CITY OF TEXARKANA

STORMWATER MANAGEMENT DESIGN MANUAL

JULY 2021

Approved by City Council on September 27, 2021 by Ordinance No. 2021-82

This document is based on the regional *i*SWM Manual prepared by the North Central Texas Council of Governments. The original iSWM document has been revised to present City of Texarkana Stormwater Management Criteria. Some of the *i*SWM sections and criteria which are not currently adopted are available in the Appendices for technical reference, utilization by developers for enhancement of land development projects, and potential future adoption by the City, as needed.

City of Texarkana Stormwater Management Design Manual Executive Summary

The purpose of this Executive Summary is to:

1. Give the user a quick reference of topics covered in the Stormwater Management Design Manual, and
2. To restate pertinent design guidelines that will allow the user to move quickly into the design stage.

The Executive Summary is color coded based on the following categories:

- Green – Restatement of sections from the Stormwater Management Design Manual
- Red - Pertinent values, formulas, and tables that are used in design
- Blue – References to sections from the Stormwater Management Design Manual

It is important that designers familiarize themselves with the entirety of the Stormwater Management Design Manual and the technical documents referenced therein.

CHAPTER 1 – STORMWATER MANAGEMENT SYSTEM PLANNING AND DESIGN

Chapter 1 of this Manual provides a foundation for stormwater management in terms of basic philosophy, principles, definitions, and land development site planning and design practices, and should therefore be utilized for general guidance throughout the development process.

Section 1.1 – Stormwater Management Planning

Stormwater management plans may benefit from a pre-submittal meeting with the City. The pre-submittal meeting is an important consideration in that it allows the developer and their design engineer to propose a potential site layout and gives City staff the opportunity to comment on a stormwater management plan concept prior to significant planning and design effort on the part of the design engineer. The pre-submittal meeting is recommended for complex projects and submittals, but it is not required. The design engineer may use the Pre-submittal checklist provided in Appendix A, to allow the design engineer, the developer and the City of Texarkana to get a “first look” at the stormwater management system for the proposed development.

The Stormwater Management Plan adds further detail to the Pre-submittal Checklist and reflects changes that are requested or required by the local review authority. It is recommended but not required that design engineers or developers submit the Stormwater Management Plan and checklist provided in Appendix A with the preliminary plan or preliminary plat submittal.

Section 1.2 – Planning and Design Approach

The City of Texarkana stormwater management approach is focused on controlling stormwater quantity and ensuring no adverse impacts to property or structures as a result of development and/or land disturbing activities. Post construction water quality protection is not currently a standard requirement in Texarkana. However, the City encourages land developers to consider the use of post construction water quality measures as regulations are being developed to comply with the City’s MS4 permit.

1.2.1 Flood Control

The intent of the flood control criteria is to provide for public safety; minimize on-site and downstream flood impacts from the 100-year storm events; maintain the boundaries of the mapped 100-year floodplain; and protect the physical integrity of the on-site stormwater controls as well as the downstream stormwater and flood control facilities.

Flood control analyses are based on 2-, 10-, and 100-year storm events.

1.2.1.1 On-Site Conveyance

The 2-year and 10-year storm events are used to design standard levels of flood protection for streets, sidewalks, structures, and properties within the development. Even though the conveyance systems may be designed for smaller storm events, overall, the site should be designed appropriately to safely pass the resulting flows from the "full build-out" 100-year storm event with no flood waters entering habitable structures.

1.2.1.2 Downstream Flood Control

Option 1: Acceptable Downstream Conditions (Downstream Assessment Required)

The developer should provide all supporting calculations and/or documentation to show that the existing downstream conveyance system has capacity to safely pass the 100-year discharge from the new development.

Option 2: Downstream Improvements (Downstream Assessment Required)

If the downstream receiving system does not have adequate capacity, then the developer may choose to provide improvements to the off-site, downstream conveyance system.

Option 3: Maintain Existing Downstream Conditions

If the downstream receiving system does not have adequate capacity, then the developer may also choose to provide stormwater controls to reduce downstream flood impacts.

