TOWN OF LITTLE ELM

ENGINEERING DESIGN STANDARDS

STORMWATER DESIGN REQUIREMENTS
TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION 1
1.1 STORMWATER GOALS AND OBJECTIVES ...................................................... 1
1.2 APPLICABILITY OF STORMWATER CRITERIA ............................................. 1
1.3 STORMWATER SUBMITTAL REQUIREMENTS ............................................... 1
  1.3.1 Stormwater Submittal Elements .................................................................. 2
  1.3.2 Permitting Requirements ............................................................................ 2
  1.3.3 Acceptable Modeling Software .................................................................. 3

CHAPTER 2. STORMWATER DESIGN STANDARDS 3
2.1 DESIGN FREQUENCY FOR DRAINAGE FEATURES ....................................... 3
2.2 DRAINAGE IMPACTS .................................................................................... 4
2.3 DRAINAGE CONSIDERATIONS FOR SITE GRADING ..................................... 5
  2.3.1 Grading Plans ........................................................................................... 5
  2.3.2 Minimum Lot and Floor Elevations ............................................................ 6
  2.3.3 Concentrated Runoff from Development .................................................. 6

CHAPTER 3. STORMWATER QUALITY 6
3.1 POST-CONSTRUCTION STORMWATER QUALITY ....................................... 7
  3.1.1 Post-Construction Stormwater Quality Objectives ................................... 7
  3.1.2 Stormwater Quality Plan .......................................................................... 7
  3.1.3 Water Quality Design Requirements ......................................................... 8
  3.1.4 Permanent Erosion Control ................................................................. 9
3.2 MAINTENANCE OF PERMANENT STORMWATER FACILITIES ................... 9
  3.2.1 Drainage Easements ................................................................................. 9
  3.2.2 Operations and Maintenance Agreements ............................................... 10
  3.2.3 Inspections .............................................................................................. 10
3.3 TEMPORARY CONSTRUCTION CONTROLS .............................................. 11
  3.3.1 Stormwater Pollution Prevention Plan ..................................................... 11
  3.3.2 Best Management Practices During Construction .................................... 11

CHAPTER 4. HYDROLOGY 11
4.1 PEAK DISCHARGES PREPARED BY TOWN ............................................... 11
4.2 RAINFALL INTENSITY .............................................................................. 11
4.3 DRAINAGE AREAS .................................................................................. 12
4.4 TIME OF CONCENTRATION ...................................................................... 12
4.5 ALLOWABLE HYDROLOGIC METHODS .................................................. 13
  4.5.1 Rational Method ...................................................................................... 14
  4.5.2 Modified Rational Method ................................................................. 15
TABLE OF CONTENTS

CHAPTER 5. HYDRAULICS

5.1 STREETS AND GUTTER FLOW

5.1.1 Street Drainage Criteria

5.2 STORMWATER INLETS

5.2.1 Curb Inlets

5.2.2 Grate Inlets

5.2.3 Combination Inlets

5.2.4 Drop Inlets

5.2.5 Low Point Inlets and Positive Overflow Requirements

5.3 STORM DRAIN (CLOSED SYSTEMS)

5.3.1 Flow in Storm Drains

5.3.2 Pipe Material and Roughness Coefficients

5.3.3 Entrance/Outfall Structures

5.3.4 Access Points

5.4 OPEN CHANNELS

5.4.1 Hydraulic Design

5.4.2 Types of Channels

5.5 CULVERTS

5.5.1 General Design Criteria

5.5.2 Minimum Elevations

5.5.3 Slope and Velocity

5.5.4 Headwater Limitations

5.5.5 Tailwater Considerations

5.6 BRIDGES

5.6.1 Hydraulic Design

5.6.2 Minimum Elevations

5.6.3 Scour Analysis

CHAPTER 6. STORMWATER STORAGE FACILITIES

6.1 DETENTION STORAGE CALCULATION

6.2 POND AND SPILLWAY GEOMETRY

6.3 PERMITTING AND DAM SAFETY REQUIREMENTS

CHAPTER 7. FLOODPLAIN DEVELOPMENT

7.1 EFFECTIVE MODELS

7.2 COMPENSATORY STORAGE

7.3 FLOODPLAIN DEVELOPMENT PERMIT

7.4 FEMA SUBMITTAL REQUIREMENTS
CHAPTER 1. INTRODUCTION

Section 1.1 | Stormwater Goals and Objectives

1.1 Stormwater Goals and Objectives

The purpose of this manual is to provide adequate stormwater management within the Town of Little Elm (Town) and its extraterritorial jurisdiction (ETJ). Adequate stormwater management is achieved by the development, adoption, and enforcement of policies and standards for drainage design that achieve the following goals:

1. Protect public health and safety
2. Prevent property damage due to flooding
3. Preserve and enhance water quality and minimize water pollution in Lewisville Lake and other natural waterbodies
4. Stabilize or decrease streambank and channel erosion on creeks, channels, and streams
5. Fully comply with all state, federal, and local regulatory and permitting requirements relating to stormwater and land development
6. Proportionally distribute the cost of necessary drainage improvements
7. Minimize the maintenance cost of drainage facilities constructed
8. Promote sustainable and productive development and redevelopment

This manual is intended to supplement the Town Code of Ordinances with procedures and technical criteria to meet the Town’s adopted policies. If any policies and requirements set forth herein conflict with, or are inconsistent with, criteria outlined elsewhere, the more stringent criteria shall apply.

1.2 Applicability of Stormwater Criteria

The stormwater criteria outlined in this manual applies to development and redevelopment activity within the limits of the Town of Little Elm and its ETJ to the extent legally authorized. Development and redevelopment activities meeting the requirements outlined in Section 1.3.1 require the submittal of a drainage plan for Town review and approval prior to commencement of land disturbing activities.

It is recognized that there will be specific situations not completely addressed by this manual. Unusual circumstances or special designs requiring variance from standards within this manual require the express written approval of the Town Engineer. All requests for variance from the Town’s drainage criteria shall be considered based on the standards, procedures, and criteria outlined in Section 107.10.01 of the Town’s Subdivision Ordinance.

1.3 Stormwater Submittal Requirements

The design of stormwater infrastructure must be performed in accordance with this manual and other applicable Town criteria. All plans and studies with stormwater elements shall be prepared and sealed by a Licensed Professional Engineer with a valid license and a valid registered firm number from the State of Texas.

All applicable calculations, plans, and other documentation necessary to evaluate the design must be provided for review. Upon receiving a stormwater submittal for review, the submittal package will receive a cursory review for completeness of submittal requirements. Incomplete submittals shall be rejected by the City without further review. The Town’s review period conforming to State regulations governing subdivision application begins on the date the application is accepted for review.
1.3.1 Stormwater Submittal Elements

The Town of Little Elm has developed a Development Application Handbook to assist developers with the preparation of applications for various types of planning and development activities. Developers shall utilize the applicable forms and checklists in the preparation and submittal of storm drainage plans for development review.

Storm drainage plans shall be prepared for subdivision applications and civil plan submittals that include the following activities:

1. Land disturbing activity or platting of 1.0 acre or more; or
2. Land disturbing activity of less than 1.0 acre where the activity is part of a common plan of development that is 1.0 acre or more.

A common plan of development consists of construction activity that is completed in separate stages, separate phases, or in combination with other construction activities. For the purposes of this policy, this classification may include, but is not limited to, a tract that:

1. Is included in a single concept plan submitted to the Town
2. Is included in a single preliminary plat submitted to the Town
3. Is comprised of contiguous land (or land separated only by roadway and/or drainage rights-of-way or easements) under the same root ownership
4. Is encumbered by a single Master Drainage Study or Plan
5. Is encumbered by a single Developer Agreement, TIF, 380 Agreement or other public/private partnership agreement
6. Is overlaid by a common Homeowner’s or Property Owner’s Association (HOA or POA), or
7. Is owned or managed by a common Master Developer.

Site developments that do not meet the applicability requirements outlined above will not require a drainage plan submittal. However, all developments within Town limits and ETJ shall comply with the Town Subdivision Ordinance and development permitting requirements, including but not limited to: building permits, floodplain development permits, SWPPP, and grading permits.

1.3.2 Permitting Requirements

The engineer must provide proof of compliance with applicable federal, state, and local environmental regulations upon request by the Town. Potential applicable regulations and permits may include, but are not limited to:

1. Section 404 of the Clean Water Act (33 USC 1344)
2. Section 106 of the National Historic Preservation Act
3. Water Rights
4. Section 303(d) Impaired Waters
5. Migratory Bird Treaty Act
6. Water Well Drilling
7. Threatened and Endangered Species Act
8. The Texas Archeological and Research Laboratory Requirements
9. The Antiquities Code of Texas
10. Air Quality
11. TCEQ Dam Requirements
The engineer is responsible for providing documentation of the relevant United States Army Corps of Engineers (USACE)-approved permits prior to beginning modification to the floodplain, or for providing a signed and sealed statement detailing why such permits are unnecessary. A preliminary Section 404 permitting evaluation shall be included as part of the downstream assessment report for the development. Should mitigation be required under Section 404 of the Clean Water Act, the areas shall be identified on the engineering construction plans.

Additional permitting requirements may apply for design of stormwater storage facilities and projects that impact regulatory floodplains. Further guidance is provided in Sections 6.3, 7.3, and 7.4.

### 1.3.3 Acceptable Modeling Software

The design of storm drainage facilities can be aided by and sometimes requires the use of hydrologic and hydraulic modeling programs. Table 1 lists several widely used modeling software which are acceptable to the Town. The use of a program that is not included in the list requires prior approval by the Town Engineer.

<table>
<thead>
<tr>
<th>Software</th>
<th>Hydrologic Calculations</th>
<th>Hydraulic Calculations</th>
<th>FEMA Approved</th>
<th>Water Quality Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEC-HMS</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEC-RAS</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Autodesk Suite – Hydraflo, Storm and Sanitary Analysis</td>
<td>X</td>
<td>X</td>
<td></td>
<td>(X)</td>
</tr>
<tr>
<td>Bentley Suite – CulvertMaster, FlowMaster, PondPack, StormCAD</td>
<td>X</td>
<td>X</td>
<td></td>
<td>(X)</td>
</tr>
<tr>
<td>Innovyze Suite – ICM, InfoWorks</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>SWMM (EPA)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>XPSWMM</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

The most recent version of the program should be used unless the Town provides an approved effective model developed using a previous version, and in other instances as approved by the Town Engineer. Only Federal Emergency Management Agency (FEMA) approved software can be used for design within the Regulatory Floodplain. Refer to Chapter 7 for additional guidance on software requirements for floodplain development applications.

