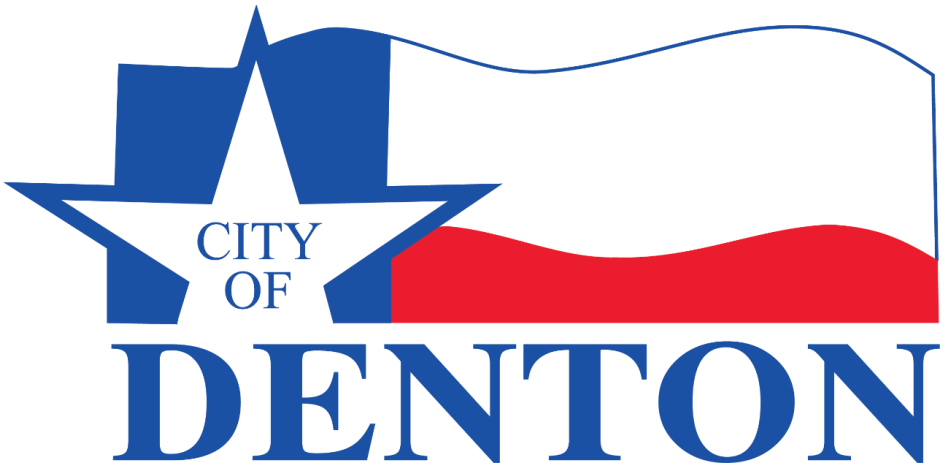


Design Criteria Manual

Published: January 2026

Table of Contents

Section 1: Introduction

1.1 Title and Effective Date

1.1.1 This document is the Design Criteria Manual of the City of Denton, Texas. It shall be officially known and cited as the "Denton Design Criteria Manual," and is referred to internally in this document as "this DCM" and "this Manual."

1.1.2 This DCM shall become effective on January 1, 2026.

1.2 Purpose

The purpose of the Denton Design Criteria Manual is to provide minimum, non-exhaustive guidelines for the design and construction of ***solid waste, stormwater, transportation, water and wastewater, and streetlight infrastructure*** within the City of Denton, Texas and its extraterritorial jurisdictions. The criteria established in this Manual have been developed from a review of various applicable publications, regulatory requirements, and City of Denton offices which oversee the design, construction and maintenance of the facilities.

These guidelines are to be used by design engineers in the City of Denton Capital Projects and Engineering Department, consulting engineers employed by the City, and engineers of subdivision and land development infrastructure projects proposed for construction and acceptance by the City, within the City and its extraterritorial jurisdictions.

Along with this Manual, the Denton Development Code (DDC) and relevant submittal checklists should be consulted for additional criteria. ***The criteria established in this Manual do not supersede the criteria contained in the DDC.*** In the case of conflict among this Manual, City of Denton Standard Details, or other cited regulations and standards, the more stringent requirement shall apply.

This DCM is ***not*** intended to be an all-inclusive design document for all circumstances and conditions. The DDC and City of Denton Code of Ordinances must be consulted for possible impacts to the proposed design. The Federal Government, the State of Texas, NCTCOG, Denton County, Denton County Transit Authority (DCTA), and other related organizations and resources should be consulted for additional criteria, as may be deemed necessary.

1.3 Organization

In addition to the design criteria established in this DCM, guidance is also provided for design deviations from the required design criteria. The contents of this Manual are categorized into sections shown below:

A. Section 1: Introduction
B. Section 2: Abbreviations and Definitions
C. Section 3: Solid Waste Design
D. Section 4: Stormwater Design
E. Section 5: Transportation Design
F. Section 6: Water and Wastewater Design
G. Section 7: Streetlight Design Criteria
H. Section 8: Design Deviations

Section 2: Abbreviations and Definitions

2.1 Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
APBP	Association of Pedestrian and Bicycle Professionals
ASTM	American Society for Testing and Materials
AWSC	All-Way Stop Control
AWWA	American Water Works Association
BFE	Base Flood Elevation
BFR	Barrier Free Ramp
BOC	Back of Curb
BMP	Best Management Practices
CCN	Certificate of Convenience and Necessity
cfs	cubic feet per second
CLOMR	Conditional Letter of Map Revision
COA	Condominium Owner's Association
CP	Cathodic Protection
cu. ft.	cubic feet
cu. in.	cubic inches
DCAD	Denton Central Appraisal District
DCM	Design Criteria Manual
DCTA	Denton County Transit Authority
DDC	Denton Development Code
DFW	Dallas-Fort Worth Metroplex
DIP	Ductile-Iron Pipe
DRP	Development Review Process
DSA	Down Stream Assessment
EOL	End-of-Line
ESA	Environmentally Sensitive Area
ft.	foot or feet
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation

FHWA	Federal Highway Administration
FIRM	Federal Insurance Rate Map
FIS	Flood Insurance Study
FM	Farm to Market
fps	feet per second
FSE	Food Service Establishment
gal.	gallon(s)
GPCD	gallons per capita per day
GPD	gallons per day
GPM	gallons per minute
GPS	Global Positioning System
HDPE	High Density Polyethylene
HEC-HMS	Hydrologic Engineering Center's Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HGI	Hydromechanical Grease Interceptor
HGL	Hydraulic Grade Line
HOA	Home Owners' Association
IBC	International Building Code
ID	Inner Diameter
IFC	International Fire Code
IH	Interstate Highway
in.	inch(es)
IPC	International Plumbing Code
ITE	Institute of Transportation Engineers
*i*SWM™	Integrated Stormwater Management
kg.	kilogram(s)
lb.	pound or pounds
LOMR	Letter of Map Revision
LOS	Level-of-Service
MEP	Mechanical, Electrical, and Plumbing
MGD	Million Gallons per Day
mL	milli-liter(s)
mph	miles per hour

NAVD	North American Vertical Datum
NCHRP	National Cooperative Highway Research Program Report
NCTCOG	North Central Texas Council of Governments
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
PHT	Peak-Hour Trips
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
POA	Property Owners' Association
POTW	Publicly Owned Treatment Works
PROWAG	Public Rights of Way Accessibility Guidelines
psi	pounds per square inch
PUCT	Public Utilities Commission of Texas
PUE	Public Utility Easement
PVC	Polyvinyl Chloride
PZC	Planning and Zoning Commission
RCP	Reinforced Concrete Pipe
ROW	Right-of-Way
RPBA	Reduced Pressure Backflow Assembly
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conservation Service
SDR	Standard Dimension Ratio
SFE	Single-Family Equivalent
SETP-PD	Safety End Treatment Plan – Parallel Drainage
SFHA	Special Flood Hazard Area
SH	State Highway
sq. ft.	square feet
sq. mi.	square mile(s)
SWFMA	Stormwater Facility Maintenance Agreement or Maintenance Agreement
TAC	Texas Administrative Code
TAS	Texas Accessibility Standards

TCEQ	Texas Commission on Environmental Quality
TDLR	Texas Department of Licensing and Registration
TGA	Trip Generation Assessment
TIA	Traffic Impact Analysis
TMUTCD	Texas Manual on Uniform Traffic Control Devices
TSS	Total Suspended Solids
TxDOT	Texas Department of Transportation
U.S.	United States of America
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VPD	Vehicle-trips per day
WOTUS	Waters of the United Stated of America
WMP	Water Master Plan
WSEL	Water surface elevation
w.s.f.u.	Water-Supply Fixture-Unit(s)
ZOI	Zone of Influence

2.2 Definitions

20-Year Horizon
The estimated traffic volume for the study area based on a 20-year growth period.

100-year Event
Event (rainfall or flood) that has a 1% chance of being equaled or exceeded in any given year.

Abutment
A wall supporting the end of a bridge or span and sustaining the pressure of the bordering earth.

Applicant
Any firm, entity, partnership, company, public utility company, or individual that submits a formal request or application.

Apron
A floor or lining of concrete, timber, or other suitable material at the toe of a dam, entrance or discharge side of a spillway, a chute, or other discharge structure, to protect the waterway from erosion from falling water or turbulent flow.

Area of Special Flood Hazard
The area designated as subject to flooding from the 1% chance flood on the flood insurance rate map. For purposes of these criteria, the term "special flood hazard area" is synonymous in meaning with the phrase "area of special flood hazard" and may be referred to as "SFHA".

Backwater
The rise of the water level upstream due to an obstruction or constriction in the channel.

Backwater Curve
The term applied to the longitudinal profile of the water surface in an open channel when flow is steady but non-uniform.

Baffles
Deflector vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water, to: (1) check or effect a more uniform distribution of velocities; (2) absorb energy; (3) divert, guide, or agitate the stormwater flow; and (4) check eddy currents.

Baffle Chute
A drop structure in a channel with baffles for energy dissipation to permit the lowering of the hydraulic energy gradient in a short distance to accommodate topography.

Base Flood Elevation
The elevation shown on the Flood Insurance Rate Map (FIRM) and found in the accompanying Flood Insurance Study (FIS) for Zones A, AE, AH, A1-30, AR, V1-30, or VE that indicates the water surface elevation resulting from the flood that has a 1% chance of equaling or exceeding that level in any given year.

Calibration
Process of checking, adjusting, or standardizing operating characteristics of instruments and model appurtenances on a physical model or coefficients in a mathematical model. The process of evaluating the scale readings of an instrument in terms of the physical quantity to be measured.

Carrier Pipe
A pipe used to carry stormwater, water, or wastewater, as opposed to an exterior protective casing pipe.

Casing Pipe
An exterior protective pipe that encases a carrier pipe for various types of crossings, including roadways, creeks, and railroads. Also known as encasement pipe.

Channel
A man-made drainageway or watercourse, generally constructed to straighten a stream or increase its capacity.

Channel Roughness
Irregularities in channel configuration which attenuate the flow of water and dissipate its energy.

Chute
An inclined conduit or structure used for conveying water to a lower level.

City's Engineer
A Professional Engineer, licensed by the State of Texas, who is the subject matter expert of the relevant topic of discussion, and employed by the City of Denton.

Conduit
Any open or closed structure for conveying flowing water.

Corner Clip
ROW dedication at intersection corners to provide sufficient room for intersection visibility, pedestrian access, and other street facilities.

Critical Flow
The state of flow for a given discharge at which the specific energy is a minimum with respect to the bottom of the conduit. The Froude Number is equal to 1.0 for critical flow conditions.

Crown
The highest point on a transverse section of conduit or the highest point of a roadway cross-section.

Culvert
Large pipe or other conduit through which a small stream passes under a road or street.

Curb
A vertical or sloping structure located along the edge of a roadway, normally constructed integrally with the gutter, which strengthens and protects the pavement edge and clearly defines the pavement edge to vehicle operators.

Dam
A barrier constructed across a watercourse for the purpose of creating a reservoir or diverting water from a conduit or channel.

Degradation
The progressive general lowering of a stream channel by erosion, other than that caused by a constriction.

Department Reviewer
A member of a City of Denton department, designated by the Department Director, with subject matter expertise related to the Design Criteria Manual who is designated as being responsible for the review of design deviation requests.

Depression Storage
Collection and storage of rainfall in natural depressions after exceeding infiltration capacity of the soil.

Design Storm or Flood
The storm or flood which is used as the basis for design.

Detention
The storage of storm runoff for a controlled release during or immediately following the design storm.
1. Off-site detention - A detention pond located outside the boundary of the area it serves.
2. On-site detention - A detention pond which is located within and serves only a specific site or subdivision.
3. Regional detention - Detention facilities provided to control excess runoff based on a watershed-wide hydrologic analysis.

Development
Any man-made change to improved or unimproved real estate, including but not limited to, buildings or other structures, paving, drainage, or utilities. Development activities include: subdivision of land; construction or alteration of structures, roads, parking, fences, pools, signs, temporary uses, utilities, and other facilities; installation of septic systems; grading; excavation, mining or drilling operations; deposit of refuse, debris, or fill materials; and clearing of natural vegetative cover (with the exception of agricultural activities as defined and as permitted). Routine repair and maintenance activities are exempted.

Development Project Facilitation
Division within the City of Denton that assists developers move projects through the City's various development review process and authorized to process the review of design deviation requests.

Drop Structures
A sloping or vertical section of a channel designed to reduce the elevation of flowing water without increasing its velocity.

Energy Dissipaters
Engineered devices such as riprap aprons or concrete baffles placed at the outlet of storm water conveyance systems for the purpose of reducing the velocity, energy and turbulence of the discharged flow.

Entrance Head
The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss
Head lost in eddies or friction at the inlet to a conduit, headwall or structure.

Existing Traffic
Existing traffic conditions based on the most recent traffic counts. Existing traffic conditions do not include the traffic created or associated with the development.

Flash Flood
A flood of short duration with a relatively high peak rate of flow, usually resulting from a high intensity rainfall over a small area.

Flood Control
The elimination or reduction of flood losses by the construction of flood storage reservoirs, channel improvements, dikes and levees, by-pass channels, or other engineering works.

Flood Hazard Area
Area subject to flooding by 1% chance floods.

Flood Management or Flood Hazard Mitigation
Any program or activity designed to reduce damages from flooding, including stream erosion.

Floodplain
The area that is subject to flooding from the 1% chance flood. The floodplain includes the regulatory floodway and floodway fringe.

Floodway
The channel and adjacent lands of a watercourse that must be reserved in order to discharge the base flood without increasing the water surface elevation more than the regulatory designated height.

Floodway Fringe
The area located within the floodplain and outside the floodway.

Freeboard
The distance between the normal operating level and the top of the side of an open conduit left to allow for wave action, floating debris, or any other condition or emergency without overtopping the structure.

Frequency (of storms, floods)
Average recurrence interval of events, over long periods of time. Mathematically, frequency is the reciprocal of the exceedance probability.

Froude Number
A flow parameter, which is a measure of the extent to which gravitational action affects the flow. A Froude number greater than one (1) indicates supercritical flow and a value less than 1 subcritical flow. The simplest

form of the Froude number is given by the following equation:

$$F = V / (g D)^{0.5} \quad \textbf{[Eqn. 2.1]}$$

Where: V = Velocity
g = the acceleration due to gravity (32.2 ft/s^2)
D = depth

Fully Developed Conditions
A description of hydrologic conditions in a watershed, if the watershed has been completely built out based on the zoning and future land use maps of the City. If there is no designated future land use, the runoff coefficient will be assumed to be (0.6) for purposes of determining fully developed water surface elevations. This term is interchangeable with the term "Ultimate Developed Conditions". This is not to be confused with a Developed Floodplain as defined in Subchapter 9.2 of the DDC, which refers to the character of the streambed itself.

Gabion
A wire container filled with rock and used in the construction of dams, retaining walls, and protection against erosion.

Grade
1. The inclination or slope of a channel, canal, conduit, etc., or natural ground surface, usually expressed in terms of the percentage of number of units of vertical rise (or fall) per unit of horizontal distance.
2. The elevation of the invert of the bottom of a conduit, canal, culvert, sewer, etc.
3. The finished surface of a canal bed, road bed, top of an embankment, or bottom of excavation.

Gutter
A generally shallow waterway adjacent to a curb used to convey stormwater.

Headwater
1. The upper reaches of a stream near its sources;
2. The region where ground waters emerge to form a surface stream;
3. The water upstream from a structure.

Hydraulic Control
The hydraulic characteristic which determines the stage-discharge relationship in a conduit. The control is usually critical depth, tailwater depth, or uniform depth.

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

Hydraulic Gradient
A hydraulic profile of the piezometric level of the water, representing the sum of the depth of flow and the pressure head. In open channel flow it is the water surface.

Hydraulic Jump
The hydraulic jump is an abrupt rise in the water surface which occurs in an open channel when water

flowing at supercritical velocity is retarded by water flowing at subcritical velocity. The transition through the jump results in a marked loss of energy, evidenced by turbulence of the flow within the area of the jump. The hydraulic jump is sometimes used as a means of energy dissipation.

Hydraulics
A branch of science that deals with practical applications of the mechanics of water movement.

Hydrograph
A graph showing stage, flow, velocity, or other property of water versus time at a given point on a stream or conduit. Examples include: Dimensionless Unit hydrograph, Unit Hydrograph.

Hydrology
The science dealing with the properties, distribution, and circulation of water on and below the Earth's surface and in the atmosphere.

Hyetograph
A histogram or graph of rainfall intensity versus time of storm.

Impervious
A term applied to a material through which water cannot pass or passes with great difficulty.

Infiltration
1. The entering of water through the interstices or pores of a soil or other porous medium.
2. The entrance of water from the ground into a sewer or drain through breaks, defective joints, or porous walls.
3. The absorption of water by the soil, either as it falls as precipitation, or from a stream flowing over the surface.

Inlet
Inlets are drainage structures used to collect surface water through grate or curb openings and convey it to storm drains or direct outlet to culverts.
Inlets used for the drainage of roadway surfaces can be divided into four major classes:
1. Grate Inlets – These inlets include grate inlets consisting of an opening in the gutter covered by one or more grates, and slotted inlets consisting of a pipe cut along the longitudinal axis with a grate or spacer bars to form slot openings.
2. Curb-Opening Inlets – These inlets are vertical openings in the curb covered by a top slab.
3. Combination Inlets – These inlets usually 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 upstream of the grate.
4. Drop Inlet (Y-Inlet) -A storm drain intake structure typically located in unpaved areas. The inlet may extend above the ground level with openings on one or more sides of the inlet or it may be flush with the ground with a grated cover.

Intensity
As applied to rainfall, a rate usually expressed in inches per hour.

Interception
As applied to hydrology, refers to the process by which precipitation is caught and held by foliage, twigs,

and branches of trees, shrubs and buildings, never reaching the surface of the ground, and then lost by evaporation.

Invert
The floor, bottom, or lowest portion of the internal cross-section of a conduit.

Lag Time
The time difference between two occurrences such as between rainfall and runoff or pumping of a well and effect on the stream. *See* Time of Concentration.

Level of Service
A qualitative measure of traffic flow and congestion, representing quality of service. It describes operational conditions within a traffic stream, generally described in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Lining
Impervious material such as concrete, clay, grass, plastic, puddled earth, etc., placed on the sides and bottom of a ditch, channel, and reservoir to prevent or reduce seepage of water through the sides and bottom and/or to prevent erosion.

Lip
A small wall on the downstream end of an apron to break the flow from the apron.

Major Stream
Waterways with a contributing drainage area of one square mile or more.

Manning's Coefficient
The coefficient of roughness used in Manning's Equation for flow in open channels.

Manning's Equation
A uniform flow equation used to relate velocity, hydraulic radius and the energy gradient slope.

Median
The portion of a divided roadway separating the opposing traffic flows. A median may be traversable or non-traversable.

Median Opening
An opening in a non-traversable median that allows accessing or crossing the opposing traffic lanes.

Minimum building elevation
The elevation to which new and substantially improved structures within the floodway or within 200 feet of the floodplain or SFHA are required to be elevated or floodproofed. This elevation would be equal 18 inches above the 100-year water surface elevation based on fully developed conditions or 30 inches above the BFE as indicated in the flood insurance study or, if the BFE is unavailable, 30 inches above the 100-year flood elevation based on current development watershed conditions.

Model
Mathematical systems analysis by computer, applied to evaluate rainfall-runoff relationships; simulate watershed characteristics, predict flood and reservoir routings, or use other aspects of planning.

Nappe
The sheet or curtain of water overflowing a weir or dam. When freely overflowing any given structure, it has a well-defined upper and lower surface.

Open Channel
A conduit in which water flows with a free surface.

Orifice
1. An opening with closed perimeter, and of regular form in a plate, wall, or partition through which water may flow.
2. The end of a small tube, such as a Pilot tube, piezometer, etc.

Peak Flow (Peak Rate of Runoff)
The maximum rate of runoff during a given runoff event.

Percolation
To pass through a permeable substance such as ground water flowing through an aquifer.

Permeability
The property of a material which permits movement of water through it when saturated and actuated by hydrostatic pressure.

Pervious
Applied to a material through which water passes relatively freely.

Pilot Channel
A constructed pathway that guides base streamflow or runoff along a specified route through a drainage facility or drainage feature.

Porosity
1. An index of the void characteristics of a soil or stratum as pertaining to percolation; degree of perviousness.
2. The ratio, usually expressed as a percentage, of (a) the volume of the interstices in a given quantity of material, to (b) the total volume of the material.

Positive Overflow
When the inlets do not function properly, or when the design capacity of the conduit is exceeded, the excess flow must be conveyed overland along a paved course. This could mean along a street or alley but could require a concrete flume and the dedication of special drainage easements on private property.

Post-development
The condition of the given site and drainage area after the anticipated development has taken place.

Precipitation
Any moisture that falls from the atmosphere, including snow, sleet, rain and hail.

Pre-development
The condition of the given site and drainage area prior to development.

Probable Maximum Flood
The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Probable Maximum Precipitation
The critical depth-duration-area rainfall relationship for a given area during the seasons of the year which would result from a storm containing the most critical meteorological conditions considered probable of occurring.

Projected Growth Rate
The estimated growth rate per year for the study area based upon the average growth in the previous 5-year period along arterials in the vicinity of the proposed project.

Proposed Site Traffic Volumes
The number of vehicles per day and per hour projected to be generated by the development.

Rainfall Duration
The length of time over which a single rainfall event occurs.

Rainfall Frequency
The average recurrence interval of rainfall events.

Rainfall Intensity
The rate of accumulation of rainfall, usually in inches or millimeters per hour.

Rational Formula
A traditional method of computing peak flow using intensity of the storm rainfall.

Reach
Any length of river or channel. Usually used to refer to sections which are uniform with respect to discharge, depth, area or slope, or sections between gaging stations.

