious	0.75
95% impervious	0.85
Pond (detention and amenity)	1.00

b. Determination of Time Concentration: Time of concentration shall be calculated based upon an analysis of the actual travel time from the most remote point in the drainage area. The travel path should be clearly denoted and a sketch included in the design calculations.

E. Design Frequency:

a. Design Frequency:

(1) Newly Developed Areas: The design storm event for sizing storm sewers in newly developing areas will be a 5-year rainfall. Detention shall be provided and in accordance with Section 5.3.6 J. Calculations shall show that water surface elevations are not increased upstream or downstream of the tract.

(2) Redevelopment or In-Fill Development: The existing storm drain will be evaluated using a 5 year storm, assuming no development takes place. The storm drain will then be evaluated with the development in place.

(a) If the proposed redevelopment has a lower or equal impervious cover, no modifications to the existing storm drain are required.

(b) If the impervious cover is increased, detention shall be provided in accordance with Section 5.3.6 J.

(2) Private Drainage Systems: Storm sewers for private drainage systems shall conform to the requirements of public drainage systems.

b. Velocity Considerations:

(1) All storm drains shall be designed by the application of the Continuity Equation and Manning's Equation.

(2) Design velocities shall be a minimum of 2 feet per second (fps) with the pipe flowing full.

(3) Maximum velocities should not exceed 7 feet per second.

(4) Minimum Storm Sewer Pipe Slopes:

(5)

Pipe Diameter	% Slope
24	0.07
30	0.05
36	0.04
42	0.032
48	0.027
54	0.023
60	0.020

For pipe sizes not listed above, the minimum slope should be determined utilizing a design velocity of 2 fps.

c. Pipe Sizes and Placement:

(1) Use the storm sewer and inlet leads with at least 24 inch inside diameter or equivalent cross-section. Box culverts shall be at least 2'x2'. Closed conduits, circular, elliptical, or box, shall be selected based on hydraulic principals and economy of size and shape.

(2) Larger pipes upstream should not flow into smaller pipes downstream unless the upstream system is intended for use in detention.

(3) Match crowns of pipe at any size change.

(4) Locate public storm sewers in public street rights-of-way or in dedicated drainage easements. Side and back lot easements are discouraged. If unavoidable, the easement shall be at least 20 feet wide with the storm sewer centered in the easement.

(5) Follow the alignment of the right-of-way or easement when designing cast-in-place concrete storm sewer easements.

(6) A straight line shall be used for inlet leads and storm sewers.

(7) Center storm sewer in side-lot storm sewer easements.

(8) Provide 5 feet minimum from edge of pipe to edge of easement.

d. Starting Water Surface and Hydraulic Gradient:

(1) The hydraulic gradient shall be calculated assuming the top of the outfall pipe as the starting water surface.

(2) At drops in pipe invert, should the upstream pipe be higher than the hydraulic grade line, then the hydraulic grade line shall be recalculated assuming the starting water surface to be at the top of pipe at that point.

(3) For the design storm, the hydraulic gradient shall at all times be below the gutter line for all newly developed areas.

e. Manhole Locations:

(1) Use manholes for precast conduits at the following locations:

(a) Size or cross-section changes.

(b) Inlet and conduit intersections.

(c) Changes in pipe grade.

(d) A maximum spacing of 500 feet measured along the conduit run.

(e) Manholes shall be placed so as not to be located in driveways.

f. Inlets:

(1) Locate inlets at all low points in gutters.

(2) Valley gutters across intersections are not permitted.

(3) Inlet spacing is generally a function of gutter slope. For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 500 feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 1000 feet of pavement draining towards any one inlet location.

(4) Use only Standard Inlets:

Inlet	General Application	Capacity
Type A	Parking Lots/Small	2.5 cfs
Type B-B	Areas	5.0 cfs
Type C	Residential	5.0 cfs
Type C-1	Streets	10.0 cfs
Type D	Commercial	2.0 cfs
Type E	Parking Lots	20.0 cfs
	Roadside Ditches	

(5) Beehive grate inlets or other specialty inlets are not allowed.

(6) Do not use grate top inlets in an unlined roadside ditch.

(7) Place inlets at the end of the proposed pavement, if drainage will enter or leave pavement.

(8) Do not locate inlets adjacent to esplanade openings.