Option 4: Maintain Existing On-Site Conditions

Lastly, on-site controls may be used to maintain existing peak discharges from the development site. A downstream assessment will not be required for sites being developed less than 1 acre.

1.2.1.3 Downstream Assessment

The downstream assessment is the first step in the process to determine if a specific development will have a flooding impact on downstream properties, structures, bridges, roadways, or other facilities. The downstream flood control criterion is based on an analysis of the 2-, 10-, and 100-year, 24-hour storm events.

- No new or increased flooding of existing structures for 2-, 10- and 100-year floods.
- No significant increases (0.1'or less) in flood elevations over existing roadways for the 2-, 10- and 100-year floods.
- No significant rise (0.1' or less) in 100-year flood elevations, unless contained in existing channel, roadway, drainage easement and/or R.O.W.
- No significant increases (maximum 5%) in channel velocities for the 2-, 10- and 100-year floods. Post-development channel velocities cannot be increased more than 5% above pre-development velocities or exceed the applicable maximum permissible velocities shown in tables 4.4-2 and 4.4-3. Exceptions to these criteria will require certified geotechnical/geomorphologic studies that provide documentation those higher velocities will not create additional erosion.
- No increases in downstream discharges caused by the proposed development that, in combination with existing discharges, exceeds the existing capacity of the downstream storm drainage system.

CHAPTER 2 – HYDROLOGIC ANALYSIS

Section 2.1 – Estimating Runoff

The following methods have been selected to support hydrologic site analysis:

- Rational Method
- SCS Unit Hydrograph Method
- Snyder's Unit Hydrograph Method
- USGS and TXDOT Regression Equations

In general, the **Rational Method** is recommended for small highly impervious drainage areas such as parking lots and roadways draining into inlets and gutters. The **SCS Method** is the recommended hydrograph method for Texarkana. Use of **Snyder's Unit Hydrograph Method**, and **USGS and TXDOT Regression Equations** require approval of the Director of Public Works.

Recommended applicable methods and constraints as well as Rainfall depth and intensity tables are provided in this section of the manual.

2.1.4 – Rational Method

The Rational Method can be used to estimate stormwater runoff peak flows for the design of gutter flows, drainage inlets, storm drain pipe, culverts, and small ditches. It is most applicable to small, highly impervious areas with a maximum recommended drainage area of 200 acres.

This section of the manual details and discusses the following parameters for using the Rational Method:

- Rational Formula
- Runoff Coefficients (C)
- Frequency Factors (Cf)
- Time of Concentration Formulas (Tc)
- Recommended Time of Concentration Limits
- Overland Flow Nomograph
- Manning's Equation Nomograph for Channels

2.1.5 – SCS Hydrologic Method

The Soil Conservation Service (SCS) hydrologic method requires basic data similar to the Rational Method, but is more sophisticated in that it also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. The SCS Method can be used for most design applications, including storage facilities and outlet structures, storm drain systems, culverts, small drainage ditches, open channels, and energy dissipators.

This section of the manual details and discusses the following parameters for using the SCS Method:

- Rainfall – Runoff Equation
- Runoff Factor (CN)
- Urban Modifications of the SCS Method
- Travel Time Estimates (Sheet Flow, Shallow Concentrated Flow, Channel Flow)
- Simplified SCS Peak Runoff Rate Estimation
- Hydrograph Generation
- Hydrologic Stream Routing