Recurrence Interval
The average interval of time within which a given event will be equaled or exceeded once. For an annual series (as opposed to a partial duration series) the probability of occurrence in anyone year is the inverse of the recurrence interval. Thus, a flood having a recurrence interval of 100 years has a 1% probability of being equaled or exceeded in any one year.

Regulatory Floodway
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.

Retention
The storage of a portion or all of the storm runoff for purposes of permanent use of the retained water. Retention facilities are similar to detention facilities with the main difference being that all of the storm runoff will not be released to the downstream drainage network.

Return Period
See Recurrence Interval

Reynold's Number (Re)
A flow parameter which is a measure of the viscous effects on the flow. Typically defined as shown in the equation below:

$$Re = (V. D) / \nu \qquad \textbf{[Eqn. 2.2]}$$

Where: V = Velocity
D = Depth
ν = kinematic viscosity of the fluid

Riprap (Revetment)
Forms of bank protection, usually using rock or concrete.

Routing
Routing is a technique used to predict the temporal and spatial variations of a flood wave as it traverses a river reach or reservoir. Generally, routing technique may be classified into two categories - hydrologic routing and hydraulic routing.

Right-of-Way
A designated section of a street, sidewalk, alley, waterway or utility easement and/or related facilities, that is dedicated for municipal usage.

Right-of-Way Width
The shortest horizontal distance between the lines which delineate the right-of-way of a street.

Runoff
That part of the precipitation which reaches a stream, drain, sewer, etc., directly or indirectly.
1. Direct Runoff - The total amount of surface runoff and subsurface storm runoff which reaches stream channels.
2. Overland Runoff - Water flowing over the land surface before it reaches a definite stream channel or body of water.

Runoff Coefficient
A decimal number used in the Rational Formula which defines the runoff characteristics of the drainage area under consideration. It may be applied to an entire drainage basin as a composite representation or it may be applied to a small individual area such as one residential lot.

Runoff Total
The total volume of flow from a drainage area for a definite period of time such as a day, month, or a year, or it may be for the duration of a particular storm.

Scour
The erosive action of running water in streams or channels in excavating and carrying away material from the bed and banks.

SCS Runoff Curve Number
Index number used by the National Resource Conservation Service, formerly the Soil Conservation Service, as a measure of the tendency of rainfall to run off into streams rather than evaporate or infiltrate.

Sediment
Material of soil and rock origin transported, carried, or deposited by water.

Sedimentation Basin
A sediment control basin required to catch runoff from common drainage areas with 10 acres or more disturbed at one time during any phase of development that dewaters from the surface unless infeasible.

Sidewalk
A paved area within the street ROW or sidewalk easement specifically designed for pedestrians and/or bicyclists.

Sight Distance
The distance visible to the driver of a passenger vehicle measured along the normal travel path of a roadway from a designated location and to a specified height above the roadway when the view is unobstructed by traffic.

Slope, Critical
The slope or grade of a channel that is exactly equal to the loss of head per foot resulting from flow at a depth that will give uniform flow at critical depth; the minimum slope of a conduit which will produce critical flow.

Slope, Friction
The friction head or loss per unit length of channel or conduit. For uniform flow the friction slope coincides with the energy gradient, but where a distinction is made between energy losses due to bends, expansions, impacts, etc., a distinction must also be made between the friction scope and the energy gradient. The friction slope is equal to the bed or surface slope only for uniform flow in uniform open channels.

Soffit
In a stormwater pipe, the uppermost point of the interior of the pipe wall. The crown is the uppermost point on the outside of the pipe wall.

Spillway
A waterway in or about a dam or other hydraulic structure, for the overflow of excess water.

Standard Details
A collection of uniform detail drawings of structures or devices adopted as standard construction details by the City of Denton.

Steady Flow
Open channel flow is said to be steady if the depth of flow does not change or if it can be assumed to be constant during the time interval of consideration.

Stormwater Facility Maintenance Agreement or Maintenance Agreement
A legal agreement between the City of Denton and a property owner, including HOAs and POAs, for perpetual maintenance of a structural BMP.

Stream
A natural drainageway that conveys stormwater, may also be referred to as a creek. References to a stream or creek in this Manual refer to the entire stormwater carrying component of the stream to the limits of the floodplain, not just to the streambed.

Stilling Basin
Pool of water conventionally used, as part of a drop structure or other structure, to dissipate energy.

Stopping Sight Distance
The distance required by a driver of a vehicle, traveling at a given speed, to bring the vehicle to a stop after an object on the roadway becomes visible. It includes the distance traveled during driver perception time, reaction time, and the vehicle braking distance.

Storage Length
The portion of an auxiliary lane required to store the number of vehicles expected to accumulate in the lane during an average peak period.

Storm Hydrology
The branch of hydrology that concentrates on the calculation of runoff from storm rainfall.

Stormwater Management
The control of storm runoff on-site or on small streams, by means of land use restrictions, detention storage, erosion control, and/or drainage measures.

Stormwater Model
Mathematical representation of a stormwater network.

Study area
The boundaries of the assessment area as determined by the City's Engineer.

Subcritical Flow
The Froude Number is less than 1.0 for subcritical flow conditions.

Supercritical Flow
The Froude Number is greater than 1.0 for supercritical flow conditions.

Tailwater
The depth of flow in the stream directly downstream of a drainage facility.

Time of Concentration
The estimated time in minutes required for runoff to flow from the most remote section of the drainage area to the point at which the flow is to be determined.

Total Head Line (Energy Line)
A line representing the energy in flowing water. The elevation of the energy line is equal to the elevation of the flow line plus the depth plus the velocity head plus the pressure head.

Traffic Queue
Vehicles within a storage queue awaiting traffic movement in a single lane, within one traffic signal cycle.

Trash Rack
Racks, gratings, or mesh designed so as to prevent leaves and rubbish from plugging the outlets from a dam or detention basin.

Trip Distribution
An estimate of the spatial pattern of trips or other flows between given sets of origins and destination pairs. Trip distribution models connect the trip origins and destination, estimated by the trip generation models to create estimated trips based on the Base year and Buildout years (24 hour counts or turning movement counts). Different trip distribution models are developed for each of the trip purposes for which trip generation has been estimated.

Trunk Line
The main line of a storm drain system extending from manhole to manhole or from manhole to outlet structure.

TxDOT Highways
State-operated highways that include Farm to Market (FM) roadways, State Highways (SH), Interstate Highway (IH), IH Frontage Roads, and United States (US) Highways.

Uniform Channel
A channel with a constant cross-section and roughness.

Uniform Flow
Open channel flow is said to be uniform if the depth of flow is the same at every section of the channel.

Unit Hydrograph
The direct runoff hydrograph resulting from one inch of precipitation excess distributed uniformly over a watershed for a specified duration.

Valley Storage
Refers to the water storage capacity of a stream and is a volume that is measured below the base flood elevation. Restrictions on loss of valley storage refer to compensation for the loss of storage caused by fill below the base flood elevation.

Velocity Head
The energy per unit weight of water due to its velocity (v). The velocity head also represents the vertical distance water must fall freely under gravity to reach its velocity (v). The velocity head can be computed from the following equation:

$$\text{Velocity Head} = v^2 / 2g \qquad \textbf{[Eqn. 2.3]}$$

Where: v = velocity
g = acceleration due to gravity (32.2 ft/s^2)

Water Year
The water year commonly used in the United States is the period from October 1 to September 30 of the following calendar year.

Watershed
The area contributing storm runoff to a stream or drainage system. Other terms are drainage area, drainage basin and catchment area.

Zone of Influence
A point downstream where the increased discharge from a proposed development results in 0.00' increase in flood elevation.

Section 3: Solid Waste Design Criteria

3.1 Overview

The purpose of Section 3 - Solid Waste Design Criteria of this DCM is to provide basic criteria and standards for the development and maintenance of solid waste and recycling container enclosures.

The Solid Waste Design Criteria established in this Manual shall apply as set forth in:

A. City of Denton Code of Ordinances – Chapter 24,

B. DDC Subchapter 7, Section 7.2 – Applicability, and

C. DDC Subchapter 7, Section 7.12 – Solid Waste and Recycling Design Standards.

The City Code of Ordinances states that the City of Denton shall be the exclusive provider of solid waste collection and disposal services within the City Limits including, but not limited to, services provided for preconstruction activities, construction activities, and residential, multifamily, and commercial activities. All contractors and subcontractors should call City of Denton Customer Service (940-349-8700) to initiate service. Third-party solid waste providers may not be used for any on-site solid waste services within the City Limits.

3.2 Design Standards

3.2.1 General

A. Nonresidential on-site solid waste and recycling container enclosures shall be located on each platted lot of non-residential property and shall be constructed and maintained by the property owner or developer and made available for use by the City of Denton Solid Waste Department or commercial recycling service provider.

B. Nonresidential on-site solid waste and recycling container enclosures shall be available for the storage of all municipal solid waste and recyclables generated for each platted property. The City reserves the ability to determine whether any parcel or area (For example, Downtown Square, strip centers, multifamily residential, etc.) must have shared container service or an alternative service. Container enclosures shall be of adequate size to contain all solid wastes, liquid wastes, and recyclables generated on the property, including, but not limited to, municipal solid waste, recyclables, grease and oils, process by-products and wastes, hazardous waste, medical waste, and any special wastes, contained in accordance with Chapter 24, City of Denton Code of Ordinances.

C. The container enclosures shall meet the Container Enclosure and Storage Space Dimensional Requirements prescribed in Section 3.2.2 of this Manual, as well as Chapter 469 of the Texas Government Code, as amended.

D. New nonresidential uses of 999 square feet ("sq. ft.") or less will be evaluated by City staff to determine the applicability of constructing an enclosure. Trash and recycling carts may be appropriate, thereby eliminating the need for the construction of an enclosure.

E. Cart storage may be utilized on property converted from a residential to non-residential use if the converted property is a structure of less than 2,500 gross sq. ft., has a waste generation rate applicable for cart service, and is in an area where commercial cart service is available.

F. Proposed future building expansion (evaluated at 50% or more of the current square footage) and

phased development shall be considered in site design with regard to sizing, location(s), and access of future solid waste and recyclables container enclosures. Solid waste and recycling areas necessary for future building expansion shall be available, but need not be utilized, nor container enclosures constructed, until future building expansion occurs.

G. Containers for solid waste and recycling service shall be screened from the public right-of-way ("ROW") and from adjacent property owners.

H. Proper construction of the container enclosures shall be completed prior to final approval of the development or property by the City's Solid Waste Department.

I. Container enclosure designs shall be consistent with the engineering drawings and specifications shown in the Solid Waste and Recycling Container Enclosure Construction Drawings in the City of Denton Standard Details.

3.2.2 Container Enclosure and Storage Space Dimensional Requirements

A. All single front-load commercial container enclosures shall have inside walls with dimensions measuring a minimum of 13 feet wide and 11.5 feet deep. The Rear face of the bollard must be three (3) feet from the rear of the enclosure and the front of the bollard must be eight (8) feet from the front of the enclosure, leaving six (6) inches of space equal to the size of the bollard. Only solid waste and recycling containers are allowed in the enclosures. Other storage containers such as grease and oil receptacles, and other items shall be stored and located in a different enclosure. These enclosures shall be located where they will not impede the service of the solid waste and/or recycling containers.

B. All dual front-load commercial container enclosures shall have inside walls with dimensions measuring 26 feet wide and 11.5 feet deep. The Rear face of the bollard must be three (3) feet from the rear of the enclosure and the front of the bollard must be eight (8) feet from the front of the enclosure, leaving six (6) inches of space equal to the size of the bollard. Only solid waste and recycling containers are allowed in the enclosures. Other storage containers such as grease and oil receptacles, and other items shall be stored and located in a different enclosure. These enclosures shall be located where they will not impede the service of the solid waste and/or recycling containers.

C. In the rare case where it is not possible to fit typical front-load enclosures as required above, a design deviation request may be submitted to the City's Solid Waste Department for the consideration of the following two alternatives:

1. Single side-load commercial container enclosures having inside walls with dimensions measuring a minimum of 10 feet wide and eight (8) feet deep. The Rear face of the bollard must be one (1) foot from the rear of the enclosure, and the front of the bollard must be 6.5 feet from the front of the enclosure, leaving six (6) inches of space equal to the size of the bollard. Only solid waste and recycling containers are allowed in the enclosures.

2. Dual side-load commercial container enclosures having inside walls with dimensions measuring 20 feet wide and eight (8) feet deep. The Rear face of the bollard must be one (1) foot from the rear of the enclosure, and the front of the bollard must be 6.5 feet from the front of the enclosure, leaving six (6) inches of space equal to the size of the bollard. Only solid waste and recycling containers are allowed in the enclosures.

D. All roll-off compactor enclosures shall have inside walls with dimensions measuring a minimum of 16 feet wide. The depth of the inside walls must accommodate the compactor size selected.

E. The City of Denton Standard Details contain the required construction specifications for container enclosures and storage spaces.

F. All developments shall be required to install container enclosures as specified in Table 3.2-A .

G. Nonresidential uses that are not required to meet the above storage space and enclosure requirements, will be reviewed for adequate solid waste and recyclables enclosures based on site-specific information and the following Solid Waste and Recycling Design Factors:

1. Type of business;
2. Waste generation potential;
3. Waste generation of similar businesses;
4. Square footage of the development and structures;
5. Number of floors;
6. Location of the business;
7. Hours of business operation;
8. Business site plan; and
9. Phased development and future use plans.

Table 3.2-A: Minimum Container Enclosure Requirements

Development Use	Required Enclosure(s) or Container(s)
RESIDENTIAL	
Single-family	Residential curbside cart pick-up
Townhomes – 4 units or fewer	
RESIDENTIAL - MULTIFAMILY	
5 – 48 units	2 front-load containers enclosed
49 – 64 units	3 front-load containers enclosed
65 – 200 units	1 compactor and 1 front-load container for recycling or 4 front-load containers enclosed
200+ units	1 compactor and 1 front-load container enclosed
GENERAL COMMERCIAL	
1 – 15,000 sq. ft.	2 front-load containers enclosed
15,001 – 50,000 sq. ft.	3 front-load containers enclosed
50,001 – 200,000 sq. ft.	1 compactor and 1 front-load container for recycling or 4 front-load containers enclosed
Over 200,000 sq. ft.	1 compactor and 1 front-load container enclosed

Notes:
[1] For industrial/warehouse development, container(s) do not require enclosures, but container(s) must be screened from public view.

3.2.3 Container Enclosure Design Requirements

A. Materials used for container enclosure construction shall be compatible with the architecture and appearance of the main building and may include the following materials:
   1. Concrete Block – Tinted, colored, painted, or with textured facing;
   2. Concrete – Poured or tilt wall construction;
   3. Brick - Double brick thickness minimum;
   4. Stone;
   5. Metal;
   6. Wood;
   7. Vinyl;
   8. Composite Material; or
   9. Any combination of materials 1-8.

B. Front-load and side-load commercial enclosures shall have walls constructed to a minimum height of six (6) feet, or as tall as required to conceal the container. Compactor enclosure walls must be a minimum height of eight (8) feet, in order to conceal the compactor and mechanical equipment.

C. Gates shall be required when the interior of the enclosure is visible from the public ROW or when it is visible from the lot of an adjacent property owner.

D. Personal access side gates are recommended as a feature of all gated enclosures. These gates should be fitted with emergency egress strike bars.

3.2.4 Enclosure Access, Placement, Ingress, and Egress Requirements

A. The required number of enclosures will be determined based on the type and size of the development.

B. Dumpster enclosures must be angled no more than 30 degrees from the center line of the solid waste collection vehicle route.

C. There must be 50 feet or more of unobstructed truck access in front of each container.

D. For safety purposes, solid waste collection vehicles will not back up more than 100 feet after servicing a container and will not make any turns while backing up.

E. Turn Radii Requirements: The turn radii must be a minimum of 30 feet for any intersection to accommodate occasional turning trucks for weekly pick-up.

F. The collection vehicle will travel through a site once without backtracking. For an example of a typical solid waste collection route, take note of the Typical Solid Waste Collection Route Schematic shown in Figure 3.1 below.

G. Container enclosures shall not be located in fire apparatus access roads, public ROW, public utility easements, or sidewalk area.

H. No solid waste container enclosure shall be located within the required front yard or protrude in front of any buildings along the designated lot frontage.

I. Parking spaces shall begin after the enclosure gates open. No obstructions permitted around enclosure or gate openings equivalent to the length of the gate.

J. The location of container enclosures may not cause the obstruction of traffic for excessive lengths of time while being serviced.

K. The solid waste service truck shall be on the property owner's property during service operations, if the site design permits.

L. Ingress and egress routes shall be designed to facilitate exiting the property in a forward driving direction for all interstate and state roads, arterial streets, and collector streets with four lanes. *See* the Backing Clearance Schematic in Figure 3.2 below.

M. Utility wires and structure overhangs should have a minimum height clearance of 20 feet along the ingress and egress route. No utility wires shall extend over the enclosure approach and service area.

N. Container enclosures shall be located a minimum of 30 feet away from any storm drain or drainage flow areas. Where site configuration allows, container enclosures shall also be placed downslope of any storm drain.

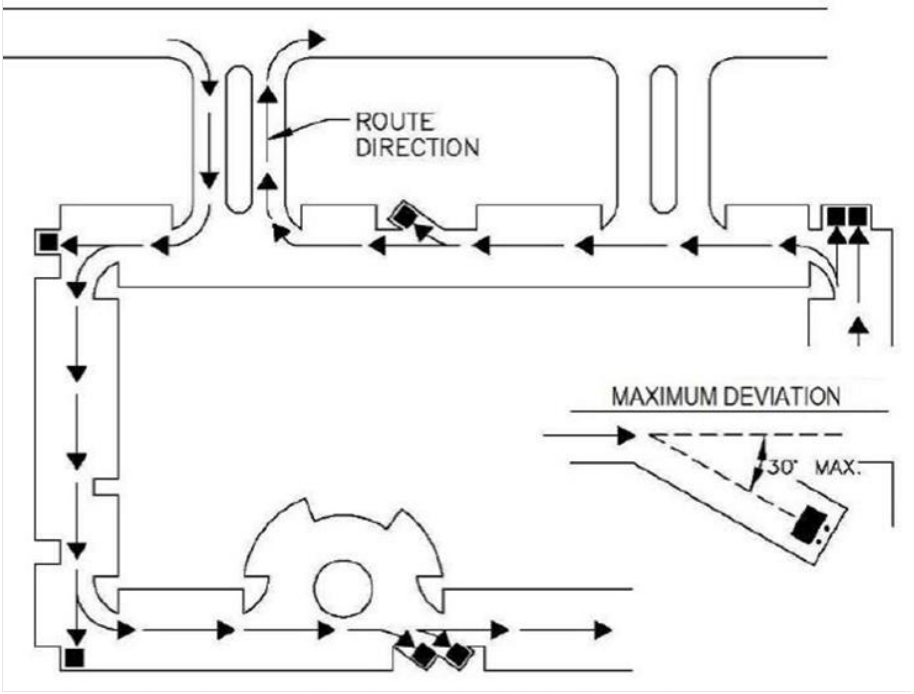


Figure 3.1 Typical Solid Waste Collection Route Schematic

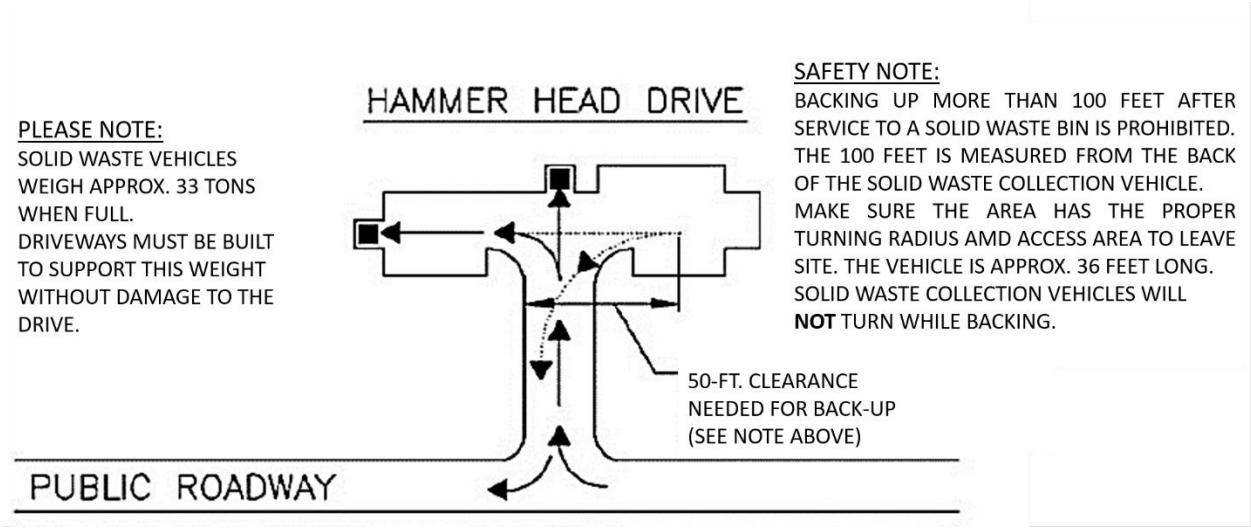


Figure 3.2 Backing Clearance Schematic

3.2.5 Alleyway Access

An alley (residential or commercial) is a private street designed to provide fire and solid waste collection access to the rear or side of a lot. Dead ends are not permitted in alleys. Alleys used for solid waste collection must comply with the Transportation Design Criteria in Section 5 of this Manual. Alleyway access must comply with the following criteria:

A. Design Factors:
   1. Turn Radius;
   2. Street Widths;
   3. Horizontal and Vertical Clearances;
   4. Pavement; and
   5. Multifamily Units

B. Turn Radii Requirements: Texas Department of Transportation (TxDOT) recommends, via AASHTO, that the turn radii be a minimum of 30 feet for alley-to-alley intersections with occasional turning trucks for weekly trash pick-up per TCEQ regulations. Turn radii must be sufficient for side-load residential collection vehicles to navigate alleyways lined with trash and recycle carts on both sides. *See* Figure 3.3 below.

