CHAPTER 5
STORMWATER DESIGN CRITERIA

5.1 GENERAL PROVISIONS

Drainage Criteria for development within the City of La Porte, and where applicable within La Porte's Extraterritorial Jurisdiction (E.T.J.) is dependent upon the size and type of development, the conditions within the individual watershed, the conditions or design of the receiving stream, bayou, channel, roadside swale, culvert, or roadway.

The basic objective of this policy is to minimize the threat of flooding to areas within the City and its E.T.J. and to minimize the effect of continued development on individual watersheds.

1. The City believes that the best long-term means of accomplishing its objective is a continued program of improvement and extension of the Harris County Flood Control District's system of open channels. This statement recognizes the technical reality that an essential prerequisite to an effective flood control program is a system of open channels capable of carrying storm runoff of any type in Harris County to Galveston Bay without adversely impacting existing urban areas adjacent to the channels.

2. The City recognizes that both District's and City's existing open channel system is, in many instances, inadequate to accomplish the goal of eliminating existing flooding conditions for existing levels of urban development, or for ultimate development in the watershed.

3. The City therefore recommends that where required, certain additional flood control facilities be utilized to supplement the open channel system. Such flood control facilities shall be designed to preclude flooding in areas that do not presently flood and not increase flood levels where flooding now occurs. Specifically, the City supports the use of storm water detention to supplement the open channel system until long-term channel improvements can be completed, or as permanent facilities where additional open channel improvements are not feasible. The result will be that new development will limit or restrict the impact downstream.

5.1.1 All the drainage plans and construction shall meet or exceed the requirements of the City of La Porte, Harris County Flood Control, Harris County, TxDOT, or any other entities having jurisdiction over a facility (i.e. roadway, channel, etc.).

5.1.2 Unless otherwise provided for in these policies, development shall follow the Harris County Flood Control District Criteria Manual for the design of Flood Control and Drainage Facilities in Harris County, Texas.

5.1.3 If application of the policies and criteria contained in this document conflict with the City's duties under the Flood Hazard Prevention Ordinance, the regulations of the Flood Hazard Prevention Ordinance shall apply.

5.1.4 Drainage structures shall be constructed in such locations and of such size and dimensions to adequately serve the development and the contributing drainage area. In new developments, the developer shall provide all the necessary easements and rights-of-way required for drainage structures, including storm sewer and open or lined channels.

5.2 CONSTRUCTION PLAN REQUIREMENTS

5.2.1 A drainage map shall be included in the construction plans. The drainage area map shall include:

A. Drainage areas, including areas draining from off-site onto or adjoining the project
B. Design storm runoff, based on the type of facility and storm frequency listed in Section 5.4.
C. 100 – year runoff sheet flow pattern.
D. Route of overland flow including the overflow to a drainage channel or detention facility
E. Water surface profiles for the 25-year and/or 100-year storms in the outfall channel. All available information will be considered when making this determination.
F. Flow per inlet
G. Maximum ponding elevation
H. For bridge designs the 100-year WSEL must be shown on the plans and the low chord of the bridge must be a minimum of eighteen inches above the 100-year WSEL.

5.2.2 Detailed drainage calculations shall be submitted with the construction plans.

5.2.3 A lot grading plan should demonstrate that the finished grading plan will drain to approved collection and discharge points and that the overland flow of water from adjacent properties will not be impacted. In no instance will plans be approved without specific detail as to how the 100-year event will sheet flow from the development to the outfall without adversely impacting structures.

5.2.4 The hydraulic gradient for the design storm may be shown on the construction drawings. Calculations for the elevation for the hydraulic gradient shall be provided with the design storm drainage calculations. The hydraulic gradient must be below the gutter line for the design storm. The tailwater elevations based on a 25-year frequency in the outfall channel shall be used for calculations of the hydraulic gradient. If the 25-year WSEL is not available then use 80% of the ultimate channel height. In areas which are tidally influenced the mean high tide elevation will be used unless it is lower than the 25-year WSEL, in which case the higher value will be used. In instances where the 25-year WSEL in the receiving channel is lower than the top of pipe then the top of pipe shall be used as the starting point for HGL calculations.