### 2.1 Design Frequency for Drainage Features

The design of drainage facilities relies on evaluation of performance during theoretical rainfall events. A rainfall event is classified by its annual exceedance probability (AEP), which describes how likely an event is to occur in a given year. This probability has classically been presented inversely as a return period, giving the estimated time interval between events of a similar size or intensity. For example, the “100-year storm” return period has an AEP of 1%. This does not mean that a storm of this duration or intensity occurs every 100 years—instead, it means that, in any given year, there is a 1% chance of such an event occurring.
Table 2 lists the storm events to be used in the design of drainage facilities.

**Table 2: Design Storm Events**

<table>
<thead>
<tr>
<th>Storm Event Name</th>
<th>Storm Event Description</th>
<th>Design Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Quality</strong></td>
<td>Criteria based on volume of 1.5 inches of rainfall; not a storm frequency.</td>
<td>• Onsite water quality controls</td>
</tr>
<tr>
<td><strong>Streambank Protection</strong></td>
<td>2-year return period (50% AEP)</td>
<td>• Low flow channels and velocity check</td>
</tr>
<tr>
<td><strong>Conveyance</strong></td>
<td>25-year return period (4% AEP)</td>
<td>• Secondary check for street inundation and open travel lanes</td>
</tr>
<tr>
<td><strong>Flood Mitigation</strong></td>
<td>100-year return period (1% AEP)</td>
<td>• Open channels&lt;br&gt;• Primary standard for street and storm drain design</td>
</tr>
</tbody>
</table>

### 2.2 Drainage Impacts

The design of a storm drainage system must account for offsite flows, flows generated by the development, and the impacts on the downstream drainage system. All stormwater discharges from the development shall be conveyed to an adequate outfall. An adequate outfall is a structure or location that is adequately designed as to not cause adverse impacts to adjacent or downstream properties or facilities. An adequate outfall shall have capacity to convey any increased stormwater runoff from the site.

In order to determine the adequate outfall, the engineer must establish the zone of influence for the development. The zone of influence is the point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system. The hydrologic and hydraulic analysis to establish the zone of influence from a proposed development and to demonstrate an adequate outfall for site drainage is called a downstream assessment.

Generally, the zone of influence will be defined by a detailed hydrologic and hydraulic analysis. For watersheds of 100 acres or less at any proposed outfall, the 10% rule of thumb may be used in order to determine the zone of influence. The 10% rule states the zone of influence is considered to be the point where the drainage area controlled by the drainage facility comprises 10% of the total drainage area. If a portion of a larger property is being developed, the zone of influence shall be determined based on the entire property. A detailed study may be required for any drainage area regardless of size at the discretion of the Town Engineer.

It shall be the responsibility of the engineer to contact the Town and inquire about other proposed or approved developments within the zone of influence. At the direction of the Town Engineer, these developments shall be accounted for in the downstream assessment.
### Table 3: Zone of Influence (Adequate Outfall) Determination

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
<th>Adverse Impact Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inhabitable Structures</td>
<td>• No new or increased flooding (0.00 feet) of existing insurable (FEMA) structures (inhabitable buildings).</td>
</tr>
</tbody>
</table>
| 2    | Flood Elevations | • No increase (0.00 feet) in the 2-, 25-, and 100-year water surface elevations unless contained within the owner’s property or within an existing channel, roadway, drainage easement, and ROW.  
• Dry lane and gutter capacity requirements set forth in Table 10 shall also be met. |
| 3    | Floodplain Ordinance | • Where provisions of the Town’s floodplain ordinance may be more restrictive, the floodplain ordinance shall have authority over the above provisions. |
| 4    | Channel Velocities | • Proposed channel velocities for 2-, 25-, and 100-year storms cannot exceed the applicable maximum permissible velocity shown in Table 9.  
• If existing channel velocities exceed maximum permissible velocities shown in Table 9, no more than a 5% increase in velocities will be allowed.  
• Exceptions to these criteria will require certified geotechnical/geomorphologic studies that provide documentation that the higher velocities will not create additional erosion. |
| 5    | Downstream Discharges | • No increase in downstream discharges caused by the proposed development that, in combination with existing discharges, exceeds the existing capacity of the downstream storm drainage system or existing right-of-way. |
| 6    | Water Quality | • Compliance with water quality standards and requirements outlined in Chapter 3. |

### 2.3 Drainage Considerations for Site Grading

#### 2.3.1 Grading Plans

Grading plans shall be submitted for any land disturbance activities. Existing (pre-project) and proposed (post-project) contours shall be shown. The natural flow of surface waters shall not be diverted or impounded in a manner that damages adjacent property.

Residential development shall be type A, B, or C drainage for each lot within the subdivision as described in Housing and Urban Development (HUD) Federal Housing Administration (FHA) Data Sheet 72, as amended. Type 1 or 2 block grading as shown in the HUD information is preferred. Type 3 and 4 block grading are allowed only if:

1. A flume or channel is constructed at the rear of the lot to intercept runoff; or
2. Runoff from no more than 3 lots is accumulated prior to constructing a drainage system to intercept the runoff.
To ensure adequate drainage between lots after final construction of residential structures, the minimum slope between lot lines is required to be at least 50% steeper than the HUD minimums. Alternatively, the builder may provide a written certification that site grading is as prescribed in the grading plan and may be held responsible for drainage complaints by residents.

The engineer may utilize swales to redirect flows. In such cases, the engineer shall provide more detailed information in addition to the lot grading type (A, B, or C) by indicating spot elevations on each lot. If the site is complex and an overall site grading plan cannot be developed in accordance with the HUD standards, an individual grading plan for each lot shall be submitted by the engineer prior to the issuance of building permits. The individual grading plans shall be coordinated with surrounding lots. For these complex plans, an as-built letter shall be submitted by the engineer prior to final inspection.

### 2.3.2 Minimum Lot and Floor Elevations

The minimum elevation for the buildable area (including parking areas) of the lot shall be set at or above the 100-year water surface elevation, or as directed by the Town Engineer. Any inhabitable structure shall have a finished floor elevation 2 feet above the 100-year water surface elevation.

For developments outside of the floodplain, minimum floor elevations shall be at or above the street curb, edge of alley, or rear property line, whichever is lower, unless otherwise approved by the Town Engineer. For lots adjacent to or in the influence of a sump area and a positive overflow, the lot elevation will be at or above the sump area top of curb or the possible maximum pool elevation when the positive overflow is functioning, whichever elevation is higher. Refer to Section 5.2.5 for additional information on positive overflow requirements.

### 2.3.3 Concentrated Runoff from Development

Site runoff due to development shall not cause adverse impacts as outlined in Table 3. When offsite grading is required or when the development discharges concentrated flow on an adjacent property, off-site conveyance to reach an adequate outfall shall be contained within a drainage easement obtained from the affected property owner(s). Drainage easement requirements are further discussed in Section 3.2.1.

## CHAPTER 3. STORMWATER QUALITY

The Town of Little Elm is one of the fastest growing cities in North Texas, with almost 70 miles of the town limits along the shoreline of Lewisville Lake. New development in the Town has contributed to increased stormwater runoff. Urban stormwater runoff has had detrimental impacts on the Town’s receiving waters, including increased flooding potential, stream channel erosion, and reduced stormwater quality. As undeveloped areas of the Town are developed and older areas are redeveloped, it is imperative that a robust stormwater quality program be implemented to protect the Lewisville Lake and the Town’s other natural resources and improve the benefits to human health, fish and wildlife habitat, and recreational opportunities.

Additionally, the Town is subject to Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) permit regulations governing discharges of stormwater from municipal separate storm sewer systems (MS4s) to surface waters of the state (TXR040000). The Town is required to develop, implement, and enforce a Stormwater Management Program (SWMP) to reduce the discharge of pollutants and protect water quality. This program requires oversight of the design, construction, and maintenance of stormwater controls in the Town to protect and enhance stormwater quality.
The following sections outline the Town’s commitment to stormwater quality and water quality provisions that apply to the design of storm drainage facilities.

### 3.1 Post-Construction Stormwater Quality

#### 3.1.1 Post-Construction Stormwater Quality Objectives

This section will establish criteria for the design, operation, and maintenance of post-construction stormwater controls and the preparation of a Stormwater Quality Plan (SWQP). Specific objectives of the Town’s post-construction stormwater policies include:

1. Protect the integrity of watersheds and preserve the health of water resources, including Lewisville Lake;
2. Minimize changes to the site hydrology for land disturbance and redevelopment to reduce flooding, streambank erosion, and pollution;
3. Implement beneficial site design practices;
4. Promote the preservation of green space and other conservation areas;
5. Establish administrative procedures for the submission, review, approval, and disapproval of stormwater best management practices, and for the inspection of approved projects;
6. Establish provisions for the long-term responsibility for and maintenance of structural and nonstructural stormwater management to ensure that they continue to function as designed, are maintained appropriately, and pose minimum risk to public safety; and
7. Meet the provisions of the Town’s MS4 permit and SWMP.

#### 3.1.2 Stormwater Quality Plan

A Stormwater Quality Plan (SWQP) shall be prepared for all land disturbing activities of 1 acre or more as part of a subdivision application or civil plan submittal. For land disturbance activities between 1 and 5 acres, the Site Plan can be considered the SWQP. The grading or drainage plans may also be used as the SWQP for capital improvement projects. The SWQP shall be sealed by a Professional Engineer in the State of Texas.

The SWQP shall identify permanent site features and controls that will be included in the design and constructed with the project to minimize and mitigate the project’s long-term effects on stormwater quality and quantity. All new development designs shall evaluate site layout to minimize impervious area and impacts to existing natural resources to promote sustainable development.

**3.1.2.1 Preparation of a SWQP**

A preliminary SWQP shall be prepared with the preliminary plat. The final SWQP shall be submitted with the site plan or construction plans. This plan must be accepted by the Town prior to any site activity, including grading. The SWQP shall be developed and coordinated with all portions of the plans, but specifically, the grading plan, the drainage plans, and the landscape plan.