C. Alley Width Requirements: Alleys must be paved and a minimum of 15-ft. wide. Additionally, alleys must be wide enough to accommodate carts, to allow vehicles to safely service carts, and to comply with the Transportation Design Criteria in Section 5 of this Manual.

D. Horizontal and Vertical Clearance Requirements: Balconies, landscaping, or other elements shall not encroach into approved horizontal or vertical clearances for vehicle travel, backing, loading, or other operations along any alley.
   1. The horizontal operating travel clearance must be 20 feet.
   2. The vertical operating travel clearance must be 15 feet.

E. Pavement Requirements: Pavement must be built to standards that allow two (2) 33-ton vehicles to travel down all alleys twice each service day. Alternatively, a responsible party, HOA, or POA must provide a waiver recorded with the property for potential damage caused over time by normal hauler operations.

F. Multifamily Unit Requirements: Any attached residential arrangement of five (5) or more dwelling units per lot will fall under the Commercial Business Category as defined by City of Denton Code of Ordinances 24-2 Definitions (Commercial), which requires a solid waste and recycling storage facility (container enclosure). *See* the Site Plan Criteria for Municipal Solid Waste & Recyclables Storage & Enclosure Requirements in the City of Denton Standard Details.

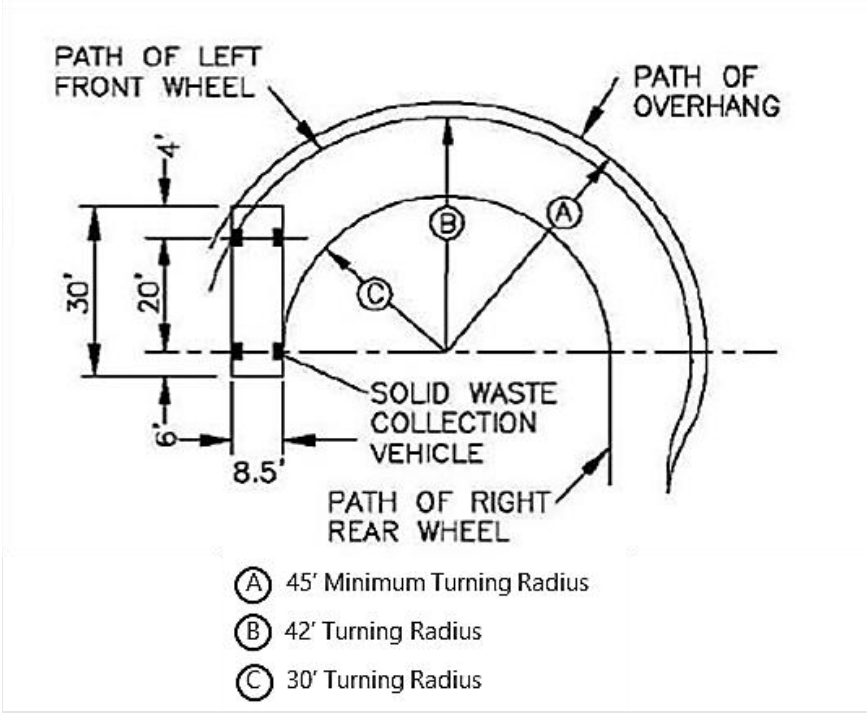


Figure 3.3 Solid Waste Collection Vehicle Turn Radius Schematic

Section 4: Stormwater Design Criteria

4.1 Overview

The purpose of Section 4 - Stormwater Design Criteria of this DCM is to establish standard principles and practices for the design and construction of storm drainage systems, to implement the policies set forth in the DDC and the City of Denton Code of Ordinances, Subpart B, Chapter 30 (Denton Flood Prevention and Protection Ordinance) within the City of Denton, Texas and its extraterritorial jurisdictions.

The following documents govern the design and construction of stormwater drainage systems:

A. City of Denton Code of Ordinances, Chapter 30, Flood Prevention and Protection;

B. DDC Subchapter 7.4 – Environmentally Sensitive Areas;

C. DDC Subchapter 7.5 – Drainage Standards;

D. *i*SWM™ Planning Technical Manual Document;

E. *i*SWM™ Water Quality Technical Manual Document;

F. *i*SWM™ Hydrology Technical Manual Document;

G. *i*swm™ Hydraulics Technical Manual Document;

H. *i*SWM™ Site Development Controls Technical Manual Document;

I. *i*SWM™ Construction Controls Technical Manual Document;

J. *i*SWM™ Construction Control Standard Details Technical Manual Document; and

K. *i*SWM™ Landscape Technical Manual Document.

The design factors, formulae, graphs, and procedures specified in this document are intended for use as minimum engineering criteria for the design of drainage systems with regards to the quantity, rate of flow, method of collection, storage, conveyance, detention, and disposal of storm water***. Responsibility for actual design remains with the design engineer. Users of this Manual should be knowledgeable and experienced in the theory and application of drainage engineering.***

The stormwater criteria contained in this Manual supersede any design criteria contained in the *i*SWM™ Planning, Water Quality, Hydraulics, and Hydrology Technical Manual Documents. The stormwater design criteria contained in this Manual ***do not*** supersede the criteria contained in the DDC or Chapter 30 of the City of Denton Code of Ordinances. Any revisions to the DDC or Chapter 30 of the City of Denton Code of Ordinances shall supersede the criteria in this Manual. In case of any conflict, the more stringent requirement shall apply.

The requirements of this Manual shall apply to all public facilities and to private facilities when the performance of such private facility has an effect on the public interest, health, or welfare.

4.1.0 Organization

Section 4 - Stormwater Design Criteria is categorized as follows:

A. Overview

B. Design Focus

4.2 Design Focus

The design criteria for stormwater management primarily focus on:

4.2.1 Streambank Protection - Regulate discharge from the site to minimize downstream bank and channel erosion;

4.2.2 Flood Mitigation and Conveyance - Control runoff within and from the site to minimize flood risk to people and properties for the conveyance storm and the 1% chance storm; and

4.2.3 Water Quality - Reduce pollutants from stormwater by either infiltrating the water quality volume, or removing 80% of total suspended solids (TSS) from any "*Water Quality*" storm event discharge.

4.3 Design Storms

Design is typically based on four (4) storm events, as detailed in Table 4.3-A.

Table 4.3-A: Design Storm Events

Storm Event Name	Storm Event Description
"Water Quality"	Criteria based on a volume of 1.5 inches of rainfall, not storm frequency
"Streambank Protection"	1-year, 24-hour storm event
"Conveyance"	25-year, 24-hour storm event
"Flood Mitigation"	100-year, 24-hour storm event

Notes:
[1] Throughout the manual, the storms will be referred to by their storm event names.

Drainage facilities shall be designed utilizing the "*Flood Mitigation*" storm event. Replacement or modification of existing drainage facilities shall not reduce capacity, but such facility replacements or modifications may be designed according to the requirements of the specific project and may utilize the "*Conveyance*" storm as the design storm event, through an approved design deviation request.

4.4 Hydrologic Methods

4.4.1 Types of Hydrologic Methods

The following empirical hydrologic methods support hydrologic site analysis for the design methods and procedures included in this Manual:

A. Rational Method;

B. SCS Unit Hydrograph Method;

C. Modified Rational Method;

D. Snyder's Unit Hydrograph Method; and

E. USGS & TxDOT Regression Equations

Table 4.4-A lists the hydrologic methods and the circumstances when they may be used in various analysis and design applications. Table 4.4-B provides some additional constraints on the use of several methods.

Table 4.4-A: Applications of the Hydrologic Methods

Method	Rational Method	SCS Method	Modified Rational	Snyder's Unit Hydrograph Method	USGS & TxDOT Equations
Streambank Protection Volume (SP_V)		✓		✓	
Flood Mitigation Discharge (Q_f)		✓		✓	✓
Storage Facilities		✓	✓	✓	
Outlet Structures		✓		✓	
Gutter Flow and Inlets	✓	✓			
Storm Drain Pipes	✓	✓		✓	
Culverts	✓	✓		✓	✓
Bridges		✓		✓	
Small Ditches	✓	✓		✓	
Open Channels	✓	✓		✓	✓

Table 4.4-B: Constraints on Using Hydrologic Methods

Method	Size Limitations [1]	Used for Estimating
Rational [2]	0 – 100 acres	Peak flows and design of small site or subdivision storm sewer systems.
Modified Rational [3]	0 – 200 acres	Runoff volumes for storage design.
Unit Hydrograph (SCS) [4]	Any Size	Peak flows and hydrographs for all design applications.
Unit Hydrograph (Snyder's) [5]	1 acre and larger	Peak flows and hydrographs for all design applications.
TxDOT Regression Equations [6]	10 – 100 sq. mi.	Peak flows for rural design applications.
USGS Regression Equations [6]	3 – 40 sq. mi.	Peak flows for urban design applications.

Notes:
[1] Size limitation refers to the drainage basin for the stormwater management facility (e.g., culvert, inlet).
[2] Acceptable for small, highly impervious drainage areas, such as parking lots and roadways draining into inlets and gutters.
[3] Used for conceptualizing; the engineer of record must use *i*SWM™ Hydrology Technical Manual Document when using this method.
[4] Refers to SCS routing methodology included in many readily-available programs (such as HEC-HMS or HEC-1) which utilize it.
[5] Refers to Snyder's methodology included in many readily-available programs (such as HEC-HMS or HEC-1) which utilize it.
[6] The USGS and TxDOT equations should not be used when there are significant storage areas within the drainage basin or where other drainage characteristics indicate general regression equations are not appropriate.

4.4.2 Rainfall Estimation

Rainfall intensities, provided in Table 5.3 of the iSWM™ Hydrology Technical Manual, are based on Atlas 14 and shall be used for all hydrologic analysis within Denton County.

4.5 Acceptable Downstream Conditions for Open Channels and Floodplains

Storm water discharge from a development shall not cause adverse impacts to adjacent, upstream, or downstream properties or facilities. The design of a storm drain facility must account for the offsite flows that are routed through the development, flows generated by the development, and the impacts of the development and the drainage system on downstream facilities.

4.5.1 Downstream Assessments

The downstream impacts of development must be carefully evaluated for the two (2) focus areas of Streambank Protection and Flood Mitigation (*See* Section 4.2 of this Manual). The purpose of the downstream assessment is to protect downstream properties from increased flooding and downstream channels from increased erosion potential due to upstream development. The importance of the downstream assessment is particularly evident for larger sites or developments that have the potential to dramatically impact downstream areas. The cumulative effect of smaller sites, however, can be just as dramatic and, as such, following the Focus Areas is just as important for the smaller sites as it is for the larger sites.

A downstream assessment will be required for all developments which alter flow patterns or increase the amount of impervious surface and do not limit the peak discharge to pre-development conditions at each outfall from their site. The assessment shall extend from the outfall of a proposed development to a point downstream where there is no calculated increase in WSEL (water surface elevation) or mean velocity within the receiving stream or storm drainage system. The City shall be consulted to obtain records and maps related to the National Flood Insurance Program (NFIP) and the availability of Flood Insurance Studies (FIS)

and Flood Insurance Rate Maps (FIRMs) which will be helpful in this assessment. The assessment must include the following properties:

A. Hydrologic analysis of the pre- and post-development on-site conditions.
B. Drainage path that defines extent of the analysis.
C. Capacity analysis of all existing constraint points along the drainage path, such as existing floodplain developments, underground storm drainage systems culverts, bridges, tributary confluences, or channels.
D. Offsite undeveloped areas are considered as "fully developed" for both the pre- and post-development analyses.
E. Evaluation of peak discharges and velocities for three (3) 24-hour storm events:
    1. "*Streambank protection*" storm
    2. "*Conveyance*" storm
    3. "*Flood Mitigation*" storm
F. Separate analysis for each major outfall from the proposed development.

Once the analysis is complete, the designer must answer the following questions at each determined junction downstream:

A. Are the post-development discharges greater than the pre-development discharges?
B. Are the post-development velocities greater than the pre-development velocities?
C. Are the post-development velocities greater than the velocities allowed for the receiving system?
D. Are there any increases in post-development flood heights above the pre-development flood heights?

These questions shall be answered for each of the three (3) storm events. The answers to these questions will determine the necessity, type, and size of non-structural and structural controls to be placed on-site or downstream of the proposed development.

Section 2.0 of the iSWM™ Hydrology Technical Manual, as amended, gives additional guidance on calculating the discharges and velocities, as well as determining the downstream extent of the assessment.

4.5.2 Adverse Impacts

Downstream Assessments shall evaluate the capacity of the downstream system within the Zone of Influence (ZOI). If the downstream system has less than fully developed capacity, the study shall demonstrate the development will produce no adverse impacts during the one (1), 25, and 100-year storm events. No adverse impacts may include, but are not limited to:

A. No new or increased flooding of existing structures;

B. Zero increases (0.00') in water surface elevations unless contained within the banks of an existing channel including 1-ft. freeboard. Dry lane requirements set forth in Section 4.6.2 shall also be met;

C. Increasing channel velocity is prohibited where existing velocities are erosive. Any increase in channel velocity in other areas must remain below the maximum allowable velocity as defined in Table 4.6-E;

D. No increases in downstream discharges caused by the proposed development that, in combination with off-site discharges, exceeds the existing capacity of the downstream storm drainage system;

E. The *Downstream Assessment* shall extend to a point downstream, known as the ZOI, where the proposed development creates no adverse impacts. The ZOI will be defined by a detailed hydrologic and hydraulic modeling analysis. The City's Engineer may require analysis beyond the ZOI

established by the Engineer of Record based on the criteria above and known flooding issues. ZOI does not automatically end based the rule of thumb known as the "10% rule"; and

F. If the subject development is part of a larger development, the *Downstream Assessment* must include the larger development, and the ZOI shall be determined based on the entire property.

4.5.3 Stormwater Diversions

Diversion of storm water away from the natural watercourse or existing discharge points will not be allowed, except within the property boundaries controlled by the developer under the following conditions:

A. The storm water is returned to its natural flowing watercourse prior to leaving the developer's property, or

B. A timing analysis of the existing and diverted hydrograph must be performed to confirm that the peak flow rate has not been increased at the point that it reenters the watercourse, as a result of the diversion. The City's Engineer may require additional downstream analysis if there are known downstream flooding or volume-sensitive areas.

4.5.4 Streambank Protection

There are two (2) options by which a developer can provide adequate streambank protection downstream of a proposed development. The first step is to perform the required downstream assessment as described earlier in Section 4.5.1 of this Manual. If it is determined that the proposed project does not exceed acceptable downstream velocities or the downstream conditions are improved to adequately handle the increased velocity, then no additional streambank protection is required. If the downstream assessment shows that the velocities are within acceptable limits, then no streambank protection is required. Acceptable limits for velocity control are provided in Table 4.6-D and Table 4.6-E of this Manual. If existing stream velocities exceed the maximum allowable velocities, then no increase in velocities will be permitted. If the downstream assessment shows an increase in velocity beyond the acceptable limits, then on-site or downstream improvements are required for streambank protection, easements or right-of-entry agreements will need to be obtained in accordance with Section 4.12 of this Manual, and one of the two options below must be utilized for streambank protection.

Option 1: Reinforce/Stabilize Downstream Conditions

If the increased velocities are greater than the allowable velocity of the downstream receiving system, then the developer must reinforce/stabilize the downstream conveyance system. The proposed modifications must be designed so that the downstream system is protected from the post-development velocities. The developer must provide supporting calculations and/or documentation that the downstream velocities do not exceed the allowable range once the downstream modifications are installed.

Allowable bank protection methods include stone riprap, gabions, and bio-engineered methods. Sections 3.2 and 4.0 of the *i*SWM™ Hydraulics Technical Manual give design guidance for designing stone riprap for open channels, culvert outfall protection, riprap aprons for erosion protection at outfalls, and riprap basins for energy dissipation.

If the downstream receiving system is designated as an Environmentally Sensitive Area (ESA) this option may not be a viable option. *See* Section 7.4 of the DDC for more information about the various types of ESAs, permitted encroachments, and processes for assessing and modifying ESAs.

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

The developer must use on-site controls to keep downstream post-development discharges at or below

allowable velocity limits. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed such that downstream velocities for the three (3) storm events ("*Streambank Protection", "Conveyance",* and *"Flood Mitigation"*) are within an allowable range once the controls are installed.

4.5.5 Flood Mitigation

A. Introduction

Flood analysis is based on the *"Flood Mitigation"* storm event (see Table 4.3-A). The intent of the flood mitigation criteria is to provide for public safety; minimize on-site and downstream flood impacts from the *"Flood Mitigation"* storm event; maintain the boundaries of the mapped 100-year floodplain; and protect the physical integrity of the on-site stormwater controls and the downstream stormwater and flood mitigation facilities.

Flood mitigation must be provided for on-site conveyance systems, as well as downstream outfalls as described in the following sections.

B. Flood Mitigation Design Options

There are three (3) options by which a developer may address downstream flood mitigation as discussed below. When on-site or downstream modifications are required for downstream flood mitigation, easements or right-of-entry agreements will need to be obtained.

The developer will provide all supporting calculations and/or documentation to show that the existing downstream conveyance system has capacity (Q_f) to safely pass the fully-developed flood mitigation storm discharge.

Option 1: Provide or Document Adequate Downstream Conveyance Systems

When the downstream receiving system does not have adequate capacity, then the developer shall provide modifications to the off-site, downstream conveyance system. If this option is chosen, the proposed modifications must be designed to adequately convey the full build-out stormwater peak discharges for the *"Flood Mitigation*" storm event. The modifications must also extend to the point at which the discharge from the proposed development no longer has an impact on the receiving stream or storm drainage system.

The developer must provide supporting calculations and/or documentation that the downstream peak discharges are safely conveyed by the proposed system, without endangering downstream properties, structures, bridges, roadways, or other facilities, and no increase in water surface elevation.

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

When the downstream receiving system does not have adequate capacity, then the developer shall provide stormwater controls to reduce downstream flood impacts. These controls include on-site controls such as detention, regional controls, and, as a last resort, local flood protection such as levees, floodwalls, floodproofing, etc.

The developer must provide supporting calculations and/or documentation for each existing discharge point indicating that the controls will be designed and constructed so that there is no increase in downstream peak discharges or water surface elevations due to development.

Option 3: In lieu of a Downstream Assessment, Maintain Existing On-Site Runoff Conditions

Lastly with Option 3, on-site controls shall be used to maintain the pre-development peak discharges for each existing discharge point from the site. The developer must provide

supporting calculations and/or documentation that the on-site controls will be designed and constructed to maintain on-site existing conditions.

It is important to note that Option 3 may not require a downstream assessment. It is a detention-based approach to addressing downstream flood mitigation after the application of the integrated site design practices. However, a downstream assessment may be required for sites adjacent to or near streams in which delayed release of flows from detention facilities could potentially increase the peak flow in the stream due to coincident peaks. This assessment of the impact of coincident peaks is required for all sites with a contributing drainage area greater than or equal to 10% of the stream drainage area at the subject discharge point.

4.6 Stormwater System Design

4.6.1 Introduction

Stormwater system design is an integral component of both site and overall stormwater management design. Good drainage design must strive to maintain compatibility and minimize interference with existing drainage patterns; control flooding of property, structures, and roadways for design flood events; and minimize the potential environmental impacts of stormwater runoff.

Stormwater collection systems must be designed to provide adequate surface drainage while at the same time meeting other stormwater management goals such as water quality, streambank protection, habitat protection, and flood mitigation. Fully developed watershed conditions shall be used for determining runoff for the *"Flood Mitigation"* storm event.

4.6.2 Hydraulic Design Criteria for Streets and Closed Conduits

A. Introduction

This section is intended to provide criteria and guidance for the design of on-site flood mitigation system components including:

1. Street and roadway gutters;
2. Stormwater inlets;
3. Storm drainpipe systems; and
4. Parking lot sheet flow.

B. Streets and ROW

1. Design Criteria
    a. Flow spread limits for curbed streets are shown in Table 4.6-A below.
    b. Inverted crown sections are permitted only in alleys.
    c. Street crowns shall be reduced for approximately 100 feet on each side of the valley gutters. No valley gutters will be permitted across collectors or arterials.
    d. For non-curbed streets the "*Flood Mitigation*" storm event shall be contained within paralleling roadside ditches, within the public ROW (Figure 4. 1 below).
    e. Roadside ditches shall be designed to carry the "*Flood Mitigation*" runoff below the roadway elevation.

f. Streets or alleys adjacent to an open channel shall have the edge of the pavement designed with a minimum elevation of one (1) foot above the "*Flood Mitigation*" elevation or as directed by the City's Engineer.

g. Where additional hydraulic capacity is required on the street, the proposed street gradient must be increased, or curb inlets and storm sewers installed to remove a portion of the flow.

h. The maximum concentrated flow directed into the street (from a driveway or flume, etc.) is three (3) cubic feet per second (cfs).