(9) Place inlets on side streets intersecting major streets, unless special conditions warrant otherwise.

F. Consideration of Overland Flow:

a. Design Frequency: The design frequency for consideration of overland sheet flow will consider extreme storm events which exceed the capacity of the underground storm sewer system resulting in ponding and overland sheet flow through the development to the primary outlet.

b. Relationship of Structure to Street: All structures will be at least 24 inches higher than the highest level of ponding anticipated resulting from the 100-year event analysis.

c. Calculation of Flow:

(1) Streets will be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet.

(2) The maximum depth of ponding will be 12 inches above the curb gutter, or 6 inches above the centerline of roads without curb, during the 100-year storm event.

(3) Sheet flow between lots can be provided only through a dedicated drainage easement.

(4) A map shall be provided to delineate extreme event flow direction through a proposed development and how this flow is discharged to the primary drainage outlet.

In areas where ponding occurs and no sheet flow path exists, then calculations showing that run-off from the 100-year event can be conveyed through inlets to the storm system and/or detention pond must be provided.

d. Overland flow shall enter the drainage facilities (channels or detention pond) through a storm sewer sized to convey the 100-year event. Calculations shall be submitted for sizing the storm sewer and determining that adequate inlet capacity exists.

G. Design of Open Channels:

a. Design Frequency:

(1) Open channels shall be designed according to the Galveston County Drainage Criteria Manual, or the applicable Drainage District, whichever is more stringent.

(2) Design standards for channel construction should follow the requirements specified in the corresponding Criteria Manual.

b. Determination of Water Surface Elevation:

(1) Water surface elevations shall be calculated using Manning's Equation and the Continuity Equation.

(2) For the design storm event, the water surface should be calculated to remain within banks and below freeboard.

c. Design of Culvert Crossings for Open Channels:

(1) Head losses in culverts shall conform to TxDOT Design Division Hydraulics Manual, Chapter 7 - Culverts.

(2) Culverts shall be Class III RCP conforming to ASTM C-76 or smooth interior dual wall corrugated polyethylene pipe conforming to AASHTO M294.

d. Channels shall be seeded or sodded and a permanent stand of grass obtained prior to project acceptance.

H. Design of Roadside Ditches:

a. Design Frequency:

(1) Roadside ditch design is permissible only for single family residential lots having widths larger than, or equal to, 120 feet.

(2) Design capacity for a roadside ditch shall be to 0.5 feet below the edge of pavement or the natural ground at the right-of-way line, whichever is lower.

(3) The design must include an extreme event analysis to indicate that structures will not be flooded.

b. Velocity Considerations:

(1) A grass lined or unimproved roadside ditch shall have side slopes no steeper than 3:1.

(2) Minimum grades for roadside ditches shall be 0.1 foot per 100 feet.

(3) Calculation of velocity will use a Manning's roughness coefficient of 0.040 for earthen sections and 0.025 for ditches with paved inverts.

(4) Use erosion control methods acceptable to the City when design velocities are expected to be greater than 4 feet per second.

c. Culverts:

(1) Culverts will be placed at all driveway and roadway crossings, and other locations where appropriate. Permanent low water crossings are not permitted.

(2) Culverts will be designed assuming outlet control.

(3) Roadside culverts are to be sized based on drainage area. Calculations are to be provided for each block based on drainage design criteria presented in this manual.

(4) Cross open channels with roadside culverts no smaller than 18 inches in diameter. The size of culvert used shall not create a head loss of more than 0.20 feet greater than the normal water surface profile without the culvert.

(5) Flow from roadside ditches must be conveyed to the drainage channel through a roadside ditch interceptor structure and pipe.

d. Depth and Size Limitations:

(1) All roadside ditches shall be fully contained in the right-of-way or a recorded drainage easement.

(2) The maximum depth in residential areas shall not exceed 3 feet from the edge of pavement.

(3) Ditches in adjoining and parallel easements shall have the top of bank not less than 2 feet from the outside easement line.

(4) Roadside ditch bottoms should be at least 2 feet wide.

(5) Roadside ditch side slopes shall not exceed 3:1.