**3.1.2.2 Post-Construction BMP Selection**

Table 4 shows the minimum number of permanent BMPs required based on acreage of post-project impervious area:
Table 4: Minimum Number of Permanent BMPs Required

<table>
<thead>
<tr>
<th>Impervious Area</th>
<th>Minimum Number of Permanent BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 acres</td>
<td>1</td>
</tr>
<tr>
<td>5 acres ≤ Impervious Area ≤ 20 acres</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 20 acres</td>
<td>3</td>
</tr>
</tbody>
</table>

The BMPs shall be designed to achieve the water quality design requirements as set forth in Section 3.1.3. The ISWM Technical Manual for Site Development Controls provides guidance on the design and selection of permanent BMPs. It is the responsibility of the engineer to design BMPs that are appropriate address specific site conditions and meet the water quality standards.

Final stabilization of disturbed areas is required for all sites, regardless of size, and shall not be considered a permanent BMP. Final stabilization is defined as 80% coverage with no large bare areas on all portions of the site that are the responsibility of the developer.

3.1.3 Water Quality Design Requirements

3.1.3.1 Floatable Capture Requirements

All storm sewer outfalls to Lewisville Lake shall include a debris separator conforming to the Standard Details. Other applications of debris separators may be approved or required at the discretion of the Town Engineer.

For developments subject to SWQP requirements, debris separators may be considered a permanent BMP to meet the requirements of Section 3.1.2.2. Where multiple debris separators are installed for a single development, they shall be considered as a single BMP.

3.1.3.2 Water Quality Volume Requirements

Studies have shown the 85th percentile storm event (i.e., the storm event that is greater than 85% of the storms that occur) is a reasonable target event to address the vast majority of smaller, pollutant-loaded storms. Based on a rainfall analysis, 1.5 inches of rainfall has been identified as the average depth corresponding to the 85th percentile storm for North Texas. The runoff from these 1.5 inches of rainfall is referred to as the Water Quality Protection Volume (WQₚ).

Developments subject to SWQP requirements are required to demonstrate treatment of the WQₚ by the installation of permanent BMPs. Calculation of the WQₚ shall adhere to procedures outlined in the ISWM Technical Manual for Water Quality. Methods to reduce the required WQₚ as outlined in the iSWM manual may also be implemented.

The WQₚ shall not be discharged in a period less than 24 hours. The water quality treatment requirement can be met by providing extended detention in stormwater storage facilities designed for mitigation of peak events. In such instances, these facilities shall be allowed to have a total drawdown time greater than 24 hours but no greater than 48 hours. Refer to Chapter 6 for additional guidance and requirements concerning the design of stormwater storage facilities.
3.1.4 Permanent Erosion Control

Adequate control for the erosion is imperative to minimize Total Suspended Solids (TSS) and to protect stormwater quality in natural drainageways. Energy dissipation, channel stabilization and/or permanent erosion control mechanisms are required in instances where the design channel velocities or discharge velocities of pipes, culverts, and flumes exceeds the maximum permissible velocities outlined in Table 9 and in other instances as determined by the Town Engineer. The ISWM Technical Manual for Hydraulics and the Federal Highway Administration Hydraulic Engineering Circular No. 14 (FHWA HEC-14) provide additional guidance on the design of energy dissipators.

3.2 Maintenance of Permanent Stormwater Facilities

3.2.1 Drainage Easements

Easements are required for all public drainage systems that convey stormwater runoff across a development and shall be required for both on-site and off-site public stormwater drainage improvements, including standard engineering channels, storm drain systems, detention and retention facilities, and other stormwater controls. All drainage easements shall be recorded on the plat. The drainage easement must include sufficient area for operation and maintenance of the drainage system, and the developer shall obtain downstream drainage easements until adequate outfall is determined.

Minimum easement requirements are discussed in the following sections. Special circumstances may require additional easement allocation at the discretion of the Town Engineer.

3.2.1.1 Open Channels

Drainage easements shall be provided for all open channels. Easements shall encompass all areas lower than a ground elevation defined as being the highest of the following:

1. Two (2) foot above the calculated water surface elevation based on the fully developed 100-year water surface elevation or the 100-year base flood elevation (BFE), whichever is higher.
2. The top of the high bank, if higher than (1) above.

An additional easement of 15 feet on each side of a channel is required by the Town for maintenance and access purposes. For the purposes of this manual, bank slope is measured in a straight line from the toe of the slope to the top of the bank. The slope within the easement shall be no greater than 6:1 (horizontal to vertical) to allow for safe access of crews and equipment. Easements shall be kept free and clear of encroachments, but the maintenance and access portion of the easement may contain designated fire lanes and parking areas as approved by the Town Engineer.

Engineered channels shall have drainage easements dedicated to meet the requirements of the width of the channel, the 1 foot of freeboard, and access easement.

3.2.1.2 Storm Sewer Easements

Easement widths will be rounded up to the nearest 5-foot increment. The minimum width of the storm sewer easement shall be the outside diameter of the storm sewer pipe or horizontal dimension of the storm sewer box plus 10 feet. For pipes or boxes in parallel, the minimum easement shall be equal to the width of the parallel storm drain system plus 10 feet. The minimum storm sewer easement that shall be provided in any case is 15 feet.
3.2.1.3 Other Stormwater Facilities

Drainage easements for structural overflows, swales, and berms shall be of sufficient width to encompass the structure or graded area. The proposed centerline of overflow swales shall normally coincide with the centerline of the easement. Drainage easements will generally extend at least 25 feet past an outfall headwall to provide an area for maintenance operations.

Easements for stormwater controls, including detention basins, sediment traps, and retention ponds, shall be negotiated between the Town and the developer but will normally include essential access to all embankment areas and inlet and outlet controls. Essential access is defined as access in at least one location. The entire reach or each section of any drainage facility must be readily accessible to maintenance equipment. Additional easement(s) shall be required at the access point(s), and the access points shall be appropriately designed to restrict access by the public.

3.2.2 Operations and Maintenance Agreements

All drainage improvements constructed within a development and any existing or natural drainage systems to remain in use shall require a maintenance agreement that identifies responsible parties for maintenance. Both private and public maintenance responsibility shall be negotiated between the municipality and the owner and documented in the agreement. The maintenance agreement shall be written such that it remains in force upon sale of transfer of the property.

The Town will provide for perpetual maintenance, in accordance with adopted Town maintenance standards, of all public drainage facilities located within dedicated easements and constructed to the Town standards. In addition, limited perpetual maintenance may be provided by the Town for riparian areas placed in a drainage easement preserved in their natural state, subject to Town approval. Access shall be provided and dedicated by the developer to all public stormwater facilities in developments for maintenance and inspection by the Town.

A Stormwater Facility Maintenance Agreement (SFMA) must be prepared by the engineer for each stormwater control that will not be wholly maintained by the Town. This agreement must outline both preventive maintenance tasks as well as major repairs, identify the schedule for each task, assign clear roles to affected parties, and provide a maintenance checklist to guide future owners. Multiple stormwater controls may be contained within a single SFMA. When areas are identified for detention that also serve other purposes for the development (e.g. parking lots, loading docks) the requirement for a SFMA may be waived.

3.2.3 Inspections

An annual self-inspection report shall be provided to the Town for all permanent stormwater controls with an active SFMA. The inspection report shall document the condition of the stormwater control and maintenance provisions undertaken to ensure the continued functionality of the stormwater control as designed. Generally, this inspection can be conducted and documented by the owner of the facility unless otherwise stated in the SFMA. An inspection report signed and sealed by a Professional Engineer in the State of Texas shall be submitted to the Town at a minimum of every 5 years, unless otherwise stated in the SFMA. The Town maintains the right, as outlined in the Town ordinances, to inspect permanent stormwater controls and enforce provisions of the SFMA and this manual.
3.3 **Temporary Construction Controls**

Construction activities shall comply with all applicable federal (EPA), state (TCEQ), and local (Town) stormwater pollution prevention regulations. When the ordinance and applicable regulations are in conflict, the most stringent requirements shall apply.

### 3.3.1 Stormwater Pollution Prevention Plan

For all construction projects that will disturb 1 acre or more of land area, the TCEQ requires operators to obtain Texas Pollutant Discharge Elimination System (TPDES) General Permit (TXR150000) coverage for the project. This requires the preparation of a Storm Water Pollution Prevention Plan (SWPPP). A SWPPP shall be provided to the Town and approved prior to the start of any construction. The contractor is responsible for implementing and maintaining the SWPPP, as well as posting and submitting construction site notifications, the Notice of Intent, and the Notice of Termination.

### 3.3.2 Best Management Practices During Construction

The SWPPP shall provide a series of best management practices (BMPs) that are appropriate for each phase of construction. The SWPPP shall also identify which owner/operator is responsible for installing, inspecting, and maintaining each BMP during the different phases of construction. All temporary BMPs must be removed after final stabilization is achieved.

Structural BMPs shall comply with the Town of Little Elm Standard Details, this manual, and the latest edition of the North Central Texas Council of Governments (NCTCOG) integrated Stormwater Management (iSWM) Criteria Manual for Site Development and Construction and Technical Manual for Construction Controls. When the iSWM manual, Town Standard Details, or this manual are in conflict, the Standard Details and then this manual shall govern.

---

**CHAPTER 4. HYDROLOGY**

Prior to hydraulic design of drainage facilities, the rate and volume of stormwater runoff at the design point must be determined. The amount of stormwater runoff from a given site is a factor of the intensity and duration of the rainfall event and the size and hydrologic characteristics of the contributing drainage area. The following sections describe the approved hydrologic criteria and procedures to be used in the calculation of design runoff values.

Several sections of this chapter are adapted from the iSWM Technical Manual for Hydrology. Please reference the latest edition of the iSWM manual for additional guidance as needed.

### 4.1 Peak Discharges Prepared by Town

Peak discharge data from an appropriate flood study or Town-approved drainage studies shall be used as the design discharges, if such data is available. When no flow rates are available, peak discharges shall be determined by the engineer. All discharge values shall be based on full development of the drainage basin as outlined in the most recently adopted versions of the Town’s Comprehensive Plan, Zoning Map, and Future Land Use Map.

### 4.2 Rainfall Intensity

Atlas 14 provides point precipitation frequency values, with rainfall intensity values varying slightly across the Town. A single coordinate (33.1870, -96.8897) has been selected to define standard rainfall intensity values throughout the Town. The standard rainfall intensities are listed in Table 5.