2. Flow Spread Limits

a. Inlets shall be spaced so that the spread of flow in the street for the *"Flood Mitigation"* storm shall not exceed the guidelines listed below in Table 4.6-A, as measured from the gutter or face of the curb:

Table 4.6-A: Flow Spread Limits

Street Classification	Allowable Encroachment
Collectors	one travel lane remains open
Arterials	one travel lane in each direction remains open
Residential Streets	curb depth

b. The allowable drainage flow across street intersections for the *"Flood Mitigation"* storm event shall be as shown in Table 4.6-B as follows:

Table 4.6-B: Permissible Flow Across Street Intersections

Street Classification	Cross-Flow
Arterial Street (divided and undivided)	None
Non-Residential Collector Street	None
Residential Street and Residential Collector	Gutter Flow of 2 inches or less

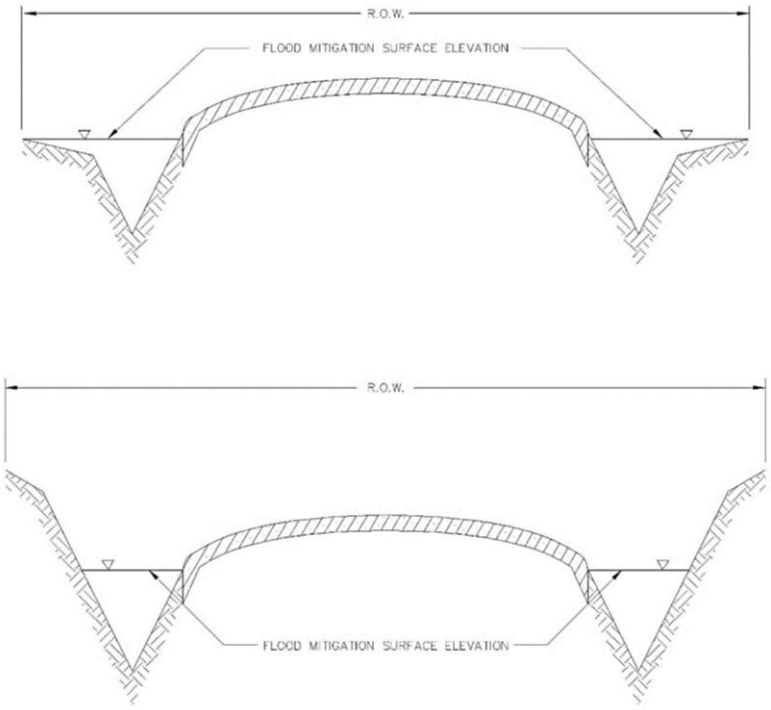


Figure 4.1 Water Spread Limits for Non-Curbed Roadways

3. Minimum Street or Alley Elevations

   No lowering of the standard height of street crown shall be allowed for the purposes of obtaining additional hydraulic capacity. Street crowns shall be in accordance with the City of Denton Standard Details.

C. Drainage Related Minimum Elevations

1. For lots in the influence of a sag area and a positive overflow, the finished floor elevation (FFE) will be at least one (1) foot above the sag area top of the curb, or one (1) foot above the possible maximum pool elevation when the positive overflow is functioning, whichever elevation is higher.
2. New and substantially improved structures within the floodplain or within 200 feet of the floodplain or SFHA must have their finished floor elevated to the minimum building elevation as defined in the City's Chapter 30 Flood Prevention and Protection Ordinance.
3. In all other areas, the minimum FFE shall be a minimum of one (1) foot above the street curb, edge of alley, or rear property line (at the midpoint of the lot), whichever is lower.

D. Storm Inlet Design

1. Permissible Types of Inlet
   a. Drop Inlets (Y-inlet) – Drop inlets are sump inlets which are not located along the curb line of a roadway.
   b. Grate Inlets – The use of grate inlets is not allowed on public drainage systems unless through an approved design deviation request. If allowed, the inlet opening shall be designed twice as large as the calculated opening to compensate for clogging. Grate

inlets may be used on private systems.

c. Curb Inlets – Curb inlets may be located at roadway low points (sumps) or on grade at such points as to meet the water spread limitations and cross-flow depth requirements. Curb inlets may be one of the following:

   i. Recessed curb inlet – Recessed curb inlets are curb inlets constructed such that the front of the inlet is two (2) feet behind the normal face of curb and the depression does not extend into the traffic lanes.

   ii. Standard curb inlet – Standard curb inlets are curb inlets that are in line with the roadway curb.

   iii. Type 2 curb inlet – Type 2 curb inlets are standard curb inlets where the inlet box is located underneath the outer roadway lane instead of behind the curb. They are only to be utilized in situations where there is insufficient parkway area or an encumbered parkway area for a standard curb inlet.

2. Design Criteria

   a. Public curb inlet size shall be 10, 15, or 20 feet. Maximum length of inlet at any one (1) curb location shall be 20 feet on each side of the street. Inlets will be placed only in straight sections of curb and at least 5 feet from any curb return. Inlets required in cul-de-sacs are the only exceptions to the straight curb section requirement. Curb inlets are not allowed in intersection or curb returns.

   b. Recessed inlets will be required on arterial and non-residential collector streets.

   c. The maximum inlet opening shall be six (6) inches. Openings larger than six (6) inches shall require approval through a design deviation request and shall contain a bar or other form of restraint.

   d. Inlets shall be located in the following locations:

      i. At low points;

      ii. Upstream of pavement crown transitions at intersections (or the developer may identify flow patterns and depths to show these inlets are not needed); and

      iii. Where street flow spread limits or permissible intersection depths are exceeded.

   e. Where possible, inlets at intersections shall be located on the street with the lesser classification or on alleys.

   f. A bypass of no more than 10% of the inlet capacity will be allowed for the *"Flood Mitigation"* storm event.

   g. To prevent water flowing across the street for the "*Flood Mitigation*" storm event, water flowing in gutters of arterials should be picked up prior to reaching super-elevated sections.

   h. In super-elevated sections of divided arterials, inlets placed against the center medians shall have no gutter depressions. Interior gutter flow (flow along the median) shall be intercepted at the point of superelevation transition to prevent street cross-flow.

   i. At bridges with curbed approaches, water should be intercepted before flowing onto the bridge to prevent icing during cold weather.

   j. New inlets shall not be constructed within a sidewalk or other pedestrian path.

k. The use of recessed inlets shall only be allowed where they do not adversely impact the access or functionality of existing utility facilities.

l. Design and location of inlets shall take into consideration pedestrian and bicycle traffic.

m. The use of slotted drains is discouraged except in instances where there is no alternative. Any use of slotted drains requires approval through a design deviation request. If used, the manufacturer's design guidelines should be followed.

n. Depressed inlets are recommended on continuous grades that exceed 1%, although their use in traffic lanes should be avoided whenever possible.

o. A redundant, flanking inlet is required wherever a sag point or low point inlet is identified, and no positive overflow path is provided. The redundant inlet shall have the same size as the sag or low point inlet but will not be considered in the hydraulic capacity calculations. The redundant inlet shall have a maximum inlet elevation of six (6) inches above the sag or low point inlet elevation to ensure ponding does not overtop the curb.

3. Inlet Computations

a. Sump Inlets and Drop Inlets

Curb inlets and drop inlets in a sump or low point can be considered to function as a rectangular broad-crested weir with a coefficient of discharge of 3.06. The capacity shall be based on the following weir equation:

$$\mathbf{Q / L \text{ or } Q / P = 3.06\ H^{3/2}} \qquad \textbf{[Eqn. 4.1]}$$

Where:
Q = Capacity of curb opening inlet or capacity of drop inlet (*cfs*)
H = Head at the inlet (*feet*)
L = Length of curb opening inlet (*feet*); or
P = Length of portion of perimeter of inlet opening, through which water enters the drop inlet (*feet*)

Inlets should be located such that the inlet openings do not become submerged. In some cases where this is not possible and the inlet operates under completely submerged conditions, the orifice equation [Eqn. 4.2] should be used to compute the inlet capacity, rather than the weir formula [Eqn. 4.1]. The capacity of a completely submerged inlet shall be based on the following orifice equation:

$$\mathbf{Q = 4.84\ A\ H^{1/2}} \qquad \textbf{[Eqn. 4.2]}$$

Where:
A = Area of inlet opening

The curves shown in Figure 4.2 and Figure 4.3 provide for direct solution of the above equations.

In order to facilitate the computations required in determining the various hydraulic properties for curb inlets and drop inlets in sump conditions, Figure 4.4 Computation Sheet has been prepared.

Column 1 Inlet number and designation.
Column 2 Total flow in *cfs* to inlet. For inlets other than the first inlet in a system, flow is the sum of runoff from the contributing area plus carry-over flow from inlet or inlets upstream.

Column 3 Assumed length of inlet opening or perimeter in feet.

Column 4 Total area of inlet opening based on assumed inlet opening length and opening height.

Column 5 Discharge per unit foot of inlet opening. Column 2 divided by Column 3.

Column 6 Computed head at inlet for weir flow conditions based on Figures 4.2 or 4.3 or the following equation:

$$H = (q / 3)^{2/3} \quad \textbf{[Eqn. 4.3]}$$

Column 7 Computed head at inlet for orifice flow conditions (submerged inlet) based on Figures 4.2 or 4.3 or the following equation:

$$H = [(Q / A) / 4.82]^2 \quad \textbf{[Eqn. 4.4]}$$

Column 8 Maximum allowable head at sump inlet. This value is determined from topographic conditions at the sump inlet site.

Column 9 Width of spread of water for curb inlets in sump.

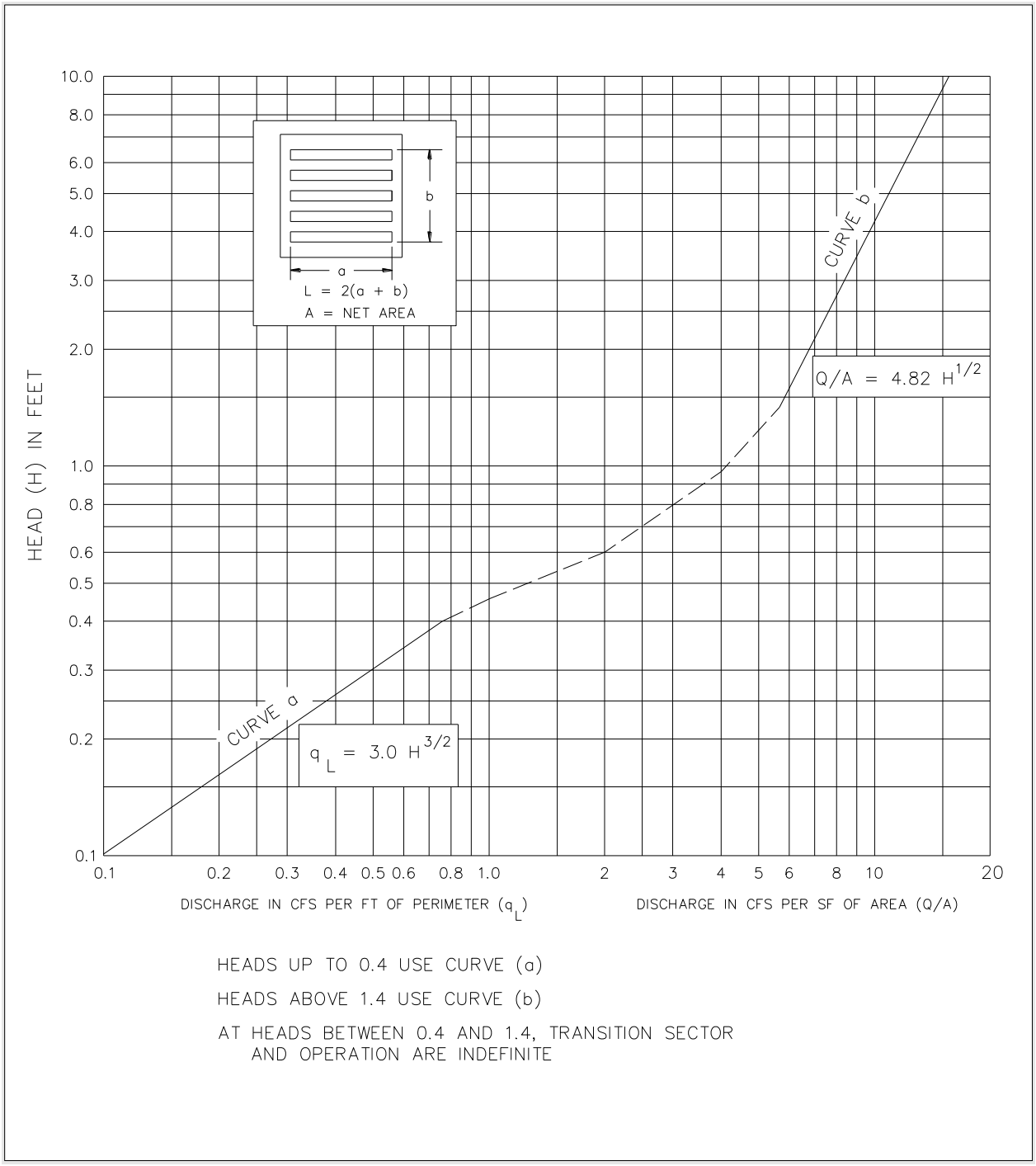


Figure 4.2 Capacity of Grate Inlet in Sump

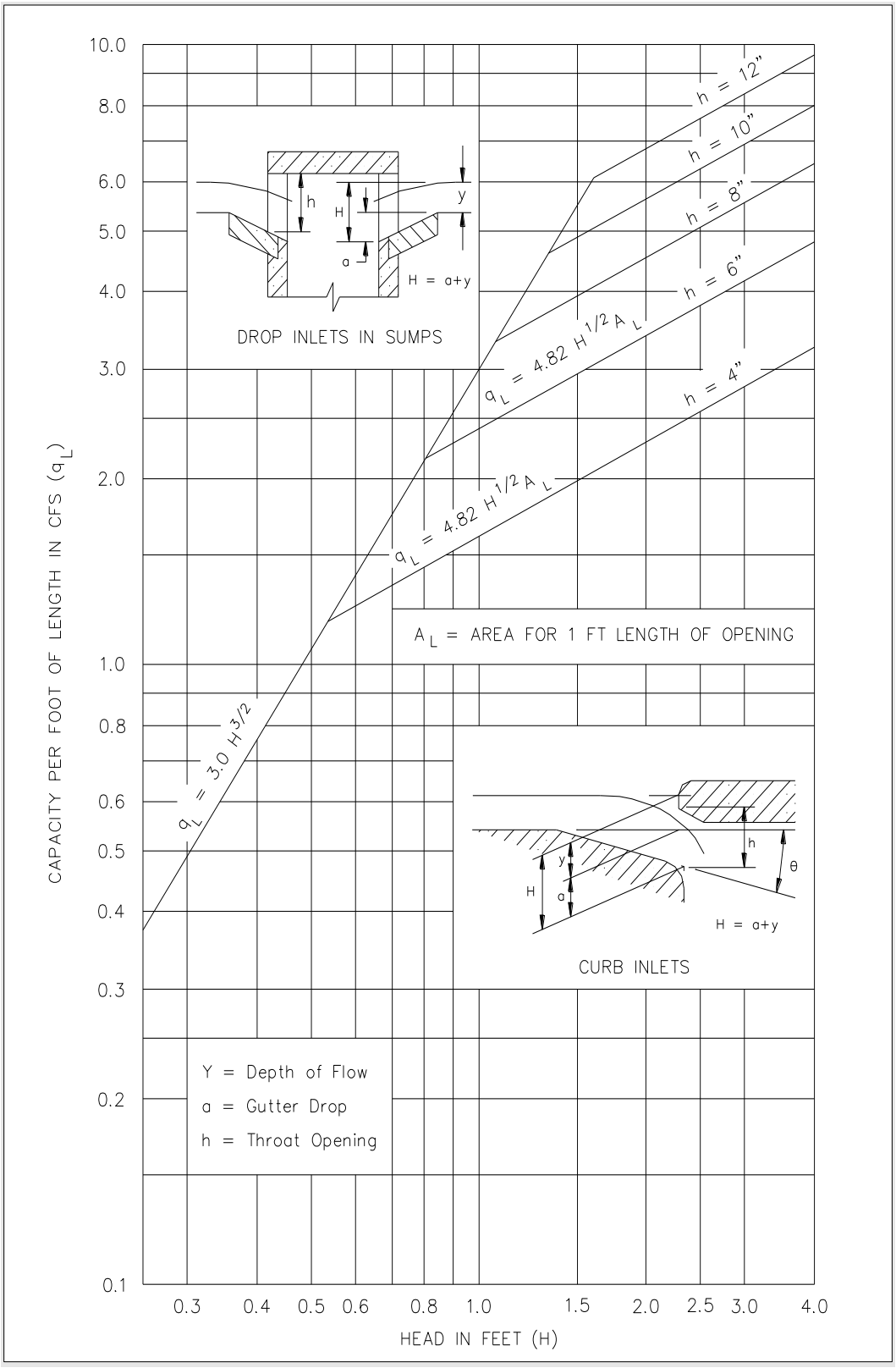
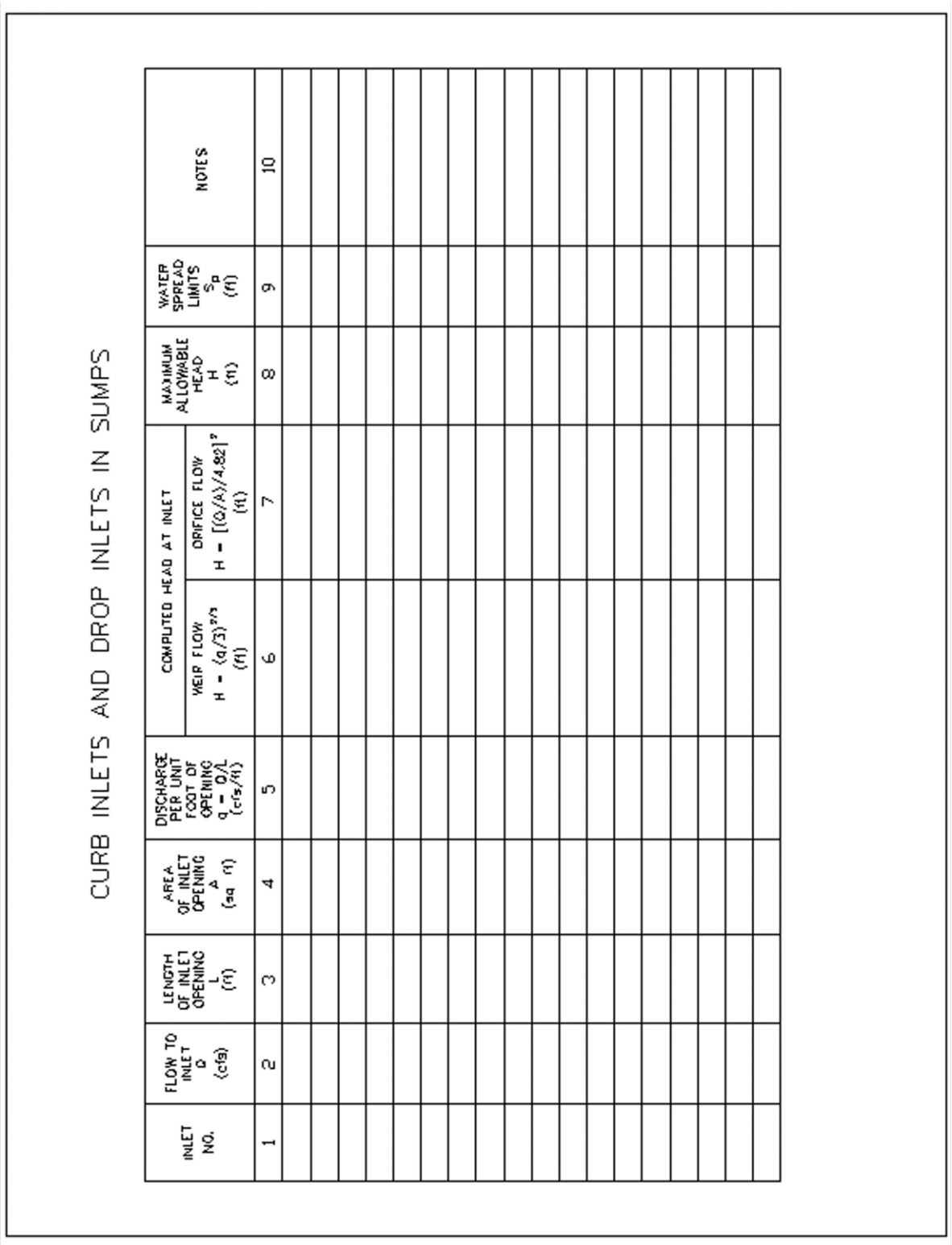


Figure 4.3 Capacity of Drop Inlets and Curb Inlets in Sumps



CURB INLETS AND DROP INLETS IN SUMPS

INLET NO.	FLOW TO INLET Q (cfs)	LENGTH OF INLET OPENING L (ft)	AREA OF INLET OPENING A (sq ft)	DISCHARGE PER UNIT FOOT OF OPENING q = Q/L (cfs/ft)	COMPUTED HEAD AT INLET		MAXIMUM ALLOWABLE HEAD H (ft)	WATER SPREAD LIMITS S_p (ft)	NOTES
					WEIR FLOW $H = (q/3)^{2/3}$ (ft)	ORIFICE FLOW $H = [(Q/A)/4.82]^2$ (ft)			
1	2	3	4	5	6	7	8	9	10

Figure 4.4 Computation Sheet for Curb Inlets and Drop Inlets in Sumps

b. Inlets on Grade

The capacity of a curb inlet on grade will be based on the following equation:

$$Q / L_o = 0.7 [1 / y_o] [(H)^{5/2} - (a)^{5/2}] \quad \textbf{[Eqn. 4.5]}$$

Where:
Q = Discharge into inlet (cfs)
L_o = Length of inlet opening (feet)
a = Gutter depression (feet)
y_o = Depth of flow in approach gutter (feet)
$H = a + y_o$

The curve shown in Figure 4.6 provides for the direct solution of the above equation when the value of y_o is known. The curve shown in Figure 4.7 provides for the determination of the ratio of the intercepted flow by the inlet to the total flow in the gutter.