5.3 USE OF PREVIOUSLY DESIGNED AND INSTALLED INFRASTRUCTURE

Situations where previously installed infrastructure is in place but not yet utilized to its design capacity will be considered on a case by case basis. The developers engineer shall after consultation with the City, prepare a report that:

a. outline the original design criteria
b. evaluates the impact of the original design on the receiving stream, adjoining properties and/or the 100 year Floodplain.

Based on the report, the City Engineer may allow full or partial use of the previously installed infrastructure and may require it to be supplemented with detention or other facilities.

5.4 STORM FREQUENCY, RUNOFF AND DATUM

A. Storm Frequency

All drainage improvements shall be designed for the following storm frequencies based on Atlas 14 rainfall data for Harris County Region 3.

Type of Facility	
Road Side Ditches and Culverts	5 year
Storm Sewers	5 year
Ditches & Culverts Drainage 100 acres and more	25 year
Bridges	100 year
Creeks	100 year

Detention Facilities Refer to Section 5.5

B. Storm Runoff

Design flow of storm water runoff is to be calculated using the Rational Method.

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

$$Q = CIA, \text{ where}$$

Q is the storm flow at a given point in cubic feet per second (c.f.s).
C is a coefficient of runoff (see Table 1).
I is the average intensity of rainfall in inches per hour for a period equal to the time of flow from the farthermost point of the drainage area to the point under consideration. (See figure 1, I-D-F Curves and Figure 2, Determination of Time of Concentration)
A is the drainage area in acres

The size and shape of the watershed must be determined for each installation. The area of each watershed may be determined through the use of planimetric-topographic maps of the area, supplemented by field surveys in areas where topographic data has changed or where the contour interval is insufficient to adequately determine the direction of flow.

The outline of the drainage area contributing to the system being designed and outline of the sub-drainage area contributing to each inlet point shall be determined.

When calculating the peak flow rate of storm water runoff, rainfall intensity will be determined from the rainfall intensity, duration and frequency curves, shown in Figure 1. The storm frequency used for this determination will be according to the facility to be designed as listed in Section A.

1. Runoff Coefficients and Time of Concentration

Runoff coefficients, as shown in Table 1, shall be the minimum used, based on total development under existing land zoning regulations. Where land uses other than those listed in Table 1 are planned, a coefficient shall be developed utilizing values comparable to those shown. Larger coefficients may be used if considered appropriate to the project by the City Engineer.

The time of concentration is defined as the longest time, without unreasonable delay, that will be required for a drop of water to flow from the upper limit of a drainage area to the point of concentration. The time of concentration to any point in a storm drainage system is a combination of the “inlet time” and the time of flow in the drain. The inlet time is the time for water to flow over the surface of the ground to the storm drain inlet. Because the area tributary to most storm sewer inlets is relatively small, it is customary in practice to determine the inlet time on the basis of experience under similar conditions. Inlet time decreases as the slope and the imperviousness of the surface increases, and it increases as the distance over which the water has to travel and retention by the contact surfaces.

Time of concentration shall be computed from Figure 2 and in no case shall the inlet time be more that the time shown in Table 1.

Table 1

Zone	Zoning District Name	Runoff Coefficient "C"	Maximum Inlet Time in Minutes
R-1	Low Density Residential	0.50	15
R-2	Mid Density Residential	0.60	15
R-3	High Density Residential	0.80	10
MH	Manufactured Housing District	0.55	15
NC	Neighborhood Commercial District	0.80	10
GC	General Commercial District	0.85	10
BI	Business Industrial Park District	0.85	10
LI	Light Industrial	0.85	10
HI	Heavy Industrial	0.85	10
PUD	Planned Unit Development District	variable	10 to 15

Miscellaneous Land Uses

Land Use	Runoff Coefficient "C"
Church	0.70 to 0.90
School	0.50 to 0.90
Park	0.30 to 0.70

C. Datum

All drainage plans shall be prepared based on North American Vertical Datum of 1988, 2001 adjustment, consistent with National Flood Insurance Program, Flood Insurance Study for the City of La Porte.