Table 5: Design Rainfall Intensities

<table>
<thead>
<tr>
<th>Duration</th>
<th>Rainfall Intensity (in/hr) by Return Period and AEP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>5</td>
<td>0.083</td>
</tr>
<tr>
<td>10</td>
<td>0.167</td>
</tr>
<tr>
<td>15</td>
<td>0.25</td>
</tr>
<tr>
<td>30</td>
<td>0.5</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>120</td>
<td>2</td>
</tr>
<tr>
<td>180</td>
<td>3</td>
</tr>
<tr>
<td>360</td>
<td>6</td>
</tr>
<tr>
<td>720</td>
<td>12</td>
</tr>
<tr>
<td>1440</td>
<td>24</td>
</tr>
</tbody>
</table>

4.3 Drainage Areas

Drainage area maps and runoff calculations shall include all drainage areas contributing to the site. Separate drainage area maps and runoff calculations shall be prepared for both the existing (pre-project) drainage area and the fully developed (post-project) drainage area. Drainage areas shall follow natural drainage features if future land disturbance is unknown or existing areas will not be changing under fully developed conditions.

Drainage area determinations shall be based on site survey and proposed grading plans, supplemented by recent aerial imagery and topographic maps. Delineations shall be performed utilizing a maximum 2-foot contour interval for existing drainage areas and a maximum 1-foot contour interval for proposed drainage areas. The performance of topographic survey used to delineate drainage areas is the responsibility of the engineer designing the drainage facility.

4.4 Time of Concentration

The time of concentration ($T_c$) is defined as the longest time, without interruption of flow by detention devices, that will be required for water to flow from the upper limit of a drainage area to the point of concentration. Times of concentration can often be assumed based on the typical inlet times shown in Table 7.

Alternatively or where no typical inlet time is provided, $T_c$ may be calculated using the National Resource Conservation Service (NRCS, formerly known as the Soil Conservation Service, SCS) methodology. The use of NRCS methodology in lieu of standard inlet times may be at the discretion of the Town Engineer. This method separates the flow through the drainage area into sheet flow, shallow concentrated flow, and open channel flow. The $T_c$ is the sum of travel times for sheet flow, shallow flow and open channel flow. Time of concentration calculations shall be provided by the engineer along with flow path delineations.

Computations for travel time ($T_t$) for sheet flow, shallow flow, and open channel flow shall adhere to the following methodology.
1. **Sheet Flow:** Sheet flow is the initial flow over the ground surface. The maximum allowable length for sheet flow is 300 feet for undeveloped drainage areas and 100 feet for developed areas. The travel time \(T_t\) in hours for sheet flow is determined using the following equation:

\[
T_t = \frac{0.007 \cdot (n \cdot L)^{0.8}}{(P_2)^{0.5} \cdot (S)^{0.4}}
\]

- \(T_t\) = travel time (hr)
- \(n\) = Manning’s roughness coefficient (Table 9)
- \(L\) = flow length (ft)
- \(P_2\) = 2-year, 24-hour rainfall, 4.1 in.
- \(S\) = longitudinal slope (ft/ft)

2. **Shallow Concentrated Flow:** Shallow concentrated flow begins where sheet flow ends. A projected average slope should be established along the flowline for the shallow concentrated flow length. The travel time \(T_t\) in hours for shallow concentrated flow is determined by the following equation:

\[
T_t = \frac{L}{3600 \cdot V}
\]

- \(V\) = average velocity (fps), calculated as follows:
  - Unpaved Surfaces = \(16.1345 \times S^{0.5}\)
  - Paved Surfaces = \(20.3282 \times S^{0.5}\)

3. **Open Channel Flow:** Open channel flow is where the runoff is located within a defined channel or in some cases, closed storm systems. The travel time \(T_t\) for open channel flow is determined using the equation for shallow concentrated flow and using Manning’s Equation to determine average velocity \(V\):

\[
V = \frac{1.486 \cdot R^{3/2} \cdot S}{n}
\]

- \(V\) = average velocity (fps)
- \(R\) = hydraulic radius \((A/P)\) (ft), where:
  - \(A\) = cross-sectional area (ft²)
  - \(P\) = wetted perimeter (ft)
- \(S\) = longitudinal slope (ft/ft)
- \(n\) = Manning’s roughness coefficient (Table 9)

### 4.5 Allowable Hydrologic Methods

There are a number of empirical hydrologic methods available to estimate runoff characteristics for a site or drainage subbasin. The following methods have been selected to support hydrologic site analysis for the design methods and procedures included in this manual:

- Rational Method
- Modified Rational Method
- Unit Hydrograph Method

The procedures and approved applications of each method are described in the following sections.
4.5.1 Rational Method

The rational method is a simple procedure for estimating peak flows from small drainage areas. The use of the rational method is limited to drainage areas of less than 100 acres, unless otherwise approved by the Town Engineer. The formula for calculation of runoff by the rational method is:

\[ Q = C_f C_i A \]

- \( Q \) = peak discharge (cfs)
- \( C_f \) = frequency factor for use with higher intensity storms
- \( C \) = runoff coefficient
- \( i \) = rainfall intensity (in/hr) for a period equal to the time of concentration
- \( A \) = contributing drainage area (acres)

The rational method was initially developed for design applications that considered storms with more frequent return periods than current flood protection standards (less than or equal to 10 years). Less frequent, higher intensity storms require use of a frequency factor \((C_f)\) to account for the fact that infiltration and other initial losses have a proportionally smaller effect on runoff than for more frequent events. Table 6 provides the frequency factors to be used with rational method applications.

**Table 6: Frequency Factors for Rational Formula**

<table>
<thead>
<tr>
<th>Recurrence Interval (years)</th>
<th>Frequency Factor ((C_f))</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 or less</td>
<td>1.0</td>
</tr>
<tr>
<td>25</td>
<td>1.1</td>
</tr>
<tr>
<td>100</td>
<td>1.25</td>
</tr>
</tbody>
</table>

The post-development runoff coefficient “C” shall be based on fully developed conditions. The most intense land use or zoning shall be used to determine the runoff coefficient for the drainage area. Table 7 gives values for runoff coefficients to be used in applications of the rational method. It is often desirable to develop a composite runoff coefficient based in part on the percentage of different types of surfaces in the drainage area. Composite “C” values and other deviations from the coefficients provided in Table 7 are subject to the approval of the Town Engineer.
Table 7: Runoff Coefficient Values and Typical Inlet Times

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Runoff Coefficient “C”</th>
<th>Minimum Inlet Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Density Residential</td>
<td>0.45</td>
<td>10</td>
</tr>
<tr>
<td>Medium Density Residential</td>
<td>0.55</td>
<td>10</td>
</tr>
<tr>
<td>High Density Residential</td>
<td>0.60</td>
<td>10</td>
</tr>
<tr>
<td>Multi-Family</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufactured Homes</td>
<td>0.60</td>
<td>10</td>
</tr>
<tr>
<td>Light (Townhomes, Duplex)</td>
<td>0.65</td>
<td>10</td>
</tr>
<tr>
<td>Heavy (Apartments)</td>
<td>0.85</td>
<td>5</td>
</tr>
<tr>
<td>Commercial/Industrial:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>0.70</td>
<td>5</td>
</tr>
<tr>
<td>Heavy</td>
<td>0.80</td>
<td>5</td>
</tr>
<tr>
<td>Business Districts (Town Center, Office)</td>
<td>0.85</td>
<td>5</td>
</tr>
<tr>
<td>Parks and Open Space</td>
<td>0.25</td>
<td>15</td>
</tr>
<tr>
<td>Streets, Drives, Walks, and Roofs</td>
<td>0.95</td>
<td>5</td>
</tr>
<tr>
<td>Gravel Areas</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Graded or No Plant Cover</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Agricultural</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Streams, Lakes, Water Surfaces</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

4.5.2 Modified Rational Method

The modified rational method uses the rational method peak flow calculations combined with assumptions about the inflow and outflow hydrographs to compute an approximation of storage volumes for simple detention calculations. Further explanation of the modified rational method and a noniterative approach for detention design calculations are presented in the iSWM manual. The modified rational method is limited in use to applications as described in Section 6.1.

4.5.3 Unit Hydrograph Method

The Town requires the use of the NRCS unit hydrograph method for drainage areas larger than 100 acres. The unit hydrograph method requires drainage area, a runoff factor, time of concentration, rainfall, and methodology to consider initial and constant losses. Details of the methodology can and additional guidance can be found in the SCS National Engineering Handbook, Section 4, Hydrology and the iSWM manual.
The Town requires the use of HEC-HMS to perform the computations and to develop runoff hydrographs for a drainage area. Additional software may be accepted at the discretion of the Town Engineer. Typical inputs required for development of a HEC-HMS hydrograph are described below.

### 4.5.3.1 Curve Numbers

Use of the runoff curve number (CN) methodology outlined in *Urban Hydrology for Small Watersheds – NRCS Technical Release (TR)-55* is required. Curve numbers indicate the runoff potential of the land cover, considering the combined hydrologic effects of the soil type, land use, hydrologic condition of the soil cover, and the antecedent soil moisture. The NRCS Soil Survey for Denton County may be used to identify the soil group within the watershed subbasins. For computation of design events, an assumption of Antecedent Moisture Condition (AMC) II is required.

The runoff CN values for urban areas provided in *TR-55* are recommended for use. When open space is used as the cover type, fair condition shall generally be assumed. Other CN values may be approved by the Town Engineer. Table 8 shows the land use categories and corresponding impervious percentages. These values do not supersede the existing conditions, or where proposed impervious conditions are known. For instance, if an industrial area is currently 95% paved, then 95% is the impervious condition that shall be used.