In order to facilitate the computations required in determining the various hydraulic properties for curb inlets on grade, Figure 4.5 shows Computation Sheet prepared.

Column 1 Inlet Type and number.
Column 2 Location of inlet by station number.
Column 3 Drainage Area designation of area entering between the previous pick up point and the inlet being designed.
Column 4 Peak Discharge (Q_p) from area of Column 3.
Column 5 Carry-over flow (q) which has been passed by the last preceding inlet to the inlet under consideration.
Column 6 Total gutter flow (Q_o) in cfs. For inlets other than the first inlet in the system, total gutter flow is the sum of the runoff from the contributing area plus carry-over flow from the inlet or inlets upstream. Column 4 plus Column 5.
Column 7 Reciprocal of the pavement cross slope for pavements with straight crown slopes.
Column 8 Reciprocal of the pavement cross slope (Z) divided by the pavement roughness coefficient (n).
Column 9 Slope of approach gutter (S_o) in feet per feet.
Column 10 Depth of gutter flow "y_o" in approach gutter direct from Manning's equation for triangular gutters:

$$y_o = 1.245 (Q^{3/8})[n^{3/8}/ S^{3/16}] [1 / Z]^{3/8} \quad \textbf{[Eqn. 4.6]}$$

Column 11 Spread of water (S_p) or width of ponding in the gutter measured from the face of curb. Column 7 times Column 10.
Column 12 Width of street and height of parabolic crown.
Column 13 Slope of approach gutter (S_o) in feet per feet.
Column 14 Depth of gutter flow " y_o " in approach gutter. Column 15 Spread of water (S_p) or width of ponding in the gutter measured from face of curb.
Column 16 Discharge (Q) in cfs which will be intercepted by an inlet one (1) foot in length for a given depth of flow in the approach gutter (y_o).

Determined from Figure 4.6 or from the solution of the following equation:

$$Q / L_o = 0.7 [1 / y_o] [(H)^{5/2} - (a)^{5/2}] \quad \textbf{[Eqn. 4.7]}$$

Column 17 Length of inlet (L_o) in feet which is necessary to intercept a given discharge Q_o. Column 6 divided by Column 16.

Column 18 Actual length (L) in feet of inlet which is to be provided.

Column 19 Ratio of the length of inlet provided (L), to the length of the inlet required for 100% interception (L_o). Column 18 divided by Column 17.

Column 20 Percentage of discharge intercepted by the inlet in question determined from Figure 4.7 using the values determined in Column 19 and Column 10 or Column 14.

Column 21 Discharge (Q) in cfs which the inlet in question actually intercepts. Column 6 times Column 20.

Column 22 Carry-over flow (q) is the amount of water which passes any inlet, and is the difference between the total flow (Q_o) of Column 6 and the intercepted flow (Q) of Column 21.

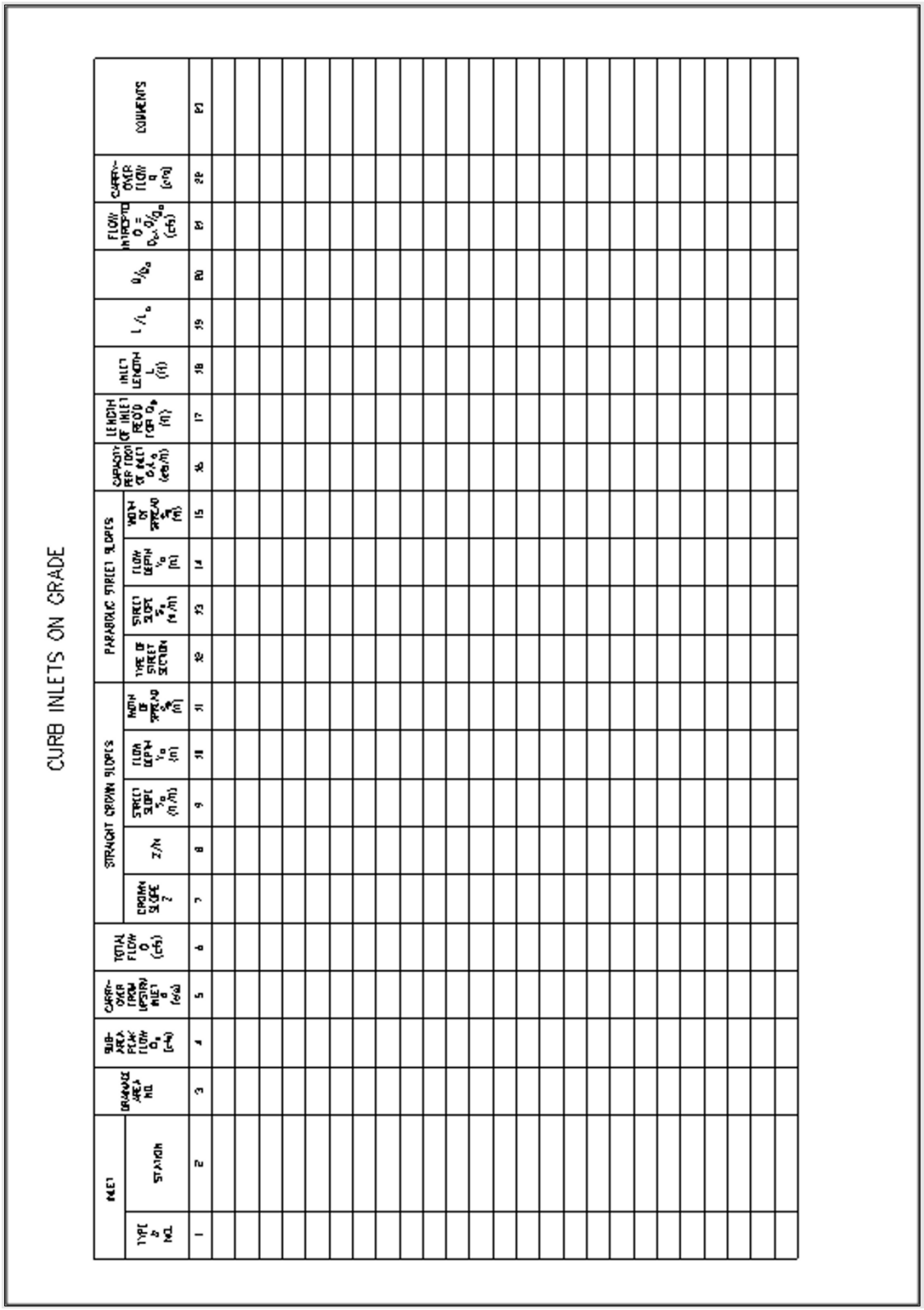


Figure 4.5 Computation Sheet for Curb Inlets On Grade

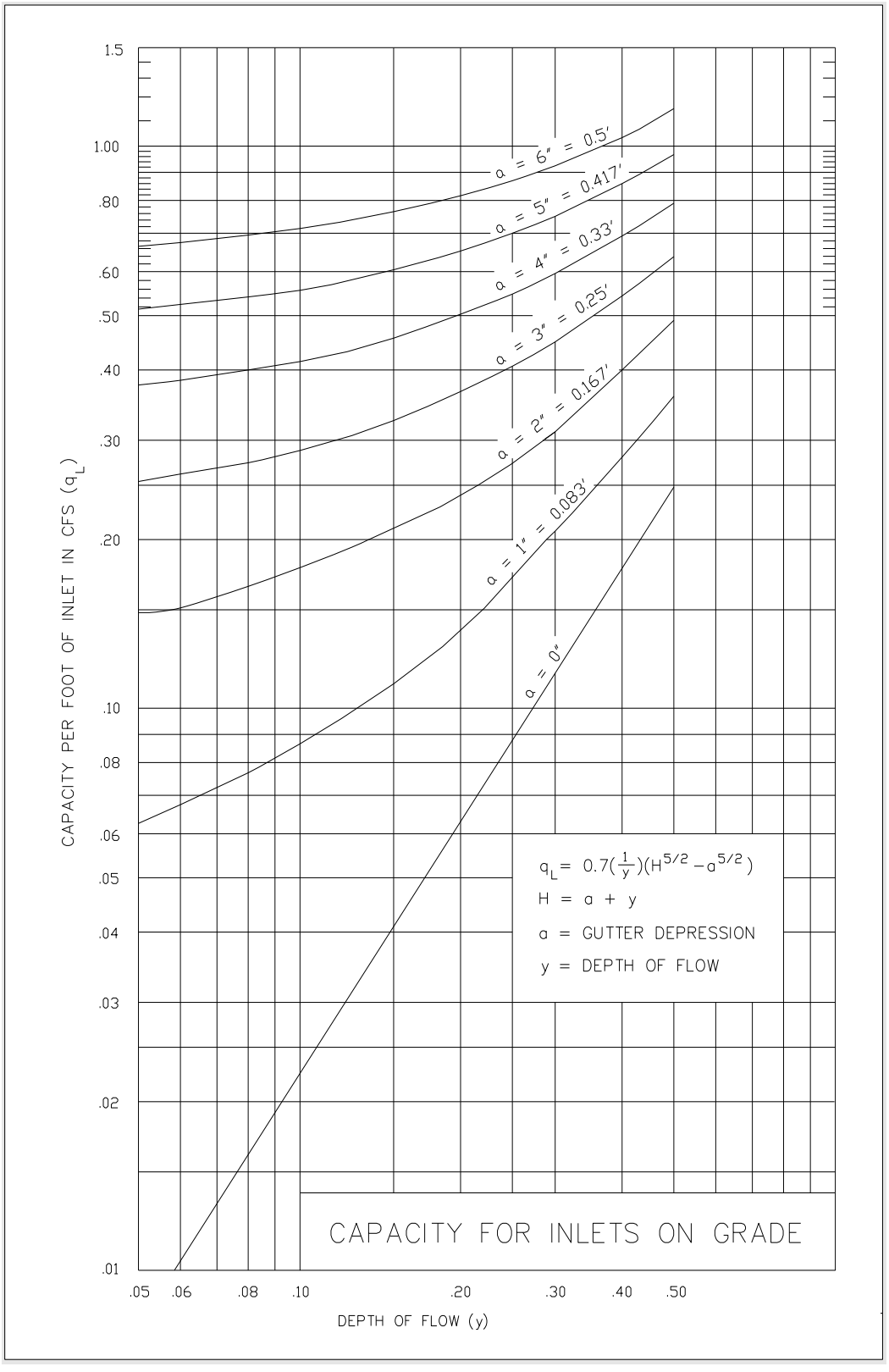


Figure 4.6 Capacity for Inlets On Grade

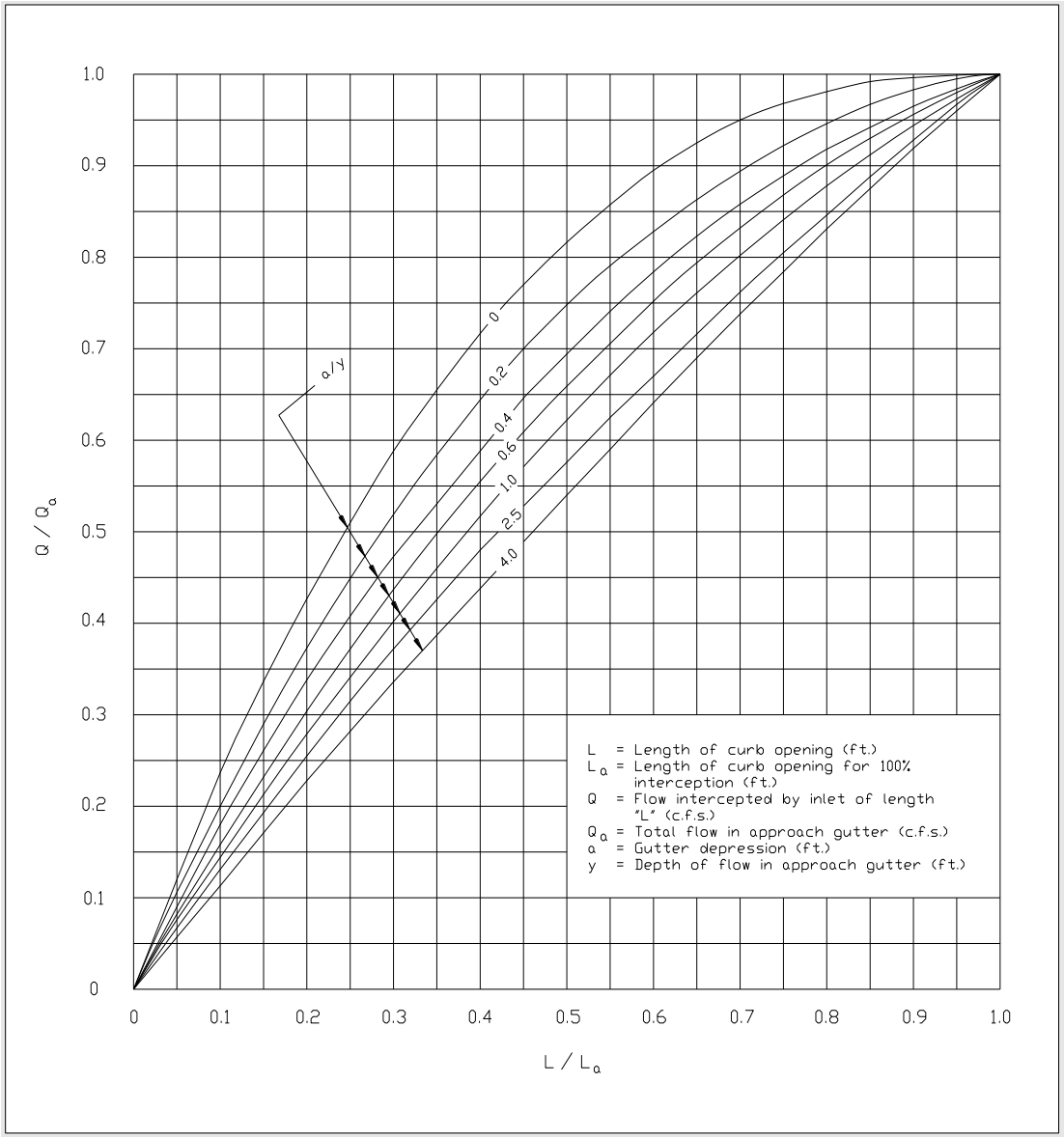


Figure 4.7 Ratio of Intercepted Flow to Total Flow for Inlet On Grade

E. Storm Drain Pipe Design

1. Design Frequency

   Pipe Design: *"Flood Mitigation"* storm event.

2. Design Criteria

   a. Storm drain systems capable of conveying the *"Flood Mitigation"* storm event are required when water spread, intersection cross-flow, and lot-to-lot drainage flow limits are exceeded, or when the minimum time of concentration shown in *Table 1.5 of the iSWM™ Hydrology Technical Manual Document* are reached. Closed pipe systems are required for discharges up to and including 300 cfs in public systems.

   b. Pipe material in a public storm drain system or in public ROW shall be reinforced concrete for all pipe sizes, or Polypropylene for sizes up to 60 inches, with appropriate bedding and class type depending on cover.

   c. Proposed storm drains may discharge into existing watercourses. *See Section 1.2.10 of the iSWM™ Hydraulics Technical Manual Document* for guidance related to the Tailwater elevation to be used for hydraulic grade line calculations.

   d. The maximum hydraulic gradient shall not produce a velocity that exceeds 15 fps. Table 4.6-C shows the desirable velocities for most storm drainage design. Storm drains shall be designed to have a minimum mean velocity flowing full at 2.5 fps.

Table 4.6-C: Desirable Velocity in Storm Drains

Description	Max. Desirable Velocity (fps)
Culverts (All types)	15
Inlet laterals	No Limit
Collectors (≤ 24 inches)	15
Mains (> 24 inches)	12

   e. The minimum desirable physical slope shall be 0.5% or the slope that will produce a velocity of 2.5 fps as required for the *"Streambank Protection"* storm event when the culvert is flowing partially full, whichever is greater.

   f. The potential hydraulic grade line elevation shall not exceed ground elevation or the gutter flow line, whichever is lowest.

   g. Access junction boxes are required along straight runs of closed conduits, with a maximum spacing of 500 feet for all pipe and box sizes.

   h. A minimum of 24 inches of vertical separation shall be maintained between storm sewer conduits and any other utility. If it is not possible to provide 24 inches of vertical separation, the design must be approved through a Design Deviation Request and shall not provide separation less than 6 inches and must provide a concrete cap between the crossing utility line.

   i. Junction Boxes shall also be located at:

      i. any point where three (3) or more drainage conduits (laterals or trunk lines) come together;

      ii. any point where a trunk line size changes;

      iii. grade changes;

iv. the upstream end of the storm drain system;

v. Bends greater than 45 degrees;

vi. Pipe junctions greater than 45 degrees; and

vii. At the connection point between public and private storm sewer pipes or boxes. If this connection point is in the public ROW, pipe materials on the private system must meet public storm drain system materials requirements. If the connection point is on private property, then the public portion of the system must be contained in an easement.

j. Inlets will not be allowed to serve as a junction box, except through an approved design deviation request. Where inlets are permitted to serve as a junction box, the width of the inlet, at a minimum, shall be doubled in size. Storm drain systems parallel to the street will not be permitted to run directly through inlets.

k. Bends without junction boxes shall be limited to 45 degrees or less.

l. The minimum storm drain pipe diameter shall be 18 inches.

m. Pipe diameters shall not decrease downstream.

n. Laterals shall be connected to trunk lines using a junction box or manufactured wye connections. Cut-in or punch-in connections to pipes are prohibited.

o. All cut-in or punch-in connections to precast inlets, junction boxes, box culverts, etc. will require a concrete collar to be poured around the connection.

p. Vertical or horizontal curves/deflections in the conduit will not be permitted.

F. Parking Lot Design

Parking lots shall be designed for the *"Flood Mitigation"* storm not to exceed top of curb with a maximum depth at low points of one (1) foot. The *"Flood Mitigation"* storm shall be contained on-site or within dedicated easements. The portion of the parking lot detaining water during the *"Flood Mitigation"* storm may be considered as part of the detention calculation for the site.

4.6.3 Open Channels

A. Design Frequency

1. Open channels, including all natural or improved channels, swales, and ditches shall be designed for the *"Flood Mitigation"* storm event.

B. Design Criteria

1. Depending on velocities (See Table 4.6-E), constructed or improved channels shall be designed with either an earthen channel or a 10-ft. minimum concrete pilot channel section and appropriate side slope protection up to the *"Streambank Protection"* storm event elevation, as described in Section 4.3.

2. All channels with contributing drainage basins larger than one (1) square mile (sq. mi.) shall remain in their natural condition.

3. Channels with a contributing drainage area of less than one (1) sq. mi. shall remain in their natural condition if they are identified as being within an ESA by the current City of Denton ESA map. Channels not identified as being within an ESA may be channelized, with the channelization method being determined by analysis of the erosive velocities.

4. All improved channels shall be designed to carry the flood mitigation flow and shall have one (1) foot of freeboard as illustrated in Figure 4.8. Freeboard requirements at bends in all improved channels shall be the greater of the following:
    a. One (1) foot; or
    b. 10% of the flow depth
5. At a minimum, channels that require concrete lining shall be lined up to an elevation of the water surface resulting from the *"Flood Mitigation"* storm event.
6. Concrete lining of a stream channel is adding fill material into Waters of the United States (WOTUS) and must comply with Section 404 of the Clean Water Act, and all requirements outlined in DDC Section 7.4. Provide either proof of mitigation or letter of permission from the United States Army Corps of Engineers (USACE).
7. Unlined improved channels that contain bends may be required to be armored if maximum permissible velocities are exceeded.
8. Unlined improved channels shall have side slopes no steeper than 4H:1V and concrete-lined channels shall have side slopes no steeper than 2H:1V.
9. The minimum grade allowed on any channel, outfall channel, or ditch shall be three-tenths (3/10) foot per 100 feet for concrete-lined channels and five-tenths (5/10) foot per 100 feet for grass-lined channels.
10. Geotechnical investigations will be required for open channel designs to determine the type of soils present and allowable velocities shown in Table 4.6-D and Table 4.6-E.
11. For vegetative channels, flow velocities within the channel shall not exceed the maximum permissible velocities given in Table 4.6-D and Table 4.6-E.
12. An evaluation of streambank stabilization shall be included in the design of open channel improvements for areas upstream and downstream of the proposed improvement. Where indicated by the analysis, stabilization of the offsite bank areas shall be included in the proposed design.
13. HEC-RAS, or similarly capable software approved by the City's Engineer, shall be used to confirm the water surface profiles in open channels.
14. The final design of artificial open channels shall be consistent with the velocity limitations for the selected channel lining. Maximum velocity values for selected lining categories are presented in Table 4.6-D below.
15. If relocation of a stream channel is unavoidable, fill material into WOTUS must comply with Section 404 of the Clean Water Act, and all requirements outlined in DDC Section 7.4 . Provide either proof of mitigation or letter of permission from the United States Army Corps of Engineers (USACE).

The design of stable rock riprap lining depends on the intersection of the velocity (local boundary shear) and the size and gradation of the riprap material. More information on calculating acceptable riprap velocity limits is available in Section 3.2.7 of the *i*SWM™ Hydraulics Technical Manual Document.