I. Design of Outfalls

a. Outfall design shall conform to the applicable Drainage District's Design Criteria Manual.

b. Outfalls shall be placed one foot above the receiving waterway.

c. Wet detention ponds may be connected by a submerged pipe. Storm sewers discharging into wet detention ponds may be submerged from the last manhole to the outfall.

d. Outfalls must have a means to control erosion and washouts (i.e. concrete paving, interlocking blocks). Rip-rap is not acceptable.

J. Storm Water Detention:

a. Application of Detention:

(1) As a normal consideration, storm water detention is required. The use of on-site detention is required in order to mitigate potential damage to existing structures unless participation in regional detention facilities is available that will provide equivalent protection to downstream property owners.

(2) Design calculations for sizing the detention basin and related structures must be performed by the applicable method described in the following sections.

(3) All calculations shall be sealed, signed, and dated by a registered professional engineer.

(4) A parking lot may be used as part of the detention system, provided that the maximum depth of water over the inlet does not

exceed nine inches (9") and the maximum depth in the parking stall does not exceed six inches (6").

(5) All detention basins shall be maintained by the property owners except regional detention facilities that are owned and operated by the City of La Marque, GCDD No. 1 and GCDD No. 2.

b. Calculation of Detention Volume:

(1) For developments with drainage areas of more than 100 acres, a detailed hydrologic analysis utilizing the HEC-HMS and HEC-RAS Flood Hydrograph method will be required following the procedure outlined the Galveston County Drainage Criteria Manual, or applicable drainage district if more stringent.

(2) For developments with drainage areas 100 acres or less, the acre-feet of flood control storage, S, to be provided by the facility for the 100-year storm event is:

$$S = I^{½} \times A$$

Where I = the average percent imperviousness of the area draining into the facility (÷ 100), and A = the drainage area of the facility in acres.

c. Calculation of Outlet Size:

(1) The minimum outflow pipe for a detention facility is 24 inches. When further flow restriction is necessary, a restriction should be placed at the entrance to the outfall pipe. Locate the restrictor to facilitate inspection and debris removal. Calculate the allowable outflow orifice size using the following equation:

$$Q = CA\sqrt{2gH}$$

Where:

Q = allowable discharge in cubic feet per second
C = coefficient of discharge
- 0.8 for short segments of pipe
- 0.6 for openings in plates or standpipes

A = maximum allowable area of orifice in square feet
g = acceleration due to gravity (32.2 feet/second^2)
H = head difference between entrance and exit in feet when orifice is fully submerged, or the difference between centroid of the orifice in feet when orifice is partially submerged.

Determine H by establishing a maximum ponding level in the

detention facility during the 100-year storm and assuming a tailwater at the top of the downstream end of the outlet pipe, or at a depth in the outlet channel associated with the maximum release flow rate, whichever is higher. In addition to a pipe outlet, the detention basin shall provide an extreme event emergency overflow spillway that will protect structures from flooding should the detention basin be overtopped.

(2) Corrugated Metal Pipe (CMP) is not allowed for outfall structures.

d. Detention Pond Structural Requirements:

(1) Side slopes shall not exceed a slope of 4 feet horizontally to one 1 vertically (4:1)

(2) Dry detention ponds exceeding 60 feet in any direction shall have concrete pilot channels to aid drainage. Unlined detention pond bottom shall have a minimum slope of 1%.

(3) Concrete pilot channels shall have a minimum width of 6 feet and a minimum thickness of 4 inches with #3 rebar spaced at 12 inches or #4 rebar spaced at 24 inches on center each way. The concrete channels shall be constructed of 5 sack cement concrete with a minimum compressive strength of 2500 psi at 28 days. Provide a 1-inch minimum depression per every 1 foot of transverse slope with redwood headers spaced every 40 feet.

(4) Appropriate covering (grass, slope paving, etc.) shall be established on side slopes and pond bottom to prevent erosion during periods of maximum water velocity.

(5) A concrete or articulated block spillway, set at the maximum ponding elevation, shall be provided near the detention pond outfall structure, starting at the detention pond top of bank and extending to the toe of slope of the receiving channel.

e. Ownership and Access:

(1) Private Facilities:

(a) Detention facilities which rely on gravity to discharge storm water are preferred by the City.

(b) Responsibility for maintenance of the detention facility must be indicated on the plat and construction plans.

(c) All private properties being served shall have drainage access to the pond.