CHAPTER 3 – HYDRAULIC DESIGN OF STREETS AND CLOSED CONDUITS

Section 3.1 – Stormwater Street and Closed Conduit Design Overview

3.1.2.5 Design Storm Recommendations

Storm Sewer System

- The design storm is a minimum 10-year for the closed conduit systems in residential and commercial areas and for thoroughfares. The 100-year storm is the design storm for the combination of the closed conduit and surface drainage system.
- Runoff from the design storm must be contained within the permissible spread of water in the gutter. The 100-year storm flow must be contained within the ROW. Adequate inlet capacity shall be provided to intercept surface flows before the street ROW capacity is exceeded. Note: The capacity of the underground system may be required to exceed the 10-year design storm in order to satisfy the 100-year storm criteria.
- Enclosed drainage systems for all street types shall be designed to contain the 10-year storm. The 10-year flow must not exceed curb depth. 100-year flows shall be contained within drainage easement and/or ROW. Safe overflow routing with supporting calculations shall be provided and indicated on plans. Grading plans must accommodate the necessary capacities to contain the 100-year flow within the street right-of-way or drainage easements.
- The closed conduit HGL must be equal to or below the gutter line for pipe systems and one (1) foot or more below top of curb at inlets. For situations where no ROW exists, the 100 year HGL must be below finished ground. The 100-year HGL will be tracked carefully throughout the system and described in the hydraulic calculation tables (Figures 3.2-26 and 3.2-27) in the construction drawings.

Sump Inlets

In sag or sump conditions, the storm drain and sump inlets should be sized to intercept and convey the 25-year storm, provided that a positive overflow is provided for the remainder of the 100-year storm. When the overflow route is between residential lots or otherwise constricted, the positive overflow structure must be concrete or other acceptable non-earthen structure with a minimum bottom width of 6 feet extending from the sump inlet to the storm sewer outfall. If the upstream pipe already conveys more than 10-year peak discharge, then the downstream pipe must have at least the same capacity from sump to outfall, and an inlet must still be installed at sump to allow for emergency overflow. If a structural overflow is not practical, then the underground system must be sized to convey the 100-year storm.

Section 3.2 – On-Site Flood Control System Design

The requirement for the City of Texarkana's typical street sections are presented in Table 3.1-1 below.

Table 3.2-1 Typical Street Sections and Storm Sewer Criteria

Street Type	Min. Back to Back Width (ft)	Section Type	Closed Conduit Design Storm	Inlet Type		Flow Spread Limits (ft)
				Recessed or Non-Recessed	Depressed or Non-Depressed	
Residential Urban Street	31	Rooftop	10 yr	Either	Either	Top of Curb or Roadway Centerline
Urban Collector	37	Rooftop	10 yr	Either	Either	One 12' Lane Clear
Arterial	50	Rooftop	10 yr	Either	Either	One 12' Lane Clear (each side)
Residential Boulevard	20/20*	Rooftop	10 yr	Either	Either	One Lane Clear (each side)
Collector Boulevard	25/25*	Rooftop	10 yr	Either	Either	One Lane Clear (each side)

* Each side

This section of the manual provides design formulas, graphs, and methodology for these storm sewer components:

- Street and Roadway Gutters (3.2.3)
- Composite Gutter Sections (3.2.3.5)
- Grate Inlets on Grade (3.2.5.1)
- Grate Inlets in Sag (3.2.5.2)
- Curb Inlets on Grade (3.2.6.1)
- Curb Inlets in Sumps (3.2.6.2)
- Combination Inlets on Grade (3.2.7.1)
- Combination Inlets in Sump (3.2.7.2)

Section 3.2.8.2 - Access Holes

Access holes shall be located at the spacing shown in Table 3.2-7 and (a) where two or more storm drains converge, (b) where pipe sizes change, and (c) where a change in alignment or grade occurs.

Table 3.2-7 Access Hole Spacing Criteria

Pipe Size (inches)	Suggested Maximum Spacing (feet)
12-24	300
27-36	400
42-54	500
60 and up	1000

Locations may be adjusted with City of Texarkana approval.

Section 3.2.8.4 - Design Criteria

The following design criteria are offered for consideration:

- For ordinary conditions, storm drain pipes should be sized on the assumption that they will flow full or practically full under the design discharge but will not be placed under pressure head. The Manning Formula is recommended for capacity calculations.
- The maximum hydraulic gradient should not produce a velocity that exceeds 15 ft/s.
- The minimum desirable physical slope is the slope that will produce a velocity of 2.5 feet per second when the storm sewer is flowing full.
- If the potential water surface elevation exceeds 1 foot below ground elevation for the design flow, the top of the pipe, or the gutter flow line, whichever is lowest, adjustments are needed in the system to reduce the elevation of the hydraulic grade line.