**Table 8: Impervious Percentage Values for Land Use Classifications**

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Impervious Condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential:</td>
<td></td>
</tr>
<tr>
<td>Single Family</td>
<td></td>
</tr>
<tr>
<td>Low Density Residential</td>
<td>25</td>
</tr>
<tr>
<td>Medium Density Residential</td>
<td>41</td>
</tr>
<tr>
<td>High Density Residential</td>
<td>47</td>
</tr>
<tr>
<td>Multi-Family</td>
<td></td>
</tr>
<tr>
<td>Manufactured Homes</td>
<td>20</td>
</tr>
<tr>
<td>Light (Townhomes, Duplex)</td>
<td>70</td>
</tr>
<tr>
<td>Heavy (Apartments)</td>
<td>70</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>90</td>
</tr>
<tr>
<td>Heavy</td>
<td>95</td>
</tr>
<tr>
<td>Business Districts (Town Center, Office)</td>
<td>85</td>
</tr>
<tr>
<td>Parks and Open Space</td>
<td>6</td>
</tr>
<tr>
<td>Streets, Drives, Walks, and Roofs</td>
<td>95</td>
</tr>
<tr>
<td>Agricultural</td>
<td>3</td>
</tr>
<tr>
<td>Forest</td>
<td>0</td>
</tr>
<tr>
<td>Streams, Lakes, Water Surfaces</td>
<td>100</td>
</tr>
</tbody>
</table>
4.5.3.2 Design Storm Rainfall
Use of the 24-hour storm duration and SCS Type II distribution is required for peak flow calculations, unless otherwise approved by the Town Engineer.

4.5.3.3 Hydrologic Stream Routing
Routing may be needed within the hydrologic model to account for the storage effects of detention facilities or significant channel reaches that are not accounted for in a hydraulic model. Detention and ponding areas shall be modeled using Modified Puls routing with explicit depth-area curves determined from topographic contours. Channel segments shall be modeled using either Modified Puls or Muskingum Cunge methods based on cross sections taken from available topography. For unsteady flow modeling, the routing is accounted for by the hydraulic software being used.

CHAPTER 5. HYDRAULICS

Hydraulic design is the process of determining the appropriate capture and transport (or storage) of stormwater that has been generated from a rainfall event to an adequate outfall. Stormwater facilities include, but are not limited to, ditches, streets, inlets, storm drain systems, swales, channels, culverts, ponds, and reservoirs.

Several sections of this chapter are adapted from the iSWM Technical Manual for Hydraulics. Please reference the latest edition of the iSWM manual for additional guidance as needed.

5.1 Streets and Gutter Flow
Surface drainage along streets is a function of transverse and longitudinal pavement slope, pavement roughness, inlet spacing, and inlet capacity. The design of these elements is dependent on storm frequency and the allowable spread of stormwater. Flow in streets and gutters is governed by Manning’s equation for open channel flow:

$$ Q = \frac{1.486}{n} A R^{2/3} S^{1/2} $$

$Q$ = flow (cfs)

$A$ = cross-sectional flow area (ft$^2$)

$R$ = hydraulic radius (ft), as defined previously

$S$ = longitudinal slope (ft/ft)

$n$ = Manning’s roughness coefficient (Table 9)

Table 9 provides Manning’s roughness coefficients and maximum permissible velocities to be used in the design of various drainage facilities in the Town. The Manning’s roughness coefficient to be used in calculation of flow in concrete streets and gutters shall be 0.016 unless otherwise approved by the Town Engineer. The iSWM manual provides alternate forms of the Manning’s equation with tables and nomographs to be used in the calculation of drainage capacities of streets with triangular, composite, and parabolic sections, as well as streets with curb splits.
Table 9: Roughness Coefficients and Maximum Permissible Velocities

<table>
<thead>
<tr>
<th>Type of Section/Feature</th>
<th>Roughness Coefficient “n”</th>
<th>Maximum Permissible Velocity (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Normal</td>
</tr>
<tr>
<td>Natural Streams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stream Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some Grass and Weeds; Little or No Brush</td>
<td>0.027</td>
<td>0.045</td>
</tr>
<tr>
<td>Dense Growth of Grass or Brush</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>Dense Brush and Trees</td>
<td>0.060</td>
<td>0.065</td>
</tr>
<tr>
<td>Floodplain/Overbank Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass, Weeds; Some Brush and Trees</td>
<td>0.027</td>
<td>0.045</td>
</tr>
<tr>
<td>Dense Grass, Weeds or Brush</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>Dense Brush and Trees</td>
<td>0.070</td>
<td>0.080</td>
</tr>
<tr>
<td>Buildings</td>
<td></td>
<td>0.500</td>
</tr>
<tr>
<td>Constructed/Modified Open Channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Blocks</td>
<td>0.015</td>
<td>0.035</td>
</tr>
<tr>
<td>Gabion</td>
<td>0.015</td>
<td>0.035</td>
</tr>
<tr>
<td>Grass (Maintained)</td>
<td>0.027</td>
<td>0.035</td>
</tr>
<tr>
<td>Concrete Riprap</td>
<td>0.014</td>
<td>0.016</td>
</tr>
<tr>
<td>Stone Riprap</td>
<td>0.033</td>
<td>0.035</td>
</tr>
<tr>
<td>Streets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth</td>
<td>0.015</td>
<td>0.016</td>
</tr>
<tr>
<td>Rough</td>
<td>0.017</td>
<td>0.018</td>
</tr>
<tr>
<td>Asphalt</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>Pipes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Pipe</td>
<td>0.012</td>
<td>0.013</td>
</tr>
<tr>
<td>Corrugated Metal Pipe</td>
<td>0.015</td>
<td>0.022</td>
</tr>
<tr>
<td>High Density Polyethylene Pipe (HDPE)</td>
<td>0.009</td>
<td>0.011</td>
</tr>
<tr>
<td>Concrete Boxes (Smooth to Rough)</td>
<td>0.012</td>
<td>0.013</td>
</tr>
</tbody>
</table>

5.1.1 Street Drainage Criteria

The surface drainage system and closed storm drain system for a street must be designed such that in combination, the systems provide enough capacity to fully contain the flow from 100-year storm within the street right-of-way or drainage easement. The Town also enforces a set of criteria for allowable spread of gutter flow depending on street classification, as outlined in Table 10. An “open” traffic lane is defined for the purposes of this manual as at least a 12-foot section of pavement that remains dry (no ponding or flowing water) for the duration of the rainfall event to allow for the safe passage of vehicles. Storm sewer inlets shall be provided along paved streets at such intervals to prevent the capacity and spread requirements from being exceeded.
Table 10: Street Drainage Criteria

<table>
<thead>
<tr>
<th>Type of Street</th>
<th>Allowable Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Thoroughfare</td>
<td>One traffic lane in each direction to remain open</td>
</tr>
<tr>
<td>Collector Street</td>
<td>One moving traffic lane to remain open</td>
</tr>
<tr>
<td>Residential Street</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Additional street drainage considerations are listed below:

1. The maximum allowable concentrated flow to a street including flow from driveways and flumes is 3 cfs.
2. Street surface drainage shall not be permitted to cross major thoroughfares or collector streets.
3. At any intersection, only one street shall be crossed with surface drainage, and this shall be the lower classified street.

5.2 Stormwater Inlets

Inlets are drainage structures used to collect surface drainage and to convey this water to storm drains or direct outlet to culverts. The capacity of an inlet depends upon its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow, and pavement roughness. Inlets servicing roadway drainage can be divided into three major classes:

- Curb Inlets
- Grate Inlets
- Combination (Grate and Curb-Opening) Inlets

Inlets may be classified as being on a continuous grade or in a sump. The term "on grade" refers to an inlet located on the street with a continuous slope past the inlet with water entering from one direction. The "sump" condition exists when the inlet is located at a low point and water enters from both directions. Artificial low points created by "seesaw" of street or alley grades will not be permitted. All low point inlets shall be designed in accordance with additional standards outlined in Section 5.2.5.

The procedures and technical criteria outlined in the iSWM manual shall be used for the hydraulic design of stormwater inlets. Additional criteria for various inlet types are summarized in the following sections. Refer to the Town of Little Elm Standard Construction Details for inlet construction and material requirements.

5.2.1 Curb Inlets

Curb inlets shall be a minimum of 8 feet in length. Recessed curb inlets are required on all collector and arterial streets. The Town Standard Details for both recessed and standard curb inlets include a depressed gutter line.

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.
5.2.2 Grate Inlets

The Town’s MS4 program encourages measures to limit the inflow of floatables to the storm system. The installation of grate inlets in lieu of or in combination with the installation of debris separators in nonresidential developments may be permitted to help meet this objective and may be required in some instances by the Town Engineer for sites outfalling to Lewisville Lake. Installation of grate inlets in other instances requires approval by the Town Engineer. Grate inlets shall be designed with a 50% clogging factor due to the tendency of these inlets to collect debris.

5.2.3 Combination Inlets

Combination inlets consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate. Combination inlets may only be used with the approval of the Town Engineer.

All debris carried by stormwater runoff that is not intercepted by upstream inlets will be concentrated at the inlet located at the low point. Because this will increase the probability of clogging for grated inlets, the capacity of a combination inlet in sump shall be assumed to be the capacity of the curb inlet, neglecting the grate inlet capacity. On a continuous grade, the capacity of an unclogged combination inlet with the curb opening located adjacent to the grate is approximately equal to the capacity of the grate inlet alone. Capacity shall be computed by neglecting the curb opening inlet and following the design procedures for grate inlets.

5.2.4 Drop Inlets

The Town allows for the installation of drop inlets to collect water in nonpaved areas, such as ditches and swales. If used, grading plans to direct flow into drop inlets shall be included in the construction plans. Drainage interceptor swales or berms should be used, as required, to direct runoff to the drop inlets. Where swales or other means of collecting and directing runoff into drop inlets are needed, they should be contained in drainage easements according to the requirements outlined in Section 3.2.1.

Drop inlet capacity shall be evaluated with a 50% clogging factor due to the tendency of these inlets to collect debris. Flow into drop inlets shall be calculated using either the weir flow formula for an unsubmerged inlet or the orifice flow formula when depth of flow exceeds the depth of the opening.

The capacity of an unsubmerged inlet operating as a weir is:

\[ \frac{Q}{P} = 2.5y^{3/2} \]

where:
- \( Q \) = flow capacity (cfs)
- 2.5 = weir coefficient (3.1) adjusted for 50% clogged inlet throat
- \( P \) = perimeter of opening (ft)
- \( y \) = head/depth (ft)

and the capacity of a submerged inlet operating as an orifice is:

\[ Q = 0.6A(2gH)^{0.5} \]
CHAPTER 5. HYDRAULICS

Section 5.3 | Storm Drain (Closed Systems)

STORMWATER DESIGN REQUIREMENTS
TOWN OF LITTLE ELM | 21

Q = flow capacity (cfs)
0.6 = orifice discharge coefficient
A = area of inlet opening (ft²)
g = acceleration due to gravity = 32.2 (ft/s²)
H = head above centerline of inlet opening height (ft)

Both conditions should be evaluated, and the capacity should be determined from the condition that produces the more conservative value. The capacity calculations for drop inlets will be limited to a maximum head of 1 foot above the flowline of the inlet throat.