(d) A recorded maintenance agreement with a specific responsible party shall be provided when multiple tracts are being served.

(e) The maintenance berms shall be at least 20 feet wide surrounding the top of bank of the detention area.

(2) Public Facilities:

(a) Facilities may be accepted for maintenance by the City but only in cases where public drainage is being provided.

(b) The City will require a maintenance work area 30 feet wide surrounding the top of bank of the detention area. Public rights-of-way or permanent access easements may be included as a portion of this 30 feet width.

(c) A dedication of the maintenance easement or reserve must be provided by plat.

(d) Proper dedication of public access to the detention pond must be shown on the plat or by separate instrument. This includes permanent access easements with overlapping public utility easements.

f. Pumped Detention

Pumped detention systems will not be maintained by the City of La Marque under any circumstances and will be considered for approval only under the following conditions:

(1) A gravity system is not feasible from an engineering standpoint.

(2) The percentage of pumped volume must not exceed 50% of the total volume of the basin, the remaining volume must be able to drain from the basin by gravity.

(3) The total time to empty the pumped volume may not exceed 72 hours after the gravity portion has vacated.

(4) At least two pumps are provided, each of which is sized to pump the design flow rate; if a three-pump system is used, any two of the three pumps must be capable of pumping the design flow rate.

(5) The selected design outflow rate must not aggravate downstream

flooding. Example: A pump station designed to discharge at the existing 100-year flow rate each time the system comes on-line could aggravate flooding for more frequent storm events.

(6) Fencing of the control panel is provided to prevent unauthorized operation and vandalism.

(7) An on-site emergency generator capable of operating the pump station for the amount of time required to vacate the pumped volume must be provided.

(8) A recorded maintenance agreement with a specific responsible party shall be provided to ensure that the system will be operated and maintained on a continuous basis.

(9) Detention volume for pump detention shall be minimum 1.0 acre-ft/acre.

If a pumped system is proposed, it is strongly recommended that preliminary conceptual design be submitted to the City Engineer and applicable Drainage District for review before any detailed engineering is performed.

5.4 SUBMITTALS

5.4.1 All preliminary drainage plan submittals shall comply with and fully follow the procedures outlined in the City of La Marque's Subdivision Ordinance.

5.4.2 Preliminary Submittals: Submit for review and comment:

A. Lot and street layout.

B. The approximate drainage areas for each system.

C. The proposed drainage system.

D. The proposed pipe diameters.

E. Proposed detention areas with approximate volumes and depths.

F. Any proposed drainage easements.

G. Floodplain boundary, if applicable.

H. Floodway boundary, if applicable.

I. Base Flood Elevation.

5.4.3 Final Design: Submit the following for approval:

A. Copies of any documents which show approval of exceptions to the City design criteria.

B. Design calculations for storm line sizes and grades and for detention facilities.

C. Design calculations for the hydraulic grade line of each line or ditch, and for detention facilities. Calculations shall show that the water surface elevations will not be increased upstream or downstream of the property on a 5 year and 100-year event.

D. Contour map of the project and drainage area map for the project and the upstream.

E. Plan and profile sheets showing storm water design.

F. Projects located within a flood plain boundary or within a flood plain management area shall:

a. Show the flood plain boundary or flood plain area, as appropriate, on the drainage area map.

b. Show the floodway boundary, if applicable.

5.4.4 Additional Submittals: Submit the following for approval:

A. Previous review prints.

B. Revised drawings.

C. Storm water detention maintenance agreement letters.

D. Pipeline company agreements.

E. Any and all applicable permits and agreements.

5.5 QUALITY ASSURANCE

5.5.1 Prepare calculations and construction drawings under the supervision of a Professional Engineer trained and licensed under the disciplines required by the drawings being prepared. The final construction drawings and all design calculations must be sealed, signed, and dated by the Professional Engineer responsible for the development of the drawings. Drawings shall contain the following statement "Based on these plans and calculations and minimum building elevations prepared under my direction, no structure will be subject to flooding in the 100-year storm and the upstream and downstream water surface elevations will not be increased."

5.5.2 A geotechnical report shall be performed by, or under the supervision of, a currently registered Professional Engineer in the State of Texas, pertaining to the Drainage Design requirements contained within this section. All reports and documents shall be sealed, dated, and signed by the Engineer responsible for the preparation thereof.