5.5 REQUIRED DETENTION

Detention will be required to mitigate increase in flows. Minimum detention rates are described in the table below. Minimum storage rate does not apply for single family residential structure and/or accessory buildings proposed on an existing lot.

Hydrograph timing may not be used as a substitute for detention when detention is required.

5.5.1 Design Standards for Detention Basins

Detention requirements for developments less than 50 acres shall be according to the following table. For developed areas of 10 acres or less, the required volume equals the total development area times the appropriate storage coefficient. For areas greater than 10 acres and less than 50 acres the volume is determined by applying Harris County Flood Control District criteria for small watersheds.

Table 2 (Also, See Figure 4)

Developed Area	Storage Coefficient
0 to 1 acres	0.20 acre ft. / acre
1 to 10 acres	0.55 acre ft. / acre
10 to 50 acres	per HCFCD criteria

For developments which are larger than 50 acres, Harris county Flood Control District and/or the City Engineer shall approve the detention facility criteria, however, a minimum detention storage rate of 0.55 acre-ft/acre will be required.

5.2.2 Outlet Sizing

1. The outlet structure shall be designed using the orifice equation as follows:

$$Q = CA \times (2gh)^{1/2}$$

Where,
C = 0.8
A = cross sectional area
g = 32.2 feet / sec^2
h = head differential

For head differential use 2' or the 100-year water surface in pond minus the 25-year water surface in receiving channel, if available.

2. Minimum restrictor shall be 6" diameter.

5.5.3 Additional Standards for Detention Basins

The detention facility shall be designed for easy maintenance. For smaller developments the designer is encouraged to use parking lots, underground piping, swales, green spaces, etc. to achieve the volume required.

For larger developments every consideration shall be given to designing of the facility for multipurpose use, such as playgrounds, ballfields, miniparks, required green spaces, etc. to assure that maintenance will be accomplished. The design shall include the following:

1. an earthen detention basin shall have minimum side slopes of 4:1 and a minimum bottom width of ten feet;
2. the bottom of the detention basin shall have a minimum 0.50% cross slope to facilitate quick drainage.
3. a v-shaped trickle channel a minimum of 5' wide, six-inch thick, reinforced concrete shall be constructed through the detention basin at a longitudinal slope of 0.20% to accommodate low flow and facilitate rapid drainage. For developments less than 3 acres, the trickle channel may be 2 feet wide and 4" thick.
4. a minimum 12-foot wide maintenance berm shall be provided around the perimeter of the detention facility.
5. ingress and egress for maintenance including a dedicated right-of-way if required, shall be provided to the detention basin and clearly shown on the construction drawings or site plan subdivision plat.
6. the detention basins, slopes, bottom, maintenance berm, and other associated right-of-way shall be final graded with a minimum of 6" top soil then hydro-mulch or drill-seeded and watered to facilitate full grass coverage.
7. parties responsible for maintenance of the detention facility must be shown on the plat and or plans.
8. Pumped detention systems may be allowed with specific approval from the City Engineer.

5.5.4 Ownership and Maintenance of Facilities

The City will not accept maintenance of on site facilities that serve only one tract or development, unless it is determined to have other public benefits, is recommended by staff and approved by the Planning and Zoning Commission.

Harris County Flood Control District may, at their discretion, accept maintenance of facilities, provided they are designed in accordance with the District's criteria manual. Requests for Harris County Flood Control District to assume maintenance of any facility should be coordinated with the City prior to any development approvals.