5.2.5 Low Point Inlets and Positive Overflow Requirements

Inlets are required at all low points in the gutter profile. Additionally, the drainage system shall provide for positive overflow at all low points. The term “positive overflow” means that when the inlets do not function properly, or when the design capacity of the conduit is exceeded, the excess flow can be conveyed overland along an open course. Generally, positive overflow is provided along a street or alley, but certain circumstances may require the dedication of drainage easement and construction of a concrete flume sized to carry the overflow. Reasonable judgment should be used to limit the easements on private property to a minimum.

In areas where positive overflow is not feasible, flanking inlets are required on each side of the low point inlet to act in relief of the inlet at the low point if it should become clogged. Flanking inlets shall be located to function before water spread exceeds the allowable spread at the sump location and shall be designed with a combined capacity to match the capacity of the primary sump inlet.

5.3 Storm Drain (Closed Systems)

A closed storm drain system shall be required within the right-of-way where the 100-year design storm exceeds the capacity of the street surface drainage system. Closed systems shall be extended to an adequate and acceptable outfall as described in Table 3.

5.3.1 Flow in Storm Drains

5.3.1.1 Full and Partial Flow

All storm drains shall be designed by the application of the continuity equation and Manning’s equation. The continuity equation is given as:

\[ Q = AV \]

Q = flow capacity (cfs)
A = cross-sectional flow area (ft²)
V = velocity (fps)

Pipe flow shall be determined either through the appropriate charts and nomographs or by direct solutions of the equations. Charts and nomographs for circular pipes flowing full and partially full are included in the iSWM manual. The Texas Department of Transportation (TxDOT) Hydraulic Design Manual includes equations for flow in conduits with other cross sections.

Pipes and boxes shall be designed as if flowing full. Design flow depth of less than full to get a lesser wetted perimeter is not acceptable. Four wall wetted perimeter is required in the calculations. There will be hydraulic
conditions that cause the conduits to flow partially full. Where this occurs, the hydraulic gradient should be shown at the inside crown of the conduit.

5.3.1.2 Hydraulic Gradient and Storm Drain Profile

The hydraulic grade line (HGL) shall be established for all storm drain systems. The 25-year HGL must be at or below the gutter line for pipe systems and 1 foot or more below the top of curb at inlets. For sump conditions without an existing structural overflow, the 100-year HGL must be 1 foot below the top of curb at the inlet. For systems where no ROW exists, the 100-year HGL must be below finished ground.

Both the fully developed 25-year and 100-year hydraulic gradient lines (HGLs) shall be shown throughout the system. They shall be labeled in the construction plans both in the hydraulic calculations and on the storm drain profile. The design storm HGL shall be below the bottom of the improved subgrade for systems under pavement. For systems outside of the pavement, the HGL shall be lower than all inlet throats. Allowance of additional head may be required for planned future extensions of the storm drainage system.

The HGL shall start at the tailwater elevation or HGL of a connecting feature; the inside top of pipe; or at the HGL determined for a coincident confluence flow condition, whichever is highest. At the discharge end of pipes outfalling to a natural creek or stream, the hydraulic gradient of the creek for the design storm must coincide with the gradient of the storm drainage conduit. If an approved flood hydrograph is available to provide a coincident flow elevation for the system’s peak, the table of coincident design frequencies in the ISWM manual can be used to assist with tailwater determination. If an approved flood hydrograph is not available, the starting HGL at the outfall into a creek or channel shall be the 100-year fully developed water surface elevation. Alternatively, a detailed hydrologic and hydraulic study can be performed to determine the coincident tailwater.

5.3.1.3 Velocities

Storm drains should operate with velocities of flow sufficient to prevent excessive deposits of solid materials. A minimum full flow velocity of 2.5 fps in the design storm and a minimum slope of 0.5% shall be maintained in the pipe unless otherwise approved by the Town Engineer. Velocities shall not exceed those listed in Table 9. Supercritical flow is not allowed in main lines.

5.3.1.4 Headlosses

Head losses at structures shall be determined for manholes, junction boxes, wye branches, bends, curves, and changes in pipe sizes in the design of closed conduits. Head losses must be incorporated into the gradient profile. Minimum head loss used at any structure shall be one-tenth (0.10) foot. Refer to the ISWM manual for the equations to calculate energy losses at pipe junctions, bends, manholes, inlets, and other situations.

Pipe direction changes will be curves using radius pipe unless approved by the Town Engineer. Ninety-degree turns on storm sewers or outfalls are prohibited. Laterals shall intersect the trunk line at 60 degrees.

5.3.2 Pipe Material and Roughness Coefficients

Underground systems shall be constructed with Class III reinforced concrete pipe or as otherwise provided in the Town’s standard construction details. Alternate materials may be approved by the Town Engineer. The pipe size shall be a minimum of 18 inches for all public systems. A higher class of pipe may be required when underground storm drainage systems are constructed at shallow or deep elevations. Refer to the pipe manufacturer specifications for cover requirements.
A roughness coefficient will be selected which will represent the average condition of the pipe consistent with the values presented in Table 9. Other roughness coefficients may be approved at the discretion of the Town Engineer.

### 5.3.3 Entrance/Outfall Structures

Headwalls or sloped end treatments shall be constructed at the pipe ends of all storm drain systems. Sloped end treatments are required along streets when the drainage feature is adjacent and parallel to traffic flow. The sloped end treatment shall be a minimum 6:1 (horizontal to vertical) end section.

Storm drain systems that outfall to a stream, natural channel, or pond shall conform to the existing side slope of the channel and be connected to a headwall. Discharge flowlines of storm sewers are to be 2 feet above the flowline of creeks and channels, unless channel lining is present. Hard armor protection and energy dissipation shall be provided when discharge velocities exceed the maximum allowable velocity in Table 9 and when specified by the Town Engineer.

### 5.3.4 Access Points

A manhole or access lateral shall be constructed at least every 500 feet to provide access into the closed system, or as otherwise directed by the Town Engineer. A lateral used as an access point shall be at least 24 inches in diameter, an approved material, and no more than 50 feet long to an open-air access point. Open air access is considered a designed entrance point or outfall without obstructions.

### 5.4 Open Channels

This section includes the drainage design criteria for ditches, channels, and dams. Land disturbances that include or are adjacent to a stream and result in impacts to the 100-year floodplain shall submit a flood study to meet the requirements of Chapter 7. If modifications to a stream or channel are determined to impact the Jurisdictional Waters of the United States (WOTUS), then the plans shall be submitted to the USACE for review and any required permitting shall be performed and approved prior to construction per the requirements of Section 1.3.2.

#### 5.4.1 Hydraulic Design

The Town requires a tailwater/headwater analysis on any proposed open channels, upstream and downstream channel transitions, energy dissipation structures, obstructions, or small dams (less than 6 feet). The tailwater/headwater analysis shall be used to determine the actual headwater and tailwater elevations, head losses, capacity, freeboard, and floodplain impacts. If an approved flood hydrograph is available to provide a coincident flow elevation for the system’s peak, the table of coincident design frequencies in the iSWM manual can be used to assist with tailwater determination. Alternatively, a detailed hydrologic and hydraulic study will be required.

For channels that require a flood study, a hydrologic routing model and hydraulic analysis will be required to determine impacts on existing floodplains and/or adjacent properties. If a stream or channel has an effective FEMA model and/or a Town Council adopted watershed model, the engineer will be required to use those models for the analysis.

For normal depth (uniform flow) calculations, the Manning’s equation and slope-area method is to be used only for initial sizing. Exceptions for small outfall channels will be made at the discretion of the Town Engineer.
Supercritical flow will not be allowed for designed channels. However, for lined channels, the HEC-RAS analysis should include a mixed-flow regime analysis, to make sure no supercritical flow occurs for the designed channel. Mixed or supercritical flow may be allowed for analysis of existing conditions when required.

Upstream or downstream transitions from natural to modified channels along with channel outfalls will require a design based on a hydraulic study and will provide a non-erosive environment. Refer to the iSWM manual for design of channel transitions and energy dissipation.

**5.4.2 Types of Channels**

**5.4.2.1 Unimproved Channels/Natural Streams**

Where natural streams connect to improved closed systems and/or improved channels, permanent transitional materials and energy dissipation are required. In areas along natural streams where potentially excessive erosion or head cutting may occur or worsen, grade control structures, drop structures, or other structures may be required to stabilize the stream in order to protect structures or infrastructure.

**5.4.2.2 Constructed/Modified Open Channels**

Where constructed or modified open channels connect to a closed system, natural streams, or a channel of a different material, permanent transitional materials and energy dissipation are required. Modified channels shall be designed with the following minimum criteria:

1. Side Slopes shall be 4:1 (horizontal to vertical) for vegetated channels or as specified by manufacturer for other channel materials.
2. Bottom width shall be at least 6 feet.
3. Minimum channel slope is 1% for vegetated channels and 0.5% for hard armor channels or pilot channels.
4. New channels shall be designed to fully contain the 100-year storm with 1 foot of freeboard at all locations along the channel, or to the elevation of the 100-year flood elevation of Lewisville Lake, whichever is lower.
5. Modification or improvement of existing constructed/modified channels shall at a minimum maintain the existing capacity.
6. The maximum design velocity for all channels shall be as specified in Table 9. Higher velocities and/or channel armoring require a sealed geotechnical study for design and approval by the Town Engineer.
7. Each reach of a channel that will require Town maintenance must have a ramp for maintenance access. Ramps shall be at least 10-feet wide and have 15% maximum grade. 12-foot width is required if the ramp is bound by vertical walls.
8. A fence shall be constructed on each side of the channel. Fences are not allowed to cross public channels.
9. New concrete channels are not allowed unless it is required as part of the repair or replacement of an existing concrete channel.