Table 4.6-D: Roughness Coefficients (Manning's *n*) and Allowable Velocities for Natural Channels

Channel Description	Manning's *n*	Max. Permissible Channel Velocity (fps)
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass weeds	0.030	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.035	3 to 6
4. Some weeds, heavy brush on banks	0.050	3 to 6
5. Some weeds, dense willows on banks	0.060	3 to 6
- For trees within channels with branches submerged at high stage, increase values by	0.010	
- Irregular section with pools, slight channel meander, increase above values by	0.010	
Floodplain - Pasture		
1. Short grass	0.030	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.030	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.040	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.050	3 to 6
2. Wooded	0.120	3 to 6
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of 'n' for larger streams of mostly regular sections , with no boulders or brush	0.028 to 0.060	3 to 6
UNLINED VEGETATED CHANNELS		
Clays (Bermuda Glass)	0.035	5 to 6
Sandy and Silty Soils (Bermuda Glass)	0.035	3 to 5
UNLINED NON-VEGETATED CHANNELS		
Sandy Soils	0.030	1.5 to 2.5
Silts	0.030	0.7 to 1.5
Sandy Silts	0.030	2.5 to 3.0
Clays	0.030	3.0 to 5.0
Coarse Gravels	0.030	5.0 to 6.0
Shale	0.030	6.0 to 10.0
Rock	0.025	15

Notes:
[1] For natural channels with specific vegetation type, refer to Table 4.6-E for more detailed velocity control.

Table 4.6-E: Maximum Velocities for Vegetative Channel Linings

Vegetation Type	Slope Range [1] (%)	Max. Velocity [2] (fps)
Bermuda Grass	0 – 5	6
Bahia	-	4
Tall fescue grass mixtures [3]	0 – 10	4
Kentucky bluegrass	0 – 5	6
Buffalo grass [4]	5 – 10 > 10	5 4
Grass mixture [4]	0 – 5 5 – 10	4 3
Sericea lespedeza, Weeping lovegrass, Alfalfa	0 – 5	3
Annuals [5]	0 – 5	3
Sod	-	4
Lapped Sod	-	5

Notes:
[1] Do not use on slopes steeper than 10% except for side-slope in combination channel.
[2] Use velocities exceeding 5 fps only where good stands can be maintained.
[3] Mixtures of Tall Fescue, Bahia and/or Bermuda.
[4] Buffalo Grass and Grass Mixture will be required over other vegetation types where the maximum velocity is not exceeded.
[5] Annuals – used on mild slopes or as temporary protection until permanent covers are established.

Source: Manual for Erosion and Sediment Control in Georgia, 1996.

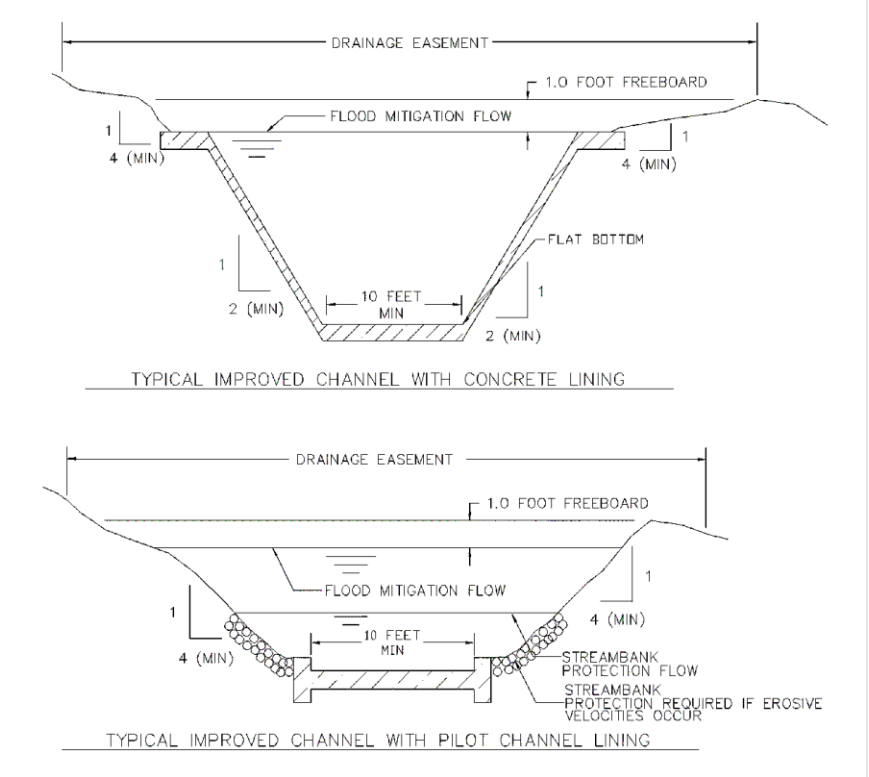


Figure 4.8 Freeboard Requirements and Channel Section Illustrations

C. Channel Drop Structures

1. Sloping channel drops are permitted and are required to have a maximum slope of 4H:1V. Vertical channel drops are not permitted.
2. The flow velocities in the channel upstream and downstream of the drop structure need to satisfy the permissible velocities allowed for channels (Table 4.6-D). The velocities shall be checked for flows produced by the *"Streambank Protection"* and *"Flood Mitigation"* storm events.
3. An apron shall be constructed immediately upstream of the chute or stilling basin to protect against the increasing velocities and turbulence which result as the water approaches the drop structure. The apron shall extend at least five (5) feet upstream of the point where flow becomes supercritical. In no case shall the length of the upstream apron be less than 10 feet.
4. An apron shall be constructed immediately downstream of the chute or stilling basin to protect against erosion due to the occurrence of the hydraulic jump. The apron shall extend a minimum of 10 feet beyond the anticipated location of the jump.
5. The design of drop structures is based on the height of the drop, the normal depths upstream and downstream of the drop structure, and discharge.
6. When used, channel drop structures shall be located near bridges or culverts, as directed by the City's Engineer.
7. The location of the hydraulic jump should be determined based on the upstream and downstream flow depths, and channel slopes.
8. The length of the hydraulic jump should be calculated to determine the length of the downstream apron required to prevent erosion.

4.7 Culverts

Culverts are cross drainage facilities that transport runoff under roadways or other improved areas.

4.7.1 Design Frequency

A. Culverts shall be designed for the *"Flood Mitigation"* storm.

B. The *"Flood Mitigation"* storm shall be routed through all culverts to ensure building structures (e.g., houses, commercial buildings) are not flooded and damage does not occur to a highway or adjacent property for this design event.

4.7.2 Design Criteria

A. Design Considerations

1. Roadway type;
2. Tailwater or depth of flow;
3. Structures, and property subject to flooding;
4. Emergency access; and
5. Road replacement costs.

B. Velocity Limitations

1. The maximum velocity shall be consistent with channel stability requirements at the culvert outlet.
2. The maximum allowable velocity is 15 fps, but outlet protection shall be provided where discharge velocities will cause erosion conditions.
3. To ensure self-cleaning during partial depth flow, a minimum velocity of 2.5 fps is required for the "*Streambank Protection*" storm when the culvert is flowing partially full.

C. Headwater Limitations

1. The *allowable headwater* is the depth of water that can be ponded at the upstream end of the culvert during the *"Flood Mitigation"* storm event. The *allowable headwater* will be limited by both of the following constraints or conditions:
   a. The headwater must not damage upstream property.
   b. The culvert headwater plus 12 inches of freeboard shall not exceed (i) top of curb or (ii) pavement for the low point of the road over the culvert, whichever is lower.

D. Tailwater Considerations

1. If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined.
2. For culverts that discharge to an open channel, the stage-discharge curve for the channel must be determined. *See* Section 2.1.4 of the *i*SWM™ Hydraulics Technical Manual on methods to determine a stage-discharge curve.
3. 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.
4. If the culvert discharges to a lake, pond, or other major water body, the expected "*Flood Mitigation*" storm event of the water body will establish the culvert tailwater.

E. Other Criteria

1. Culvert skews shall not exceed 30 degrees, as measured from a line perpendicular to the roadway centerline, without approval.
2. Erosion, sediment control, and velocity dissipation shall be designed in accordance with Section 4.0 of the *i*SWM™ Hydraulics Technical Manual Document.
3. Where applicable, culverts must comply with DDC Section 7.4 regarding Environmentally Sensitive Areas.

4.7.3 Driveway Culverts

Driveway culverts are only permitted in non-curbed roadway sections. All driveway culvert construction shall be inspected by the City during construction. All driveway culverts shall meet the following requirements:

A. All new driveway culverts must be designed to convey flows from a "*Flood Mitigation*" storm. Replacement driveway culverts shall be designed to convey the maximum reasonable discharge based on the existing ditch dimensions adjacent to the culvert.

B. Culverts shall have a minimum pipe diameter of 18 inches.

C. Acceptable culvert material shall be Reinforced Concrete Pipe (RCP) with a diameter of 18 to 42 inches. The RCP must be designated Class III at a minimum.

D. Box culverts shall have a minimum height of 24 inches. Culverts under City streets used for entrances to a subdivision shall be made of approved classes of reinforced concrete pipe or box.

E. The top of pipe elevation must be below the adjacent roadway edge of pavement elevation.

F. Pipe culverts shall utilize a safety end treatment conforming to the most current version of the TxDOT standard detail Safety End Treatment Plan – Parallel Drainage (SETP-PD) with the slope of the riprap being 6H:1V.

G. A driveway approach may utilize a low-water crossing in lieu of a driveway culvert, if all of the following conditions are met:

1. The lowest elevation of the proposed crossing can be no more than eight (8) inches below the road edge elevation.
2. The proposed low-water crossing cannot create a ponding effect on the upstream ditch (i.e., ditch flow line must be equal to or higher than the crossing).
3. Minimum cross slope for the crossing of 1.5%.
4. Low-water crossing shall be constructed of concrete adhering to the City of Denton Standard Details.
5. Toe walls on each side of the crossing shall be extended at least 15 inches below grade to prevent undercutting.

H. Culvert Slope requirements:

1. Culvert slope must provide positive drainage.
2. Culvert slope shall be set as shown on the approved subdivision construction plans.
3. Minimum slope shall be 0.3%.

I. Ditch Slope Requirements

1. The ditch shall be graded upstream and downstream as far as necessary to provide positive drainage with no areas of standing water.
2. Minimum earthen slope is 0.5%.
3. Minimum concrete slope is 0.3% for 2-ft. concrete pilot channels, if 0.5% earthen slope is unobtainable.

4.8 Bridges

4.8.1 Design Frequency

A. *"Flood Mitigation"* storm must be used for all bridges.

4.8.2 Design Criteria

A. A freeboard of two (2) feet shall be maintained between the computed design water surface and the low chord of all bridges.

B. Design guidance is provided in *Section 3.4 of the iSWM™ Hydraulics Technical Manual Document*.

4.8.3 Other Criteria

A. Where applicable, bridges must comply with DDC Section 7.4 regarding Environmentally Sensitive Areas.

4.9 Detention Facilities

4.9.1 Design Requirements

A. Detention facilities shall be designed for the four storms ("*Water Quality*", "*Streambank Protection*", "*Conveyance*", and *"Flood Mitigation"*) for the critical storm duration that results in the maximum (or near maximum) peak flow.

B. Dry detention basins must be sized to temporarily store the volume of runoff required to provide flood protection up to the "*Flood Mitigation*" storm.

C. Routing calculations must be used to demonstrate that the storage volume and outlet structure configuration comply with Section 4.5.5 of this Manual.

D. A calculation summary shall be provided on construction plans as shown in the computation sheet in Figure 4.9 or its equivalent. Stage-storage-discharge values shall be tabulated and flow calculations for discharge structures shall be shown on the construction plans. Detention design shall follow *i*SWM™ guidelines. It is the responsibility of the Engineer of Record to use appropriate methodologies presented in *i*SWM™ based on specific basin characteristics. Detailed calculations and a design narrative shall be provided for review in a supplemental report that is referenced on the construction plans. In general, the narrative shall provide basic design information, such as the hydrologic method applied, design assumptions, pre- and post-development site conditions, downstream constraints, environmental considerations, and design software version used, if applicable.

E. Storage and dam safety design may be subject to the requirements of the Texas Dam Safety Program based on the volume, dam height, and level of hazard. Earthen embankments six (6) feet in height or greater shall be designed per the TCEQ guidelines for dam safety (*See* Texas Administrative Code, Title 30, Part 1, Chapter 299 Dams and Reservoirs for current dam safety criteria).

F. An Operation and Maintenance Manual must be submitted with the civil engineering plans for all private detention basins. Private detention basins shall be inspected by Public Works Inspection to ensure compliance with the design standards required by Section 7.5.3.F. of the DDC. Inspection fees will apply.

4.9.2 Design Criteria for Above Grade Detention Facilities

A. Grading Standards for Above Grade Detention Facilities:

1. Vegetated channel slopes shall not exceed 4H:1V slope. Concrete-lined embankment slopes shall not exceed 2H:1V slope. Vertical walls may be allowed but must be structurally designed to account for inundation of the base and drawdown upon pond draining and must have a 6-ft. high security fence at the top.

2. The side slope for any excavated detention basin, which is not in rock, shall not exceed a 4H:1V slope.
3. Bottom slopes of detention facilities should not be less than 1%.
4. Armored slopes shall be no steeper than 2H:1V.
5. The embankment crown width shall be determined based on a geotechnical investigation of the detention facility site. The minimum width of the embankment crown shall be 12 feet.
6. Earthen embankments used to impound detention water must have a non-permeable core and shall be based on a geotechnical investigation of the site. The geotechnical investigation shall be performed by a Professional Engineer, licensed by the State of Texas, and shall include at a minimum the type of material on-site (or other material to be used in the embankment), moisture content, liquid limit, plasticity index, and required compaction.
7. A Concrete pilot channel with a minimum width of 10 feet, and a minimum slope of 0.5% shall be constructed at the bottom of the detention pond. Privately maintained ponds shall have a concrete pilot channel with a minimum width of six (6) feet.
8. Private Detention Basins shall be designed with 10-ft. wide unobstructed maintenance access around the entire perimeter of the pond.
9. Public Detention Basins shall be designed with 20-ft. wide unobstructed maintenance access around the entire perimeter of the pond.
10. Where deemed necessary by the City's Engineer, security fencing with a minimum height of six (6) feet shall encompass the detention storage area if the velocity, depth, or slopes create a potentially dangerous condition. The fence shall be designed to allow access for maintenance and so as not to restrict stormwater flow into or out of the detention basin. A maintenance equipment access ramp shall be provided for all detention facilities. The slope of the ramp shall not exceed 6H:1V and the minimum width shall be 12 feet.

B. Emergency Spillway, Overflow Path, and Freeboard:
1. A freeboard of one (1) foot will be required between the *"Flood Mitigation"* storm water surface elevation and top of bank.
2. An emergency spillway shall be provided at the flood mitigation maximum storage elevation with sufficient capacity to convey *"Flood Mitigation"* storm inflow rates with six (6) inches of freeboard. This is the peak of the inflow hydrograph coming into the pond and must not account for attenuation effects of the pond. Spillway requirements must also meet all appropriate State and Federal criteria.
3. An emergency overflow path, free of structures or obstructions, must be provided to convey the spillway design discharge to a downstream ROW or drainageway with adequate capacity for the discharge. No impediments to flow are allowed within the emergency overflow path (E.g., fences, trees, parking areas, or buildings). If a fence around a detention facility is needed to restrict access, the bottom of the fence must be elevated to provide a minimum of one foot of freeboard above the emergency overflow WSEL where the fence crosses the spillway. Nevertheless, fences across spillways should be avoided whenever possible. Even if the fence is elevated to the freeboard elevation, there is still the potential for the fence to catch debris floating on the water surface.
4. An emergency spillway must be constructed of concrete.

5. Design calculations shall be provided for all spillways and outlet structures.

C. Landscaping Requirements:

1. All detention basins shall be designed with plantings that minimize erosion based on expected inundation frequencies. Design guidance is provided in the *iSWM™ Landscape Technical Manual Document*.

D. Multiple Use Guidance

Limited recreational equipment (such as picnic tables or playground equipment) and trees may be permitted in private detention facilities with the following restrictions:

1. User access must be provided at a maximum 10% slope in at least two (2) locations, or one (1) location that comprises not less than 20% of the perimeter of the facility.

2. No recreational equipment is permitted in any portion of the facility that lies more than 18 inches below the flood mitigation water surface elevation level of the facility.

3. Recreational structures including, but not limited to, picnic tables and playground equipment, must be rust-resistant and anchored to the ground.

4. Mulch, wood chips, gravel, or rubberized pellets are not permitted within a detention facility due to the likelihood of their floating into the outlet structure.

5. Trees, shrubs, and other woody vegetation will not be permitted in the embankment of any detention facility or in the maintenance access area around such a facility.

6. A maximum of one (1) isolated tree per 5,600 sq. ft. may be permitted in the recreational area of the pond. A trash rack must be used to prevent clogging of the outlet structure. No bark mulch may be used around trees.

E. Retaining Walls

1. Any freestanding retaining wall used to detain water must be designed by a structural engineer to withstand the expected hydraulic forces when the detention area is filled to capacity. These walls must be constructed using reinforced concrete.

2. Any inlet or pipe connections to retaining walls must be designed with a reinforced concrete headwall. The height of this headwall shall match the height of the adjacent retaining wall. The most recent TxDOT details for concrete headwalls shall be used to determine other headwall dimensions and reinforced schedule.

4.9.3 Design Criteria for Underground Detention Facilities

Underground detention is highly discouraged because of the potential for deferred maintenance, the difficult and potentially hazardous nature of access for maintenance, and issues related to anaerobic conditions and pollutant mobility from devices that retain water between events. In any instance where underground detention is contemplated, thorough consideration must be given to the concerns described above to ensure ongoing inspection, maintenance, and functionality. Care should be taken to address material selection for underground detention due to the potential for adverse soil conditions to inhibit the system from functioning properly. A geotechnical engineer shall be consulted to ensure soil and other conditions are appropriate for the selected detention material.

A. Underground detention facilities shall be designed with reinforced concrete and have a minimum pipe diameter of 30 inches to allow for safe access and maintenance of the facility.

B. If an underground vault has multiple chambers, access openings with a maximum spacing of 500 feet must be provided for each chamber.

C. Underground facilities must be located to enable safe access for maintenance and minimize disruption of aboveground uses during maintenance. Access openings shall not be placed in areas that are routinely used for parking.

D. Easements must be provided for all underground detention facilities. If underground detention facilities are bound by private property, the easements must include an additional four (4) feet from the perimeter of the facilities.

E. Underground detention and water quality facilities are prohibited underneath buildings, walls, or other structures.

F. Every SWFMA involving underground detention and water quality facilities must include inspection and maintenance requirements to be performed quarterly and following any rainfall event of 0.5 inches or more. The inspection and maintenance frequency may be reduced after five (5) years of operation, if the owner demonstrates that a lesser frequency is appropriate.

G. A surface emergency overflow path, free of obstructions, must be provided for all underground detention facilities. The emergency overflow path must have sufficient capacity to convey the *"Flood Mitigation"* storm inflow rates to the underground detention facility. This is the peak of the inflow hydrograph coming into the underground detention facility, and must not account for any attenuation effects from the facility. The criteria for emergency overflow paths for surface detention facilities denoted in Section 4.9.2 above also apply to underground detention facilities.

H. Outlets from underground detention must consist of a pipe that can convey 120% of the 100-year outflow, with a minimum diameter of 12 inches. The invert of the outlet pipe must be at the lowest point in the detention facility to ensure that it fully drains.

I. Underground detention facilities shall be sloped to drain at a minimum floor slope of one (1) %.

4.9.4 Design Criteria for Parking Lot Detention

Parking lot detention may be allowed if the following minimum criteria are met:

A. Use of parking lot surface area as detention is permitted, but only up to the lowest curb elevation of the parking lot.

B. The maximum ponding depth for the 100-year storm must be no more than 12 inches at the deepest point.

C. The outlet must be designed to minimize modifications that affect detention functions. The applicant must evaluate potential future resurfacing activities for impacts to detention volumes and release rates.

D. Ponding water in frequently used portions of parking lots must be avoided. At least two signs are required for all parking lot detention areas. The signs must have a minimum area of 1.5 square feet and contain the following message:

WARNING

This area is a detention basin and is subject to periodic flooding to a depth of (provide design depth).

Sign materials, geometry, and location must be submitted to Development Facilitation and approved by the City's Engineer.

4.9.5 Design Criteria for Pumped Detention

A. A detention facility may not rely on a pump or other mechanical equipment to drain water during a design storm.

4.9.6 Outlet Structures for Detention Facilities

A. Design Frequency

1. *"Water Quality"* storm
2. *"Streambank Protection"* storm
3. *"Conveyance"* storm
4. *"Flood Mitigation"* storm

B. Design Criteria

1. Outlet structures shall be designed in accordance with Section 2.2 of the *iSWM™ Hydraulics Technical Manual*. For water quality, refer to Section 2.2.3 for design of extended detention outlets.
2. The required storage volumes for "*Water Quality*", "*Streambank Protection*", "*Conveyance*", and *"Flood Mitigation"* storm events must be estimated.
3. If a detention facility includes extended detention, refer to Section 2.2.3 of the *iSWM™ Hydraulics Technical Manual* for design requirements.
4. All outlet orifices must be adequately protected from clogging and designed to ensure that people and large animals are kept out of confined outlet areas. Refer to Sections 2.2.5-*Extended Detention Outlet Protection* and 2.2.6-*Trash Racks and Safety Grates* of the *iSWM™ Hydraulics Technical Manual* for design guidance.
5. Any top orifice on an outlet riser must be designed with a grate to prevent fall injuries.
6. Outlet velocities shall be within the maximum allowable range based on channel material, as shown in Table 4.6-D and Table 4.6-E.
7. Outlet protection and energy dissipation facilities must be designed to avoid erosion problems downstream from outlet devices and emergency spillway(s).
8. Buoyancy calculations must be performed for the outlet structure and footing to ensure the outlet structure will not float. Flotation will occur when the weight of the structure is less than or equal to the buoyant force exerted by the water.
9. Any outflow structure that conveys water through an embankment in a conduit shall be reinforced concrete designed to support the external loads. The conduit shall be able to withstand the internal hydraulic pressure without leakage under full external load or settlement and must convey water at the design velocity without damage to the interior surface of the conduit.
10. The minimum opening of an inlet shall be six (6) inches in diameter or a 6-in. by 6-in. square. Smaller inlet openings may be used with a junction box and properly sized outlet structure.