5.6 ADDITIONAL DESIGN REQUIREMENTS

5.6.1 Discharge Points

The developer shall terminate all drainage improvements at a discharge point approved by the City. The developer shall design and construct such discharge point, or outlet, to prevent damage to or overflowing into adjacent property. The City may require creek improvement, channel lining, energy dissipaters or other improvements for such outlet to prevent erosion or increase the flow capacity.

Finished elevations of new pavement, parking areas, or other improvements shall be designed so that each succeeding high point is lower when moving in a downstream direction. This ensures the 100-year discharge has an unobstructed path to the discharge point whether discharging to a channel or detention pond.

5.6.2 Public Streets as Drainage Facilities

1. Maximum depth of water to be allowed in local streets during design flow shall be at the top crown, or top of curb, whichever is less.
2. Maximum spread of water in collector streets during design flow shall allow for one clear lane of traffic (12 feet wide).
3. Maximum spread of water in arterial streets during design flow shall allow for two clear lanes of traffic (24 feet wide).
4. The street is to be designed to convey the 100-year event to the outfall point by successively lower high points. A dedicated easement must be provided at the terminus to allow the 100-year event to sheet flow to the ultimate outfall. In lieu of sheet flow it is allowable for the developer to construct an underground system to convey the 100-year event.

5.6.3 Drainage Channels and Structures

1. The developer shall install an underground storm drain on curb and gutter streets beginning at the point where calculated storm water runoff is of such quantity that it exceeds the height specified above. The developer shall construct the storm drain system from the point to an approved outlet.
2. For non-curb and gutter streets, the developer may use open channel (channel or ditch) methods to dispose of storm water specified above. Such channels may be in dedicated draining easements outside the standard street right-of-way upon City approval of the location and alignment of such easements. Alternatively, the developer may widen the street right-of-way to accommodate an open channel of greater capacity than the standard street/ditch section.
3. If the developer locates the channel in a widened street right-of-way, the City shall approve the right-of-way width and channel configuration. The depth of flow in the channel shall not exceed one (1) foot as measured from the ditch flowline to the point on the roadway established as the high water level in this section.
4. The developer shall design and construct all channels to terminate at an approved outlet.

5.6.4 Habitable Structures

The developer shall provide adequate means for storm water run-off in excess of the "design storm" capacity (i.e., 3, 10-year storm) to flow around habitable structures.

a.) The developer shall provide a grading/drainage plan which shows that all building sites can provide a finished floor elevation:

(1) At least one foot (1') above the top of the curb using the highest point along the portion of such curb fronting the building site, or
(2) At least one foot (1') above the crown of the road elevation, using the highest point along the portion of such road fronting the building site.
(3) At least one foot above the ground elevation along all sides of the building site.

b.) In addition to paragraph (a) above, the developer shall provide a grading/drainage plan which meets or exceeds the provisions of Chapter 94, Code of Ordinances, Flood Hazard Reduction.
c.) The developer shall design and construct all streets to minimize any fill required to bring building pads into compliance with this code.
d.) Alternate methods of building protection may be accepted by the City upon submittal of detailed information, review and approval by the City Engineer.

5.6.5 Drainage System Criteria

If an underground drainage system is required, and a 60-inch or smaller pipe will handle the design flow, pipe shall be used. If a 60-inch pipe is not adequate, the developer has the option to use concrete pipe or natural and/or a lined open drainage channel. If pipe is selected, the maximum allowable velocity shall be 8fps in the pipe. Lining materials, if used, shall be approved by the City.

5.6.6 Public storm sewers are 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, private storm sewers provide internal drainage for a reserve or other tract. Private storm or sewer connections to public storm sewers shall occur at a manhole or at the back of an inlet as approved by the City Engineer. All private storm sewers within the public right-of-way shall be constructed in conformance with the Standards.

5.6.7 All construction shall conform with the City of La Porte Construction Details.

5.6.8 All storm sewers shall meet or exceed the requirements of the "Drainage Criteria Manual for Harris County, Texas" and the requirements of the City of La Porte.