Additional hydraulic design criteria can be found in the following sections:

- Storm Drain Capacity Calculations Using Manning's Equation (3.2.8.6)
- Min. Grades and Desirable Velocities (3.2.8.7)
- Energy Grade Line / Hydraulic Grade Line Calculations (3.2.8.9)

- Storm Drain Outfall Considerations (3.2.8.10)
- Energy Losses (3.2.8.11)

Section 3.3 – General Design and Construction Standards

This section of the manual contains general design & construction considerations including but not limited to:

Materials - Only reinforced concrete, high-performance polypropylene, steel reinforced polyethylene, and high-density polyethylene pipe are allowed under pavement for public storm drains in the City of Texarkana.

HGL - The hydraulic grade line shall in no case be above the surface of the ground or street gutter for the design storm. Allowance of head must also be provided for future extensions of the storm drainage system. In all cases the maximum HGL must be 12" below top of curb at any inlet.

Utilities - The City of Texarkana prefers a minimum of 2 feet of clearance with all conflicting utilities. All utilities in the vicinity of a proposed storm drain shall be clearly indicated on both plan and profile sheets.

Minimum Pipe Sizes and Depths - Minimum pipe sizes are 24" diameter for mains and 15" diameter for inlet leads. Minimum sizes of conduits of other shapes should have equivalent cross-sectional areas. Minimum depth of storm sewer from outside top of conduit to top of curb is 30 inches.

Inlets - Curb inlets shall be 5, 10, 15 or 20 feet in length. Proposed inlet lengths greater than 20 feet must be approved by the Director of Public Works. Care should be taken in laying out inlets to allow for adequate driveway access between the inlet and the far property line.

Streets - To minimize standing water, the minimum street grade shall be 0.50%. Along a curve, this grade shall be measured along the outer gutter line. The minimum grade along a cul-de-sac or elbow gutter shall be 0.50%. Alternatively, elbows may be designed with a valley gutter along the normal outer gutter line, with two percent cross slope from curb to the valley gutter. The minimum grade for any valley gutter shall be 0.50%. Where a crest or sag is designed on a residential street, a PVI shall be used instead of a vertical curve where the total gradient change is no more than two percent ($\Delta \leq 2.0\%$).

Flow in Driveways and Intersections - At any intersection, only one street shall be crossed with surface drainage and this street shall be the lower classified street. Where an alley or street intersects a street, inlets shall be placed in the intersecting alley or street whenever the combination of flow down the alley or intersecting street would cause the capacity of the downstream street to be exceeded. Inlets shall be placed upstream from an intersection whenever possible. All driveways shall be sloped up from the gutter line to the right of way and further into the property if necessary, in order to maintain 6" of gutter flow in the street section.

The cumulative flows from existing driveways shall be considered and inlets provided as necessary where the flow exceeds the specified design capacity of the street.

Section 3.4 – Easements for Closed Conduit Systems

Minimum easement requirements for storm sewer pipe shall be as follows:

Table 3.4-1 Closed Conduit Easements

Pipe Size	Minimum Easement Width Required
39" and under	15 Feet
42" through 54"	20 Feet
60" through 66"	25 Feet
72" through 102"	30 Feet

The proposed centerline of overflow swales and storm drain lines shall normally coincide with the centerline of the easement.

Box culverts shall have an easement width equal to the width of the box plus twenty (20) additional feet, and shall be centered within the easement where possible.

Drainage easements will generally extend beyond an outfall headwall to provide for velocity dissipation devices and an area for maintenance operations. Drainage easements along a required outfall channel or ditch shall be provided until the flowline reaches an acceptable outfall.

CHAPTER 4 – HYDRAULIC DESIGN OF CULVERTS, BRIDGES, OPEN CHANNELS, AND DETENTION STRUCTURES

Section 4.1 – Stormwater Open Channels, Culverts, Bridges, and Detention Structure Design Overview

Design Storm Recommendations

Listed below are the design storm recommendations for various stormwater drainage system components to be designed and constructed in accordance with the minimum stormwater management standards.

Roadway Culvert Design - 100-year storm for fully developed watershed conditions **unless Open Channel Design (Section 4.4), FEMA or TxDOT criteria control.**

Bridge Design - 100-year storm for fully developed watershed conditions.