**5.5 Culverts**

**5.5.1 General Design Criteria**

Culverts shall be designed based on standard design procedures outlined in the iSWM manual. Used to carry ditch or surface flow safely under roadways and driveways in order to meet conveyance standards for the design storm. The driveway or roadway shall have an invert above the pipe for positive overflow. If a culvert is not feasible for a driveway, then the driveway shall be constructed with an invert.
Concrete sloped end treatments are required when culverts are adjacent and parallel to traffic flow. Erosion protection will be provided at the upstream and downstream ends of the sloped end treatment for all culverts. Stabilization and/or energy dissipation shall be provided where allowable channel velocities are exceeded upstream and downstream of the culvert.

Culverts shall be constructed with Class III reinforced concrete pipe or another approved material as shown in the Town’s standard construction details. The pipe size shall be a minimum of 24 inches for roadway crossings and 18 inches for driveway culverts. A higher class of pipe may be required when underground storm drainage systems are constructed at shallow or deep elevations. Refer to the pipe manufacturer specifications for cover requirements.

When practical for multiple barrel culverts (3 or more), one of the barrels should be placed at the flowline of the stream with the other barrels at a higher elevation to create a single flow path for lower flows and reduced sediment and debris accumulation.

5.5.2 Minimum Elevations

Culverts shall be designed with a minimum 1 foot of freeboard between the 100-year headwater elevation and the surface of the road and/or 2 feet of freeboard below any adjacent habitable structure, whichever establishes the more stringent requirement. Other surrounding physical conditions may be cause for an increase in this requirement at the discretion of the Town Engineer.

5.5.3 Slope and Velocity

The maximum slope using concrete pipe is 10% before pipe-restraining methods must be taken. The minimum slope is 0.5%. Maximum vertical distance from throat of intake to flowline in a drainage structure is 10 feet. Drops greater than 4 feet will require additional structural design.

Velocities in culverts should be limited to no more than 15 feet per second, but downstream conditions very likely will impose more stringent controls. Culvert discharge velocities shall not exceed the maximum permissible velocities for open channels listed in Table 9. Discharge velocities that are too high must be reduced to allowable velocities using appropriate energy dissipation structures or techniques.

5.5.4 Headwater Limitations

For safety reasons, headwater depth/culvert diameter ratio (HW/D) should not exceed 1.5 for the 100-year event peak flow. Variance to this criteria may be permitted by the Town if justification is provided and sufficient measures are taken to reasonably avoid any safety impacts. Assessment of the impacts caused by exceeding the design headwater depth should account for:

- Hazard to human life and safety.
- Potential damage to the culvert, embankment stability and roadway.
- Traffic interruption in the event of roadway overtopping.
- Anticipated upstream and downstream flood risks, for a range of return frequencies.

The headwater shall be checked for the 100-year storm event elevation to ensure compliance with floodplain management criteria and to ensure it is contained within the right-of-way or easement. The headwater shall not cause damages to the upstream property.
5.5.5 Tailwater Considerations

If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined. If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert will establish the design tailwater depth for the upstream culvert. For culverts discharging into natural creeks, channels, or ponds, the tailwater shall be assumed to be the 100-year fully developed water surface elevation. If an approved flood hydrograph is available to provide a coincident flow elevation for the system’s peak, the table of coincident design frequencies in the iSWM manual can be used to establish the tailwater elevation. Alternatively, a detailed hydrol ogic and hydraulic study can be performed to establish the tailwater elevation.

5.6 Bridges

5.6.1 Hydraulic Design

A hydrologic and hydraulic analysis using HEC-RAS is required for designing all new bridges, bridge widening, bridge replacement, and roadway profile modifications that may adversely affect the floodplain, even if no structural modifications are necessary. The hydraulic analysis should demonstrate no-rise (0.00 feet) in the water surface elevation for the 100-year storm. Typically, this analysis should include the following:

1. Peak discharges for fully developed watershed conditions,
2. Proposed conditions water surface profiles for design flood and other frequency flood impacts.
3. Consideration of the potential for stream stability problems and scour potential.

Additional discussion on bridge hydraulics is included in the TxDOT Hydraulic Design Manual.

5.6.1.1 Loss Coefficients for Hydraulic Models

The contraction and expansion of water through the bridge opening creates hydraulic losses. These losses are accounted for through the use of loss coefficients. Contraction ($K_c$) and Expansion ($K_e$) Coefficients shall be used at the bridge location in accordance with current FEMA guidelines.

5.6.2 Minimum Elevations

Bridges shall be designed to pass the 100-year flow with a minimum 1 foot of freeboard between the 100-year surface elevation and the low chord of the bridge. Analysis must consider both the fully developed and FEMA effective discharges, and the freeboard elevation will be set using the most conservative results. Where fully developed discharges are not available, the Engineer will be required to perform a flood study to determine 100-year water surface elevations.

5.6.3 Scour Analysis

A scour analysis shall be submitted with bridge design plans. Scour analysis shall be performed in accordance with the latest edition of the TxDOT Geotechnical Manual, based on the guidelines and procedures outlined in HEC-18 Evaluating Scour at Bridges (5th Ed.). The HEC-RAS scour routines shall generally be used to perform bridge scour computations. Aerial utility crossings with piers located in the main channel shall also be evaluated for local pier scour using the methodology outlined in HEC-18.
Scour revetment shall be provided as needed and shall be designed using the methodology outlined in *HEC-23 Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Guidance*. Alternative methodologies for scour analysis and revetment may be approved at the discretion of the Town Engineer.

CHAPTER 6. STORMWATER STORAGE FACILITIES

Proposed stormwater discharge from a site shall not exceed the calculated discharges from existing conditions for the 2-, 25-, and 100-year design storm. On-site detention may be proposed to mitigate the impacts of increased discharges due to site development. In some instances, detention may be shown to exacerbate potential flooding conditions downstream. In lieu of a detention facility, the Engineer may document that the excess flow will not create adverse impacts as defined in **Table 3**.

6.1 Detention Storage Calculation

The modified rational method is allowed for planning and conceptual design for watersheds of 200 acres and less. Sizing is not exact and may result in undersized detention/retention pond requirements. For final design purposes, the modified rational method is allowed only for watersheds of 25 acres and less. The modified rational method is not acceptable for basins in series. Detention basins draining watersheds over 25 acres shall be designed using unit hydrograph methodology. The unit hydrograph method is also allowed for basins with watersheds less than 25 acres and may be required at the discretion of the Town Engineer.

A calculation summary shall be provided on construction plans. For detailed calculations of unit hydrograph studies, a separate report shall be provided to the Town for review and referenced with date, engineer, and title on the construction plans. Stage-storage-discharge values shall be tabulated, and flow calculations for discharge structures shall be shown on the construction plans. Routing calculations must be used to demonstrate that the storage volume and outlet structure configuration are adequate.

6.2 Pond and Spillway Geometry

The following criteria shall apply:

1. Detention basin embankments shall have a 10-foot crown width.
2. Fencing may be required around the detention area at the discretion of the Town Engineer.
3. Detention Basins shall be designed with at least one maintenance ramp of at least 10 feet wide with a maximum slope of 15%. Twelve (12) feet in width is required next to vertical walls.
4. A freeboard of 1 foot will be required for all detention ponds.
5. Grassed side slopes shall be 4:1 or flatter and less than 20 feet in height. Slopes protected with concrete riprap shall be no steeper than 2:1. A detailed geotechnical investigation and slope stability analysis is required for grass and concrete slope pavement slopes greater than 12 feet in height. A concrete-lined or structural embankment can be steeper with the approval of the Town Engineer.
6. An emergency spillway shall be provided at the 100-year maximum storage elevation with sufficient capacity to convey the fully urbanized flood mitigation storm assuming blockage of the closed conduit portion outlet works with 6 inches of freeboard. Spillway requirements must also meet all appropriate state and federal criteria. Design calculations will be added for all spillways.
7. Dry detention basins are sized to temporarily store the volume of runoff required to provide flood protection up to the flood mitigation storm, if required. Dry detention basin design should consider...
multiple uses, such as recreation. As such, pilot channels should follow the edges of the basin to the extent practical.

8. The bottom of the basin shall have a minimum grade of 1%, although swales may have minimum grades of 0.5%. Concrete flumes shall be provided for slopes less than 0.5% and may have slopes as shallow as 0.2%. They shall be at least 6 feet wide.

### 6.3 Permitting and Dam Safety Requirements

All federal, state, and local laws pertaining to the impoundment of surface water relating to the design, construction, and safety of the impounding structure shall apply. Criteria established by the State of Texas for dam safety ([TAC Title 30, Part 1, Chapter 299](#)) and impoundment of state waters ([Texas Water Code Chapter 11](#)) shall apply where required by the state, and where required by the Town Engineer. Should the engineer desire to utilize an existing facility that would qualify under these criteria and the use of the facility changes from an agricultural use to another use, the existing facility may need to be brought into compliance with the TCEQ dam safety criteria.

If a dam falls under the TCEQ dam safety criteria, the Town will require review and approval from TCEQ prior to authorizing construction. Copies of any federal, state, or local permits issued for the proposed impoundments shall be submitted to the Town Engineer. TCEQ rules and regulations regarding impoundments shall be followed. In accordance with Texas Water Code §11.142, permanent surface impoundments including retention and detention ponds may be required to obtain a water rights permit from the TCEQ.

### CHAPTER 7. FLOODPLAIN DEVELOPMENT

The following information is included for reference and to supplement the provisions outlined in the Town’s Flood Control and Prevention Ordinance. Where codified flood protection provisions conflict with the provisions of this manual, the more stringent of the criteria shall apply.

The Town regulates development in all flood-prone areas. Flood-prone areas include areas located within the FEMA Special Flood Hazard Area (SFHA), flood hazards identified as part of a drainage study or Town Council adopted watershed study, or reported flood-prone areas located in Zone X. Reported flood-prone areas are subject to the requirements of this manual even if a flood zone has not been identified for the area.

Any land disturbance that includes impacts to a flood-prone area or could have impacts on floodplain limits for an associated stream shall require a hydraulic analysis (flood study) to determine drainage easements, establish minimum finished floors for insurable structures, and evaluate proposed modifications to existing floodplains or floodways. Depending upon the proposed project, location, and type of stream, the stormwater submittals may include a Flood Study, No Rise Certification, Floodplain Development Permit, FEMA Letter of Concurrent/Approval, and/or a USACE Section 10 and Section 404 Permit.