11. A concrete headwall and wingwalls shall be constructed at the outlet pipe opening. Orientation of the wingwalls will be governed by site specific conditions. Headwalls and wingwalls shall be designed to TxDOT standards.

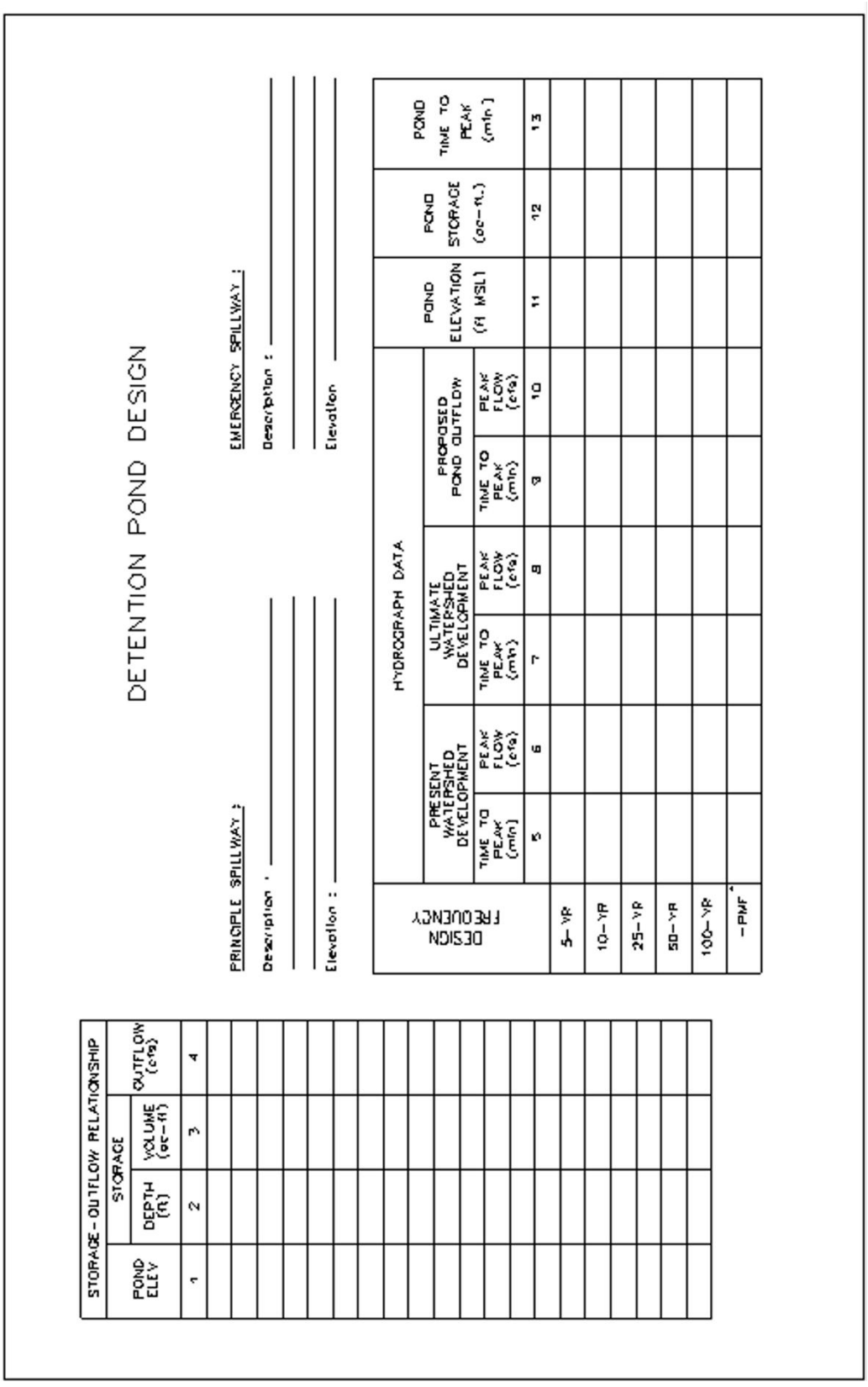


Figure 4.9 Computation Sheet for Detention Pond Design

4.10 Energy Dissipation

All drainage system outlets, whether for closed conduits, culverts, bridges, open channels, or storage facilities, shall provide energy dissipation when necessary to protect the receiving drainage element from erosion.

4.10.1 Design Frequency

A. *"Flood Mitigation"* storm

4.10.2 Design Criteria

A. Erosion problems at culvert, pipe and engineered channel outlets are common. Determination of the flow conditions, scour potential, and channel erosion resistance shall be standard procedure for all designs.

B. Energy dissipaters shall be employed whenever the velocity of flows leaving a stormwater management facility exceeds the erosion velocity of the downstream area channel system.

C. Energy dissipater designs will vary based on discharge specifics and tailwater conditions.

D. Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence.

4.10.3 Recommended Energy Dissipater for outlet protection

A. Concrete or grouted rock riprap apron

B. Riprap outlet basins

C. Baffled outlets

D. Grade Control Structures

Design guidance is provided in Section 4.0 of the *i*SWM™ Hydraulics Technical Manual.

4.11 Floodplain

4.11.1 Floodplain Development Criteria

A. Floodplain alterations shall be allowed only if all the following criteria are met:

1. An approved Floodplain Development Permit must be issued by the City before any development is done within the floodplain.
2. Flood studies shall include flows generated for existing conditions and fully-developed conditions for the 10, 50, 100, and 500-year storm events.
3. Alterations shall not increase the 100-year fully-developed water surface elevation on other properties.
4. Alterations to the regulatory Floodway shall not increase the 100-year fully-developed water surface elevation at any point.
5. Alterations shall be in compliance with Federal Emergency Management Agency (FEMA) guidelines.

6. Alterations of the floodplain shall meet the requirements of Section 4.5 of this Manual.
7. Alterations shall result in no loss of valley storage for a Major Creek, as defined by the DDC, and a 15% maximum loss of valley storage for any other tributary for any reach, except at bridge and culvert crossings where it can be proven that there are no detrimental effects upstream or downstream.
8. Alteration of floodplain areas shall not cause any additional expense, including maintenance, related to any current or projected public improvements.
9. The floodplain shall be altered only to the extent permitted by equal conveyance on both sides of the natural channel, as defined by the USACE in a HEC-RAS analysis. The right of equal conveyance applies to all owners and uses, including greenbelt, park areas, and recreational areas. Owners may relinquish their right to equal conveyance by providing a written agreement to the City's Engineer.
10. A grading permit and/or construction plan approval shall be required to perform any grading activities on site.
11. The toe of any fill shall parallel the natural direction of the flow.
12. Floodplain alterations shall incorporate and consider other City planning documents and ordinances such as the Tree Preservation Ordinance (Section 7.7.4 – DDC), , the Subdivision Ordinance (Subchapter 8 – DDC), and the Floodplain Prevention and Protection Ordinance (Chapter 30 – City of Denton, Code of Ordinances).
13. Unless a pre-existing model is in place, USACE's HEC-HMS and HEC-RAS shall be used. A request to use another type of hydrologic or hydraulic model must be submitted for approval through a design deviation request. The Modified Puls method shall be used for flood routing information to ensure that the cumulative effects of the reduction in floodplain storage of floodwater will not cause downstream or upstream increases in water surface elevations and erosive velocities. If the Modified Puls method is not feasible, a request to use another type of flood routing method must be submitted for approval through a design deviation request.

B. The engineer of record is responsible for providing documentation of the relevant USACE approved permits prior to beginning modification of the floodplain and prior to causing any impacts to WOTUS. If applicable, the engineer of record is also responsible for providing a signed and sealed statement detailing why such permits are unnecessary.

C. Verification of Floodplain Alterations:
1. The owner and/or developer shall furnish, at their expense, to Development Services sufficient engineering information to confirm that the minimum FFEs proposed meet the requirements of the Flood Prevention Ordinance.
2. Construction plans will not be released for construction within areas subject to a Conditional Letter of Map Revision (CLOMR) or amendment until such plans are accepted by Development Services and FEMA.
3. Letters of Map Revision (LOMR) applications shall be submitted to Development Services (i) no later than 60-days from the City's final acceptance of the construction and (ii) prior to submittal to FEMA.
4. All submittals to FEMA shall be submitted to Development Services prior to submittal to

FEMA. A copy of all responses to FEMA comments shall be submitted to the City.

D. Development within the floodplain which does not result in any change to the topography, the amount or location of impervious area, or any change in the characteristics of the floodplain cross-section, such as underground utility construction, may not require a flood study, CLOMR, LOMR, or DSA unless requested by the City.

The following decision charts are intended to consolidate the floodplain development criteria in the City of Denton. They reference information found in the DDC Subchapters 7.4 and 7.5, the Code of the City of Denton, Texas, Chapter 30, and this Manual. They are not an exhaustive list of criteria and are only to be used as guidance as to the information provided in the above-referenced documents. Criteria in those documents supersedes the decision charts.

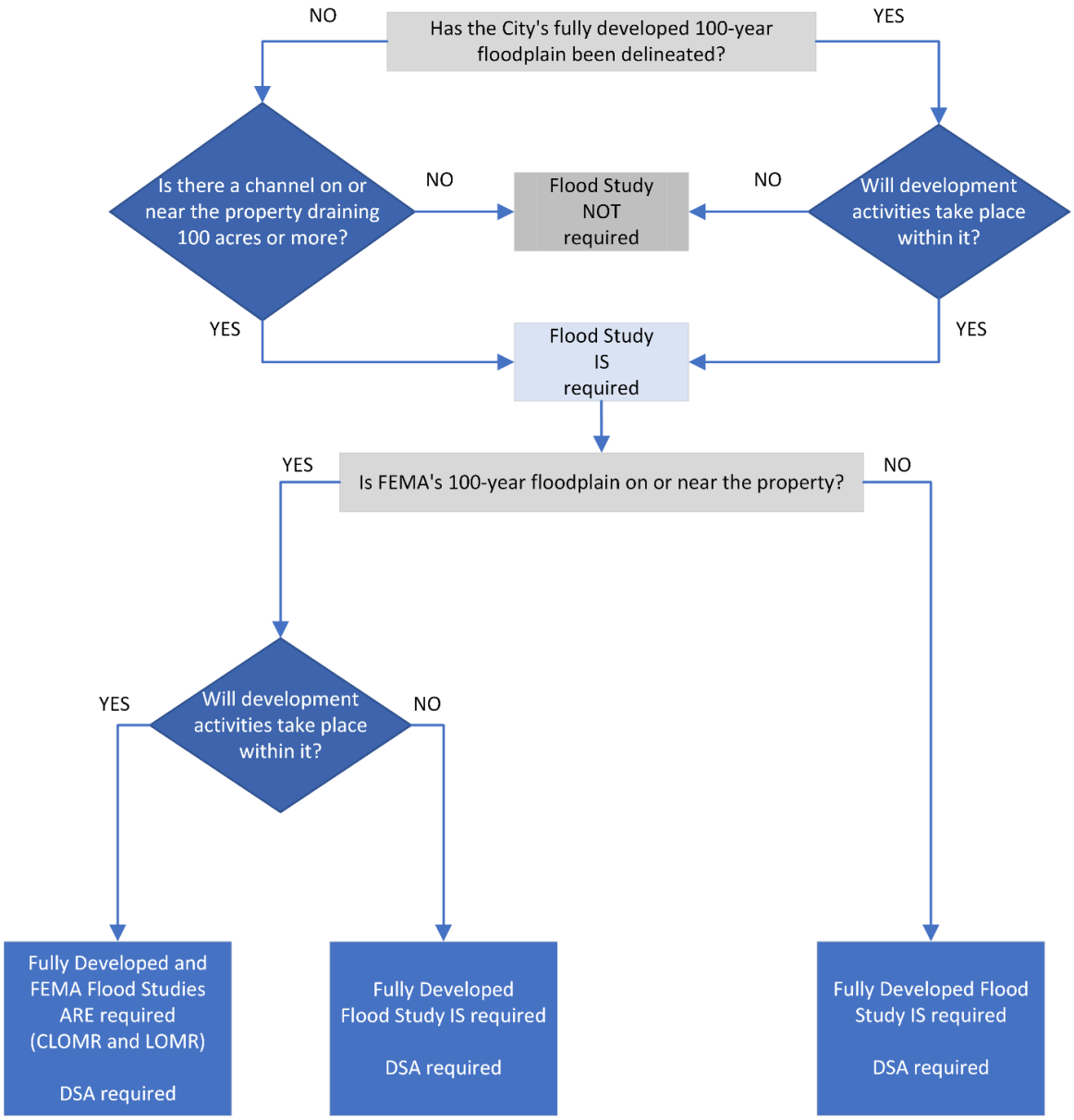


Figure 4.10 Flood Study Decision Chart

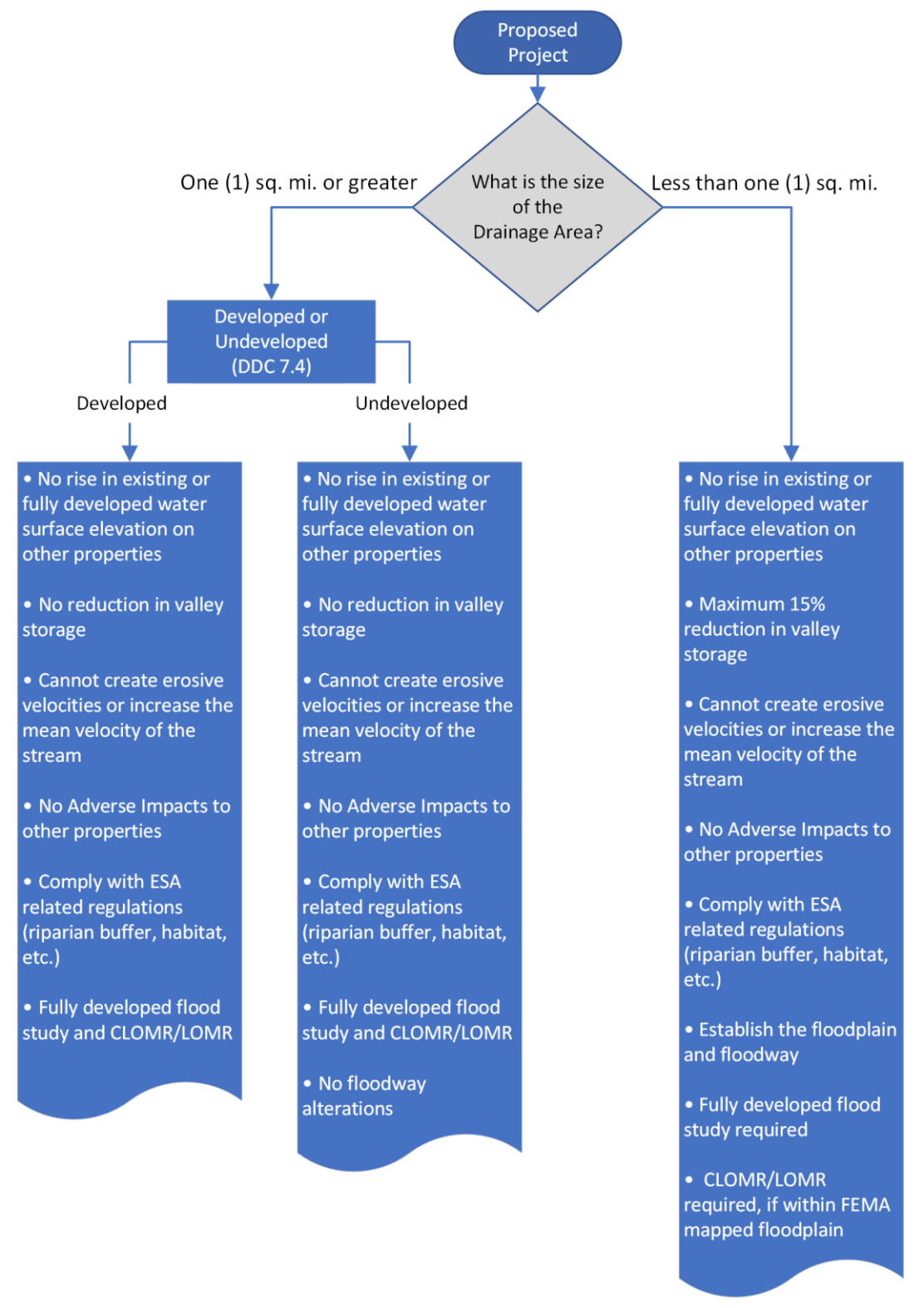


Figure 4.11 Summarized Floodplain Development Procedure

4.11.2 Procedures for Floodplain Alteration

Floodplain development is permitted when it complies with all requirements of the DDC, Flood Prevention Ordinance, and this Manual. The following are the engineering criteria for such requests.

Developments which impact designated FEMA flood plains in the City (Zones AE, A, and X shaded) shall submit minimum data required by FEMA, indicated on the City's CLOMR submittal checklist, and/or indicated in this Manual to FEMA for conditional approval. The Conditional Letter of Map Revision (CLOMR) shall be submitted to the City prior to approval of any Zoning Compliance Plan. Approval of CLOMR from FEMA will be required prior to acceptance of Civil Engineering Plans.

A. A written description of the scope of the proposed project and the methodology used to analyze the project's effects.

B. Hydraulic backwater models for 10, 50, 100, and 500-year floods for the following:
   1. Duplicate of the effective FIS model. The model must include:
      a. Existing conditions (effective FIS model including cross-sections through the project site. All cross-sections should reflect conditions prior to construction of the project); and
      b. Proposed conditions (existing conditions model reflecting the proposed project).

C. Floodway hydraulic backwater models of the following:
   1. Duplicate effective;
   2. Existing condition; and
   3. Proposed conditions.

D. In all the above hydraulic models, the following rules will apply:
   1. The hydraulic parameters, such as bridge loss coefficients, "*n*" values, etc., used in the effective FIS models will only be changed where obvious errors or changes have taken place and must be documented;
   2. The computed water surface elevation profiles must converge with the existing profiles; and
   3. Information should be shown on a map of suitable scale and topographic definition to provide reasonable accuracy.

E. A copy of the FIRM with the project area indicated.

F. Topographic mapping of the entire area covered by the proposed condition model, indicating the locations of all cross-sections used in the hydraulic model and delineating the proposed 100-year flood plain boundary.

G. Topographic mapping of the entire area covered by the proposed conditions model, indicating the locations of all cross-sections used in the hydraulic model and delineating:
   1. The proposed 100-year and 500-year floodplain boundaries; and
   2. The proposed floodway boundary.

H. Projects must comply with the requirements of 44 C.F.R. § 60.3(d)(2).

I. Upon completion of the proposed project, "as-built" and final LOMR plans certified by a Professional Engineer licensed by the State of Texas shall be submitted to the City for review and subsequent transmittal to FEMA. FEMA requires that individual legal notices be sent to all affected property owners when development (cut or fill) occurs in the regulatory floodway that would cause

any rise in the 100-year FIS water surface elevation. Public notice in the official community newspaper is required for proposed modifications to the regulatory floodway.

J. All items should be labeled for easy cross-referencing to the hydraulic model and summary data.

K. FEMA may have questions regarding the project. The engineer of record must address all of FEMA's comments. It is not anticipated, but if revisions to the development are required by FEMA, the developer is responsible for making the changes.

4.11.3 Fully Developed Water Surface Elevation Calculations

A. The following hydraulic data should be submitted to the City, preferably using the USACE HEC-RAS program to compute the channel's water surface elevation. The data should be submitted electronically as part of the CLOMR, LOMR, or flood study submittal.

1. Duplicate of the effective City fully developed backwater model or as developed by developer or property owner and approved by the City.
2. Modified existing condition backwater model – this model should include pre-development cross-sections through the project site obtained from field surveys or updated topographic information.
3. Proposed condition reflecting the development's impact on the flood plain area.
4. Water surface elevation and velocity summary tables tabulating the results of the above analysis.
5. Topographic map at a suitable scale with cross-sections that delineates the existing and proposed 1% chance (100-year) fully developed flood plain and shows the area being developed.
6. Analysis of the existing and proposed valley storage conditions of the area.
7. Documentation from the USACE determining if a 404 permit is required for the project.

4.11.4 Floodplain Alteration Guidelines

A. Side Slopes

1. To ensure maximum accessibility to the floodplain for maintenance and other purposes, and to lessen the probability of slope erosion during periods of high water, maximum slopes of filled area shall usually not exceed 4H:1V. Grass cover is required for all cut and fill slopes unless other armoring is required. Concrete riprap or an approved equal erosion protection measure is required on slopes steeper than 4H:1V. Vertical walls, terracing and other slope treatments will be considered only as:
    a. Part of a landscaping plan submission, and
    b. If no unbalancing of stream flow results.

B. Vegetation/Landscaping

1. Engineering plan submission shall include plans for:
    a. Erosion control of cut and fill slopes;
    b. Restoration of excavated areas; and
    c. Tree protection in and below fill areas.