5.6.9 All storm sewer shall be sized based on Atlas 14 rainfall data as described in Section 5.4. Any new development proposed to discharge to a City of La Porte conveyance system (i.e. storm sewer system, roadside ditch, etc.) will require detention at a minimum storage rate of 0.55 acre-ft/acre.

5.7 LOCATION OF STORM SEWER

5.7.1 Public storm sewers shall be located within a public street right-of-way or storm sewer easement, dedicated to the public and adjoining a public street right-of-way. Storm sewers through side lot drainage easements are highly discouraged. Limited use may be approved at the discretion of the City Engineer. If approved, a minimum twenty-foot (20') wide easement is required (10' on each lot).

5.7.2 Recommended alignment within a public street right-of-way.

A. Boulevard pavement section with median – along centerline of the right-of-way.
B. Undivided pavement section five feet (5') inside the right-of-way. For storm sewer located in a public street right-of-way, a minimum of two-foot (2') shall be maintained inside the right-of-way line to the outside edge of the storm sewer unless otherwise accompanied by an adjacent easement.
C. Alternate locations for a storm sewer will be permitted by the City Engineer.

5.7.3 Recommended alignment within an exclusive storm sewer easement.

A. Storm sewers placed in easements shall conform to the requirements of Section 2.4.5

B. Storm sewers within easements shall be placed no closer than five feet (5') measured from the outside edge of the pipe to the edge of an easement, except when adjoining another easement or public right-of-way where the distance may be reduced to two feet (2'). The storm sewer shall be placed in the center of the easement. When the storm sewer easement adjoins a public right-of-way, the easement may be reduced to a minimum of ten feet (10') and the storm sewer may be aligned close to the right-of-way line, as long as required clearances are met, with specific approval of the City Engineer.

5.8 STORM SEWER MATERIALS

5.8.1 Storm sewer and culvert pipe shall be precast reinforced concrete pipe, unless specifically approved by the City Engineer. Concrete pipe shall be manufactured in conformance with the requirements of ASTM C 76, "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe," current revision. Reinforced concrete pipe shall be Class III or stronger. The design engineer shall provide for increased pipe strength when conditions of the proposed installation exceed the allowable load for Class III pipe. All concrete pipe constructed in water-bearing soil or forty-two inches (42") in diameter or larger, shall have rubber gasket joints meeting the requirements of ANSI/ASTM C 443, "Joints for Circular Concrete Sewer and Culvert pipe, Using Rubber Gaskets", current revision. Concrete pipe with diameter of less than forty-two inches (42") may be installed using pipe with tongue and groove type joint and Ram-nek, or approved equal, as a joint filler. When specifically approved by the City Engineer, reinforced concrete arch and elliptical pipe conforming to ASTM C506 and ASTM C507, respectively, current revision, may be installed in lieu of circular pipe. Reinforced concrete box culverts shall meet the minimum requirements of ASTM C789, "Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers", current revision. Pipe joints for arch and elliptical pipe and box culverts shall be sealed using Ram-nek or approved equal.

5.8.2 Storm sewer outfalls into open channels shall be constructed using corrugated steel pipe. Corrugated steel pipe shall be manufactured in conformance with the requirements of AASHTO Designation M-36-82, current revision. Pipe material shall be Aluminized Steel Type 2, meeting the requirements of AASHTO Designation M-27-79I, current revision, or Pre-coated Galvanized Steel, AASHTO M-246, 10 mil coating on both sides. All pipe shall have a full double coating, Type A, in accordance with AASHTO Designation M-190, current revision. Pipe joints and fittings shall meet the minimum requirements of these specifications and shall have an O-ring gasket seal meeting the requirements of AASHTO C-361, current revision. (See City of La Porte Construction Details).