#### 7.1 Effective Models

When available, effective models provided by the Town are required to be utilized to establish existing conditions and evaluate proposed project impacts to the watershed. When Town adopted models are utilized, any submitted models shall be consistent with the base modeling platform and version. Proposed conditions shall be incorporated into the Town’s watershed models and submitted for review.

#### 7.2 Compensatory Storage
Compensatory storage is required for all storage lost or displaced in a Regulatory Floodplain due to land disturbance. Hydraulically equivalent compensatory storage requirements for fill or structures placed in the SFHA and/or within a riverine flood hazard area identified in a Town Council adopted watershed study shall be at least equal to the volume of the storage lost or displaced. Such compensation areas shall be designed to drain freely and openly to the channel and shall be located opposite or adjacent to fill areas. The Regulatory Floodplain storage volume lost below the existing 10-year frequency flood elevation must be replaced below the proposed 10-year frequency flood elevation. The Regulatory Floodplain storage volume lost above the 10-year existing frequency flood elevation must be replaced above the proposed 10-year frequency elevation.

### 7.3 Floodplain Development Permit

Any work to be performed within any flood-prone area of the town required a Floodplain Development Permit. Variances will not be issued from this requirement for proposed projects in the SFHA. Applications for a Floodplain Development permit shall be submitted to the Town with the flood study that evaluates existing conditions and proposed project impacts.

### 7.4 FEMA Submittal Requirements

Coordination with and approval from the Town Floodplain Administrator is required for all floodplain submittals. Payment of a review fee to the Town may be required.

All proposed projects located in the SFHA shall be evaluated for the need of a Conditional Letter of Map Revision (CLOMR). A CLOMR shall be submitted to FEMA in the event that the proposed modifications to the SFHA result in a rise greater than 0.0 feet to the effective base flood elevation. The Town reserves the right to require a CLOMR for any proposed project located within the SFHA.

Upon completion of construction within the SFHA, all applicants shall verify that the site was constructed according the proposed conditions. As-built plans, certified by a professional engineer registered in Texas, shall be submitted to the Town for verification of as-built conditions. Hydraulic modeling to reflect as-built conditions is required for projects constructed without conditional approval or where as-built conditions differ from the proposed conditions modeling. In all cases, a Letter of Map Revision (LOMR) shall be submitted to FEMA for approval.
CHAPTER 8. DEFINITIONS AND ABBREVIATIONS

TERMS BEGINNING WITH “A”

1. Annual Exceedance Probability
   Defined as a percentage based on the probability that a certain amount of rainfall will be exceeded any given year.

2. As-Built
   Set of drawings submitted after concluding a project or specific task. These drawings capture all alterations made to the specifications and working drawings throughout the construction process. They provide precise information, including dimensions, geometry, and surveyed positions of every element within the completed work under the contract.

TERMS BEGINNING WITH “B”

3. Base Flood
   The flood having a one percent probability of being equaled or exceeded in any given year. The base flood is also known as the 100-year frequency flood event.

4. Base Flood Elevation
   The elevation delineating the level of flooding resulting from the Base Flood.

5. Best Management Practice
   A structural or non-structural managerial practice or device that prevents, reduces, or treats pollution of stormwater; prevents or reduces soil erosion; and/or reduces or minimize stormwater runoff. A BMP may be temporary to protect during construction or permanent to protect water from the long-term effects of development and increased impervious area.

TERMS BEGINNING WITH “C”

6. Channel
   Any river, stream, creek, branch, ditch, swale, natural or man-made drainageway into which surface or groundwater flows, either perennially or intermittently.

7. Collector Street
   Major and minor roads that connect local roads and streets with arterials.

TERMS BEGINNING WITH “D”

8. Design Storm
   A hypothetical discrete rainstorm characterized by a specific duration, temporal distribution, rainfall intensity, return frequency, and total depth of rainfall.

9. Detention Facility
   A manmade structure designed to temporarily hold and then discharge stormwater runoff.
10. **Development**
   A contiguous tract of land (or a tract of land separated only by roadway and/or drainage right-of-way or easements) to be considered as a single development for purposes of this policy. Or it refers to the project being designed or constructed. (See also Subdivision Ordinance).

11. **Drainage Area**
   An area from which stormwater runoff normally drains to a single point.

**TERMS BEGINNING WITH “E”**

12. **Engineer**
    A person who is currently licensed by the Texas Board of Professional Engineers to engage in the practice of engineering in the State of Texas.

13. **Erosion**
    The gradual “wearing away” of soil typically along stream banks or culvert outlets attributed to streamflow and sediment transport.

14. **Existing Conditions**
    The circumstances of the site at the time of first review of site plans or upon initial submittal of permit applications.

**TERMS BEGINNING WITH “F”**

15. **FEMA**

16. **Floatables**
    Litter and other pollutants that float on the surface of water, including but not limited to plastic bottles, aluminum cans, cigarette butts, and plastic grocery bags.

17. **Flood**
    A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waves, or the unusual and rapid accumulation of runoff of surface waters from any source.

18. **Flood Frequency**
    A period of years, based on statistical analysis, during which a flood of a stated magnitude may be expected to be equaled or exceeded.

19. **Floodplain**
    Any land area susceptible to inundation by the design flood.

20. **Flood Study**
    A technical investigation of flood behavior for a particular catchment, river or creek.

21. **Flowline**
    The lowest conveyance elevation of a particular feature/structure.
22. **Freeboard**
An increment of height added to a flood elevation to provide a factor of safety for uncertainties in calculations, unknown local conditions, wave actions, and unpredictable effects such as those caused by ice or debris jams.

23. **Hydrologic and Hydraulic (H&H) Calculations**
Calculations performed to ascertain the quantity (Hydrologic) of water moving through a system and the characteristics (Hydraulic) of its movement.

24. **Impervious Area**
A hard area that doesn’t allow water to seep into the ground, such as a concrete parking lot, road, or sidewalk.

25. **Inspect**
Provide a thorough examination and assessment of various aspects of the construction or infrastructure work to ensure compliance with specifications, codes, and standards.

26. **Lake**
A large body of surface water.

27. **Land Disturbing Activity**
Any development activity that results in a change in the natural cover or topography and that may cause or contribute to sedimentation, additional pollutant runoff, increased peak discharge rates, or increased total stormwater runoff volumes.
28. Major Thoroughfare
   Streets and highways used as through-routes for large volumes of traffic.

29. Mitigation
   To lessen the severity of.

30. Municipal Separate Storm Sewer System (MS4)
   A separate storm sewer system (includes ditches, curbs, gutters, storm sewers, and similar means of collecting or conveying runoff that do not connect with a wastewater collection system or treatment plant) owned or operated by a public agency.

TERMS BEGINNING WITH “N”

31. Natural Channel
   Channels that have occurred naturally due to the flow of surface waters.

32. Notice of Intent (NOI)
   A formal document submitted to regulatory authorities to indicate an entity’s intention to undertake a particular project or activity that may have environmental implications.

33. Notice of Termination (NOT)
   A formal document that is issued to communicate the conclusion or cessation of a construction project or contractual arrangement.

TERMS BEGINNING WITH “O”

34. Open Channel
   A channel that conveys stormwater with a surface open to the atmosphere.

TERMS BEGINNING WITH “P”

35. Pollutant
   A substance that disrupts the natural order of the environment.

36. Pond
   A man-made pool of still water, could be kept dry or full.

37. Positive Overflow
   When storm inlets do not function properly, or when the design capacity of the conduit is exceeded, the excess flow can be conveyed overland along an open course.

38. Pre-Project
   The project area in its existing condition, before any construction has begun.

39. Private...
40. **Public**

Owned or operated by a public entity, such as the U.S. government, the town, or other government agency.

**TERMS BEGINNING WITH “Q”**

**TERMS BEGINNING WITH “R”**

41. **Redevelopment**

Construction on a site that has previous developments or uses.

42. **Regulatory Floodplain**

The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

43. **Residential Street**

A street that primarily connects residential properties to one another and to local or collector streets.

**TERMS BEGINNING WITH “S”**

44. **Sedimentation**

The natural process in which material (such as stones and sand) is carried to the bottom of a body of water and forms a solid layer.

45. **Specifications or Technical Specifications**

Document giving a detailed description of the quantitative and qualitative requirements for products, materials, and workmanship.

46. **Sumps**

Drainage features of levee systems that temporarily store storm water runoff before it is conveyed to a river system by pumping over or draining through a levee.

47. **Supercritical Flow**

Shallow fast flow with a high energy state and has a Froude number greater than one; the flow at which the depth of the channel is less than critical depth, the velocity of flow is greater than critical velocity and the slope of the channel is also greater than the critical slope.

48. **Sustainable Drainage Measures**

Stormwater infrastructure that uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments; sustainable
drainage measures include a range of soil-water-plant systems that intercept stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air, and release a portion of it slowly back into the sewer system.

49. **Stormwater**
   Water that originates during precipitation events and snow/ice melt. Stormwater can soak into the soil, be held on the surface and evaporate, or runoff and end up in nearby streams, lakes, and rivers.

50. **Stormwater Facility Maintenance Agreement or Maintenance Agreement (SFMA)**
   A legal agreement between the Town of Little Elm and a property owner, including HOAs and POAs, for perpetual maintenance of a structural BMP.

51. **Stormwater Pollution Prevention Plan or SWPPP**
   The site design, operations, and inspections plan required by the Environmental Protection Agency (EPA) and the Texas Council on Environmental Quality (TCEQ) for the control of erosion and sediment during construction.

52. **State water**
   as defined in Texas Water Code Title 2 Subtitle B Chapter 11 Subchapter A: A) The water of the ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state is the property of the state. B) Water imported from any source outside the boundaries of the state for use in the state and which is transported through the beds and banks of any navigable stream within the state or by utilizing any facilities owned or operated by the state is the property of the state.

**TERMS BEGINNING WITH “T”**

53. **Town**
   The Town of Little Elm, Texas, a municipal corporation, authorized and chartered under the Texas State Statutes, acting by and through its governing body or its Town Manager or his/her duly authorized representatives.

**TERMS BEGINNING WITH “U”**

**TERMS BEGINNING WITH “V”**

**TERMS BEGINNING WITH “W”**
CHAPTER 8. DEFINITIONS AND ABBREVIATIONS
Section 7.4 | FEMA Submittal Requirements

TERMS BEGINNING WITH “X”

TERMS BEGINNING WITH “Y”

TERMS BEGINNING WITH “Z”