Open Channel Design - 100-year storm for fully developed watershed conditions. For roadside ditches 10-year storm in ditch and 100-year storm in roadway right-of-way.

Energy Dissipation Design - 100-year design for fully developed watershed conditions.

Storage (Detention Basin Design) - 2-year, 10-year and 100-year storm for the critical storm duration (i.e. 3 hour, 6 hour or 24 hour duration) that results in the maximum (or near maximum) peak flow. Analysis should consider both existing watershed plus developed site conditions and fully developed watershed conditions.

Section 4.2 – Culvert Design

This section of the manual provides design formulas, graphs, and methodology for these culvert components:

- Frequency Flood (4.2.3.1)
- Velocity Limitations (4.2.3.2)
- Headwater and Tailwater Considerations (4.2.3.6 & 4.2.3.7)
- Material, skew, & size (4.2.3.13-15)
- Inlet Control & Outlet Control Flow (4.2.4)
- Design Procedures and Examples (4.2.4)

Section 4.3 – Bridge Design

This section of the manual presents considerations related to the hydraulics of bridges. It is generally excerpted from Chapter 9 of the Texas Department of Transportation (TxDOT) Hydraulics Design Manual dated March 2004.

This section provides general considerations for these bridge components:

- Freeboard (4.3.1.3)
- Roadway/Bridge Profile (4.3.1.4)
- Flow Zones and Energy Losses (4.3.2.1)
- Bridge Flow Class (4.3.2.2)
- Frequency Flood (4.3.3.1)
- Design Procedures (4.3.4)

Section 4.4 – Open Channel Design

General Criteria

The purpose of this section of the manual is to provide an overview of open channel design criteria and methods for the following main classifications of open channels:

- Vegetative Linings (Earthen Channels)
- Flexible Linings (Rock Riprap, Gabions)
- Rigid Linings (Concrete)

In general, lined channels are discouraged, and require approval of the Director of Public Works.

Each reach of a channel requiring vehicular access for maintenance must have an access ramp. (4.4.3.1)

This section of the manual provides design formulas, graphs, and methodology for these culvert components:

- Velocity Limitations (4.4.3.2)
- Mannings "N" Values (4.4.4)
- Uniform Flow Calculations (4.4.5)

- Critical Flow Calculations (4.4.6)
- Vegetative Design (4.4.7)
- Stone Riprap Design (4.4.8)
- Gabion Design (4.4.9)
- Rectangular, Triangular, and Trapezoidal Open Channel Design (4.4.12)

Section 4.5 – Storage Design

This section of the manual provides general guidance on stormwater runoff storage for meeting stormwater management control objectives.

Stormwater storage can be classified as either detention, extended detention, or retention, and can also be categorized as on-line or off-line.

Other topics covered in this section of the manual are:

- Stage-Storage Relationship (4.5.1.3)
- Stage-Discharge Relationship (4.5.1.4)
- General Storage Design Procedures (4.5.3.1)
- Peak Flow Reduction (4.5.4.4)

Section 4.6 – Pond Outlet Structures

Primary outlets provide the critical function of the regulation of flow for structural stormwater controls. The types of outlets considered in this section of the manual are:

- Orifices (4.6.2.3)
- Perforated Risers (4.6.2.4)
- Pipes / Culverts (4.6.2.5)
- Sharp-Crested Weirs (4.6.2.6)
- Broad-Crested Weirs (4.6.2.7)
- V-Notch Weirs (4.6.2.8)
- Proportional Weirs (4.6.2.9)
- Combination Outlets (4.6.2.10)

Other design considerations discussed in this chapter of the manual are Multi-Stage Outlet Design (4.6.3) and Trash Racks and Safety Grates (4.6.4).

Section 4.7 – Energy Dissipation

The outlets of pipes and lined channels are points of critical erosion potential. Energy dissipators are engineered devices placed at the outlet of stormwater conveyance for the purpose of reducing velocity, energy, and turbulence of the discharged flow. Energy dissipator types covered in this section of the manual include:

- Riprap Aprons (4.7.4)
- Riprap Outlet Basins (4.7.5)
- Baffled Outlets (4.7.6)
- Grade Control Structures (4.7.7)