5.8.3 Storm sewer outfalls shall have a slope protection to prevent erosion. Slope protection may be constructed of slope paving or rip rap. Slope paving shall be four-inch (4") five (5) sack concrete with six-inch by six-inch (6" x 6") welded wire mesh (W14 x W14) or three eighths inch (3/8") steel rebar on twenty-four-inch (24") centers, each way. Rip rap shall be a minimum of six-inch (6") broken concrete rubble with no exposed steel or well-rounded stone and shall be a minimum of eighteen inches (18") thick. Slope protection texturing shall be required where public access likely. Refer to the Construction Details for minimum dimensions.

5.9 ADDITIONAL REQUIREMENTS

5.9.1 Minimum depth of storm sewer (measured to the top of pipe) shall be twenty-four (24") below the top of curb or finished grade, whichever is lower. Minimum size storm sewer for main and inlet lead shall be twenty-four inches (24").

5.9.2 Storm sewers shall be bedded using cement stabilized sand (see specification in Section 4.2.3) as shown in the City of La Porte Construction Details.

5.9.3 Pipe requirements.

A. Reinforced concrete pipe installed at a depth greater than thirty feet (30') shall be designed by the engineer for the specific installation and approved by the City Engineer, Reinforced concrete pipe shall be designed in accordance with the American Concrete Pipe Association, "Concrete Pipe Design Manual", Maximum cover on the pipe shall be measured from the top of pipe to the ultimate finished grade or natural ground, whichever is greater.

B. Corrugated steel pipe shall have a minimum thickness as follows:

PIPE SIZE (Inches) Corrugations (Inches)	MINIMUM THICKNESS
242-2/3" X 1/2"	0.052
30- 482-2/3" X 1/21	0.064
54- 723't X 1" or 511 X 1"	0.064
78- 102311 X 1" or 5" X 1"	0.079

Bedding for corrugated steel pipe shall be cement-stabilized sand. Corrugated steel pipe less than or equal to fifty-four inches (54") in diameter and less than thirty feet (30') deep shall have the minimum thickness given above.

C. Design storm flow in a street shall not exceed the capacity of the street, for the water surface equal to the top or curb and shall not exceed the inlet capacity. Design storm flow shall meet Harris County criteria.

D. All bridges must be a minimum of eighteen inches (18") above the 100-year water surface elevation or in accordance with the Federal Emergency Management Agency (FEMA) regulations, latest revisions, or HCFCD requirements, whichever is greater.

5.9.4 Storm sewers less than forty-two inches (42") in diameter shall be constructed on a straight horizontal and vertical alignment between manholes. Storm sewers greater than or equal to forty-two inches (42") in diameter may be laid along a curve using manufactured bends of less than or equal to 11¼'.

5.10 APPURTENANCES

5.10.1 Manholes

A. Manholes shall be placed at all changes in alignment, grade and size of the storm sewers; at the intersection of two or more storm sewers; at all inlet leads; and at the end of all storm sewers.
B. Maximum spacing between manholes shall be four hundred feet (400').
C. Manhole covers shall be cast iron, traffic bearing, type ring and cover with the words "storm sewer" cast into the cover.

5.10.2 Inlets

A. Curb inlets shall be spaced and sized to intercept the calculated runoff for the design storm. The water surface elevation at the inlet shall be less than or equal to the gutter for the design storm flow.

B. Maximum travel distance of water in the street to a curb inlet shall be three hundred feet (300') on a major thoroughfare and in a commercial area. The maximum travel distance of water in the street permitted in a single-family residential area shall be four hundred feet (400').

C. No Valley Gutter without prior approval.

D. Curb inlets should be on the intersecting side street at intersections with a major thoroughfare. The City Engineer shall specifically approve locations at intersections.

E. Grated inlets will not be permitted in an open ditch.

F. Backslope swale interceptors shall be placed in accordance with the requirements of Harris County.

G. Curb inlets shall have solid inlet lids. Grate or Curb and Grate inlets shall not be allowed for residential subdivisions. Curb inlets shall be recessed, unless otherwise directed by the City Engineer.

H. Backfill around inlets and to top of first stage inlet with cement stabilized sand.