2. Landscaping should incorporate natural materials (earth, stone, and wood) on cut or fill slopes wherever possible.
3. Applicant shall show in the plan the general nature and extent of existing vegetation on the tract, the location of trees in accordance with the requirements of the tree survey required by Section 7.7.4.E of the DDC, the areas which will be preserved, altered, or removed as a result of the proposed alterations.
4. Locations and construction details should be provided, showing how trees will be preserved in areas which will be altered by filling or paving within the drip line of those trees.
5. Applicant shall also submit plans showing location, type, and size of new plant materials and other landscape features planned for altered flood plain areas.

4.12 Drainage and Floodplain Easements

4.12.1 General

A. Drainage and floodplain easements shall be provided for all open natural streams or manmade drainage facilities. Easements shall encompass all areas lower than a ground elevation defined as being the highest of the following:
   1. 15 feet outside the calculated fully developed water surface elevation and associated flood boundary based on a design storm whose frequency is 100 years. All contributing watersheds are to be treated as fully developed for purposes of calculating the water surface elevation.
   2. The top of the high bank plus a minimum of 20 feet, if higher than stated in A.1. above.
   3. Existing natural banks with a slope steeper than 4H:1V shall have the easement line no closer than the intersection of a 4H:1V line extending from the toe of the slope to the proposed grade at the top of the bank, plus an additional 15 feet.
   4. Additional access area may be required according to the Section 4.12.2 below.

4.12.2 Storm Drain Easements

A. Above Ground Systems

Where an access road is required adjacent to a channel, an additional easement area of a minimum width of 15 feet shall be provided. The maximum cross slope shall be 2%. All access roads adjacent to improved channels shall be located within the drainage easement.

1. No structures, pavement, landscaping, or other above-ground man-made improvement shall be placed in a drainage easement, except where the easement is a public or private open space or park. Any such improvement within a drainage easement must be approved through a design deviation request.

B. Closed Systems

1. Easements for closed drainage systems shall meet the following minimum standards as shown below in Table 4.12-A.

Table 4.12-A: Easement Requirements for Closed Drainage Systems

Pipe or Box Size	Minimum Easement Width (feet)
36 inches and under	16
42 to 54 inches	20
60 to 66 inches	25
72 inches and above	30

2. Utilities such as water and sanitary sewer lines may share a portion of a drainage easement, containing an underground enclosed drainage system where an additional easement width for a minimum of 10 feet is added to create a public drainage and utility easement. No utilities shall be located in any lined channel, pipe, or box in such a way as to interfere with flow capacity or maintenance of or access to the channel, pipe or box.
3. A drainage easement shall be provided for the area within a required outfall channel or ditch to the point where the flowline "day lights" on natural grade or matches existing topography.
4. To provide for maintenance, a drainage easement shall be provided at least 25 feet beyond any outfall headwall.
5. No structures, pavement, landscaping, or other above-ground man-made improvement shall be placed in a drainage easement containing a closed drainage facility.

4.12.3 Channel Access

A. Access areas and ramps shall be provided for all publicly maintained channels to allow for maintenance of the channels. These access areas and ramps shall be contained within a drainage easement. Access areas shall have a width of at least 12 feet, a minimum cross slope of 2%, and a maximum cross slope of 5%.

B. Access easements shall be provided from the public ROW to the access area, if the access area is not directly connected to the public ROW. Access easements shall remain free of obstacles that block the use of the easement, including ungated fencing across the easement.

C. A concrete drive approach serving the access easement must be available and free of obstructions. Any sidewalk crossing the access easement must be constructed using a residential street cross-section, or otherwise designed to accommodate vehicle loads so that equipment may use the access easement without damaging the sidewalk.

D. Access to all improved earthen channels shall be provided by one (1) of the following methods, depending on the size and depth of the channel:
   1. A clear access area must be provided on one side of the improved earthen channel along the full length of the channel; or
   2. If the channel is deeper than 4 feet or has a top width greater than 25 feet, an access area must be provided on both sides along the full length of the channel. Access areas shall have a width of at least 15 feet, a minimum cross slope of 2%, and a maximum cross slope of 5%.

E. All lined channels, and earthen channels with concrete pilot channels shall have a minimum bottom width of ten (10) feet and shall be provided with concrete access ramps. Concrete access ramps

shall have a minimum width of 12 feet, maximum slope of 6H:1V, and maximum cross slope of 5%. All access roads shall be located within a dedicated easement. Access road pavement cross-sections shall conform to the standards of the concrete residential street cross-section detail located in the City of Denton Standard Details.

4.12.4 Detention Facilities Easements

A. Detention facility easements must encompass the entirety of the detention facility plus any required maintenance access areas adjacent or leading to the facility.

B. All detention maintenance access easements must be connected to a public ROW, be a minimum of 10 feet wide, and be free of obstructions which could prevent personnel and equipment from accessing the detention facility.

4.12.5 Post-Construction Water Quality Control Structure Easements

A. All post-construction structural stormwater control structures must be located within an inspection access easement. The intent of this easement is to allow City staff to access and inspect the control structure to ensure it is being maintained in accordance with the SWFMA. This easement must be connected to a public ROW, be a minimum of five (5) feet wide, and be free of obstructions which could prevent City staff from accessing the control structure.

4.12.6 Fences

A. Fences in drainage easements are prohibited by the DDC, except as specifically provided for below.

1. Fences may cross drainage easements that contain an underground stormwater system provided the fence is constructed with any type of non-masonry material and the fence is constructed with knock-out panels to facilitate maintenance.

2. Fences in drainage easements that contain overland flow may cross the easement if the fence is constructed with wrought iron (pickets and rails), pipe, or pipe and cable. Fence height, minimum picket spacing, and maximum ground clearance spacing shall be governed by appropriate child safety measures.

3. No fences are allowed across inlet or outlet structures of drainage detention facilities. Fences are permitted around the detention facility if they do not block or inhibit the flow conveyance of the detention facility.

4. No fencing is allowed across easements which share water or wastewater facilities with the drainage facility.

B. Fences in the floodplain are prohibited.

4.13 Water Quality

4.13.1 Water Quality Protection Volume

It is required that all development sites disturbing a land area larger than (1) one acre or part of a common plan of development disturbing a land area greater than (1) one acre treat their stormwater runoff either through extended detention and/or include site development controls necessary to remove 80% of the TSS from the water quality protection volume (WQ_V). *See* the iSWM™ Water Quality Protection Technical Manual

for information regarding the design of this WQ_V and appropriate discharge design. *See* the *i*SWM™ Site Development Controls Technical Manual for information regarding structural stormwater controls and their ability to remove pollutants in stormwater runoff to protect water quality. Any combination of structural stormwater controls may be used to achieve the required 80% TSS removal from all runoff from impervious surfaces on the site. Any proposed proprietary treatment devices must be certified by either the New Jersey Department of Environmental Protection (NJDEP), the Washington state Technology Assessment Protocol – Ecology (TAPE) program, or the Technology Acceptance Reciprocity Partnership (TARP).

The percent TSS removal (%TSS) that is achieved on a site can be calculated using equation 4.8 below. This equation is an area-weighted TSS reduction equation that accounts for the TSS reduction attributable to each stormwater treatment best management practice (BMP) that is utilized on the site.

$$\%TSS = \frac{\Sigma_n^1 (TSS_1A_1 + TSS_2A_2 + \ldots + TSS_nA_n)}{\Sigma_n^1 (A_1 + A_2 + \ldots + A_n)} \quad \textbf{[Eqn. 4.8]}$$

Where: TSS_n = TSS removal percentage for each structural BMP located on-site (%);
A_n = the area draining to each BMP (acres).

When two or more BMPs are used in series (stormwater discharges from one BMP into another), a different calculation is necessary. This scenario is called a ***treatment train***. Stormwater discharging from the upper most BMP will be considerably "cleaner" than the influent, meaning TSS particle sizes will be much smaller. Pollutant removal rates for BMPs used in a treatment train are not additive. To calculate the total % TSS removal for a treatment train comprised of two or more structural BMPs, the following equation should be used.

$$TSS_{train} = A + B - \frac{A \times B}{100} \quad \textbf{[Eqn. 4.9]}$$

Where: TSS_{train} = total TSS removal for treatment train (%);
A = % TSS removal of the first (upstream) BMP
B = % TSS removal of the second (downstream) BMP

4.13.2 Water Quality Hotspots

Not all structural stormwater controls are appropriate for receiving runoff from hotspots. Hotspots are land uses or activities which produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning sites, landfills, construction sites, industrial sites, industrial rooftops, auto salvage or recycling facilities, and dog parks. Only appropriate structural stormwater controls identified in the *i*SWM™ Site Development Controls Technical Manual may be used for receiving hotspot runoff.

Facilities that discharge stormwater associated with industrial activity permitted under TCEQ Multi-Sector General Permit (TXR050000) may incorporate WQ_v requirements into point source discharge control requirements.

4.13.3 Required Stormwater Facility Maintenance Agreements

All private post-construction structural stormwater controls shall require a SWFMA in accordance with Section 4.14 of this manual.

4.13.4 Construction Erosion and Sediment Control Requirements

All land-disturbing activities must include provisions for erosion and sediment control in accordance with Section 7.3 (Land-Disturbing Activities) of the DDC, the *i*SWM™ Water Quality Technical Manual, the *i*SWM™ Construction Controls Technical Manual, and the *i*SWM™ Site Development Technical Manual.

A. Erosion Control Plans

The purpose of the Erosion Control Plan is to reduce erosion, retain sedimentation and, to the greatest extent, prevent off-site drainage during land-disturbing and construction activities. It does this by assessing the site's erosion potential to determine structural controls and site management practices, also known as Best Management Practices (BMPs).

1. General Erosion Control Plan Requirements

   The erosion control plan must contain the following:

   a. A narrative description of the project, total acreage of the parcel, total acreage to be disturbed, the construction sequence, the potential sources of erosion and sedimentation, BMPs, their maintenance, and inspection procedures.

   b. A list of BMPs that will be implemented during each phase of construction, such as preservation of existing vegetation, stockpile management, silt fencing, outlet protection, runoff interception, vegetated buffers, etc.

   c. A sequence of construction of the development site, including stripping and clearing; rough grading; construction of utilities, infrastructure, and buildings; and final grading and landscaping. Sequencing shall identify the expected date on which clearing will begin, the estimated duration of exposure of cleared areas, areas of clearing, installation of temporary erosion and sediment control measures, and establishment of permanent vegetation.

   d. Description of on-site spoils and borrow areas, including handling and disposal of borrow materials, as well as size, depth of fill and revegetation procedures.

   e. Descriptions of on-site and adjacent critical areas

   f. Description of vegetative temporary and permanent stabilization practices

      i. Areas within the limits of construction (LOC) that will require temporary stabilization

      ii. Seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and kind and quantity of mulching for both temporary and permanent vegetative control measures

      iii. Specific limits on the time frame between initial exposure of soils by construction activity to the temporary or final stabilization of those surfaces

      iv. Schedule for converting temporary controls to permanent functions (e.g. basins)

   g. Drawings and specifications of structural controls and site management practices, with supporting calculations and assumptions

2. Phased Erosion Control Plans

   For projects with earthwork construction totaling five (5) acres or more, a two-phased erosion control plan is required for all non-linear projects. Each phase must be provided as a drawing on a separate plan sheet. Drawings should address the transition between phases.

a. Phase 1 – Initial Land Disturbance: This drawing shows BMPs to be installed prior to general clearing of the site. It should also show the existing contours, adjacent streets, ROW, easements and property lines. Do not show final contours on this drawing.
   i. Show the BMPs selected for the following:
      a) Downslope perimeter controls
      b) Side-slope controls as needed per site conditions
      c) Controls that will intercept runoff
      d) Access barriers for areas to remain undisturbed, such as ESA and tree protection fencing
   ii. Must show structures to be demolished and trees to be removed
   iii. If installing sediment-trapping impoundments, such as sediment basins or interceptor swales, they must be shown on this phase as they are installed at the initiation of grading.

b. Phase 2 – Construction and Stabilization: This phase shows BMPs required during the rest of grading and construction, such as inlet protection. It must also include BMPs appropriate for final stabilization; seeding, sodding, flatwork, etc.

   Individual Lot Phase: For multi-family development projects, the Phase 2 plan will also show behind-the-curb controls for individual lots, such as silt fencing, ground cover, and stabilized construction entrances.

3. For projects with earthwork construction totaling less than five (5) acres, phased erosion control plans are not required; the erosion control plan may be shown on a single sheet with the following:
   a. Show existing contours
   b. Show final contours
   c. Show direction of flow during grading operations with arrows

   Show areas to be permanently stabilized.

B. Mass-Graded Drainage Area Map

In addition to an existing conditions drainage area map (DAM) and proposed conditions DAM, sites with earthwork construction ten (10) acres or greater must provide a mass-graded DAM showing interim contours and temporary drainage conditions created by earthwork construction and soil-leveling activities.

1. General Mass-Graded Drainage Area Map Requirements
   a. Show the delineation and contributing drainage area of temporary basins; do not show any basins that drain to permanent stormwater infrastructure. Temporary basins can only flow to existing features.
   b. Show and label contours created by earthwork construction. Do not show precise grades such as building footprints, lot lines, or finished floor elevations.
   c. Show the direction of flow for each temporary basin using arrows.
   d. Show the locations of any existing basins.
   e. Show the locations of any temporary sediment-trapping impoundments (optional)
2. For Sites with Ten (10) Acres or More Common Drainage

a. Show and label the locations of any sediment-trapping impoundments, such as sediment basins or traps, or interceptor swales.

C. Sediment Basins

A sedimentation basin or similar sediment-trapping impoundment is required where 10 or more acres drain to a common area during any phase of development.

1. Sediment basins and other detention structures must provide storage volume for the runoff from a 2-year, 24-hour storm. Calculations must be included with the erosion control plan.
2. Sediment basin(s) or impoundments must provide at least 3,600 cubic feet (cu. ft.) of storage per acre drained until final stabilization of the contributing drainage area.
3. Sedimentation basins or impoundments must be designed by a Professional Engineer licensed in Texas or a Certified Professional in Erosion and Sediment Control (CPESC)
4. Sediment basins must be able to control and treat runoff within site boundaries; they should be installed as close as possible to the disturbed area or sediment source as possible. Existing detention or retention ponds at the site may not be appropriate, as determined by City review staff.
5. Sediment basins must be designed, constructed, and maintained to minimize mosquito breeding habitats by minimizing the creation of standing water. Outlet structures shall be designed to provide a minimum dewatering time of 36 hours and a maximum dewatering time of 72 hours.
6. When discharging from sedimentation basins and impoundments, the plan must utilize outlet structures that withdraw water from the surface. If this is infeasible, a reason must be provided to City review staff during planning.

D. Vegetation

1. Criteria for Stabilization

   You are required to stabilize exposed portions of your site in accordance with DDC § 7.3.5.E, the TXR150000 CGP, the NPDES CGP, and federal "C&D Rule" permit requirements as found in 40 CFR 450.21. To be considered adequately stabilized, you must meet the criteria below depending on the type of cover you are using, either vegetative or non-vegetative:

   a. Vegetative Stabilization: If you are vegetatively stabilizing any exposed portion of your site through the use of seed or planted vegetation, you must provide established uniform vegetation (e.g., evenly distributed without large bare areas), which provides 70 percent or more of the density of coverage that was provided by vegetation prior to commencing earth-disturbing activities.
      i. Immediately after seeding or planting the area to be vegetatively stabilized, to the extent necessary to prevent erosion on the seeded or planted area, you must select, design, and install non-vegetative erosion controls that provide cover (e.g., mulch, rolled erosion control products) to the area while vegetation is becoming established.
      ii. For final stabilization, vegetative cover must be perennial
   b. Deadline to Initiate Stabilization: You must initiate soil stabilization measures immediately whenever earth-disturbing activities have permanently or temporarily ceased on any portion of the site.

i. The term "immediately" means as soon as practicable, but no later than the end of the next workday, following the day when the earth-disturbing activities have temporarily or permanently ceased.

ii. Earth-disturbing activities have temporarily ceased when clearing, grading, and excavation within any area of the site that will not include permanent structures will not resume (i.e., the land will be idle) for a period of 14 or more calendar days, but such activities will resume in the future.

iii. The City closely adheres to the EPA's Construction General Permit and will consider any of the following types of activities to constitute the initiation of stabilization.

a) prepping the soil for vegetative or non-vegetative stabilization;
b) applying mulch or other non-vegetative product to the exposed area;
c) seeding or planting the exposed area;
d) starting any of the three activities stated just above on a portion of the area to be stabilized, but not on the entire area; and
e) finalizing arrangements to have stabilization product fully installed in compliance with the applicable deadline for completing stabilization

c. Deadline to Complete Stabilization Activities. As soon as practicable, but no later than 14 calendar days after the initiation of soil stabilization measures, you are required to have completed:

i. All activities necessary to initially seed or plant the area to be stabilized.

ii. You are required to have stabilized the exposed portions of your site prior to terminating permit coverage. You must submit your notice of termination (NOT) within 30 calendar days of completing earth-disturbing activities at your site.

2. Vegetative stabilization is required for all permanent and temporary channels and basins. Plant selection guidance is provided in the *i*SWM™ Landscape Technical Manual.

3. The erosion control plan must demonstrate reasonable preservation of trees and understory and that the following criteria is demonstrated in selection of trees to be preserved or removed:

a. Proximity of the trees critical root zone or drip line to proposed grading activity.

b. Permanent tree protection methods are employed to protect the preserved tree from damage where the trees critical root zone may be impacted.

c. Other measures have been employed, including site design that improves the chances for tree survival.

d. Temporary tree protection methods are adequately employed.

e. Construction methods for utility service to the site are used that allow protection and preservation of additional trees, such as, tunneling under the critical root zone, tree walls, or tree wells.

f. Utility trenching activities are indicated on the plan.

E. Structural Controls and Site Management Practices

1. Erosion and sediment control BMP design criteria shall adhere to the most current version of the *i*SWM™ Construction Controls Technical Manual, unless one of the following exceptions applies:

a. Linear projects may follow TxDOT standards; or

b. Proprietary erosion or sediment control devices may be utilized when:

i. Independent performance data is provided to prove a demonstrated capability of meeting a stormwater management efficiency equivalent to *i*SWM™ methods; and

ii. Supplementary data for systems or devices, such as instruction manuals and specification sheets, are provided and are demonstrated to be appropriate for use in North Central Texas site conditions, as determined by Environmental Services and Sustainability (ESS) department staff.

2. The City has restrictions on certain structural controls:

a. Curb inlet protection requires ESS approval to be used on active City streets

i. Organic filter tube curb inlet protection is prohibited

ii. Block and gravel filter curb inlet protection is prohibited

iii. Curb rock sock on-grade curb inlet protection is prohibited

F. Procedures During Construction

The Watershed Protection Division of the Environmental Services & Sustainability Department is primarily responsible for the inspection and enforcement of erosion and sedimentation control requirements on site developments and subdivisions. The City will monitor compliance with plan requirements and judge the effectiveness of the controls during different stages of construction and before and after significant rainfall. The criteria and procedures contained in this section closely adhere to DDC § 7.3.4-6, the TXR150000 CGP, the NPDES CGP, and federal permit requirements as found in 40 CFR 122.26 & 123.25.

1. Criteria for Approvals Required Prior to the Commencement of Land-Disturbing Activities

a. The project must have a valid, current city development permit or site plan.

b. The developer, owner, or otherwise delegated applicant shall complete the appropriate survey(s)

i. Applicants requiring a demolition permit must complete the Demolition Survey

ii. Applicants requiring all other permits must complete the Construction Survey

c. The applicant shall provide approved site plans and specifications for the development permit. For plans to be accepted, the locations and dimensions of all temporary and permanent erosion and sediment controls must be depicted. Specifications must include the maintenance routines, and schedules for installation and removal of controls, through all phases of construction.

d. If the project requires a Stormwater Pollution Prevention Plan (SWPPP), the plan must be reviewed for completeness by City staff.

i. The SWPPP must show consistency with City-approved plans (i.e. civil engineering plans and zoning compliance plans)

e. Projects disturbing five (5) or more acres must submit a Notice of Intent to the City; or when the project is part of a common plan of development with disturbed acreage totaling five acres or more.

f. Construction Site Notice (CSN)

i. Executed CSN(s) are included in the SWPPP.

ii. CSN(s) are posted publicly in locations near the site entrance, where they can be viewed by the general public.

2. Compliance Inspection by the City

a. The project must pass an initial inspection for approval of permits and/or Notice to Proceed.

i. The project must be in substantial compliance with the approved plans and specifications (ESCP) for the development permit

ii. Controls must be installed in all required areas, such as:

a) Perimeter controls
b) Stabilized construction exit
c) Protection of existing inlets

iii. Clearing for the installation of erosion control devices shall not exceed a width of eight (8) feet and must not encroach into the dripline or critical root zone of any tree to be protected.

b. The project will be routinely inspected during all phases of development to determine the compliance or non-compliance of a project's temporary erosion and sedimentation controls.

i. Erosion and sediment controls must be installed for current development phase.

ii. Sediment basins (when required) must be installed at the initiation of grading at the associated drainage area; the deadline for installation is seven days after initiation.

iii. Vegetative temporary stabilization measures must demonstrate consistent progress toward stabilization. See previous section for criteria.

iv. Permanent stabilization must be initiated within 48 hours of completion of construction activities on areas of the site and completed for project prior to issuance of final Certificate of Occupancy.

v. Vegetative stabilization must demonstrate consistent progress toward 70% density of perennial vegetative cover.

3. Reinspection

a. Reinspection is conducted for sites that are out of compliance.

i. Standard timeframe for corrections is seven (7) business days.

ii. Enforcement may be escalated if there are impacts to offsite property or waterways.

iii. A reinspection fee may be assessed.

b. Reinspection with Notice of Violation (NOV) will be issued for continued stormwater non-compliance affecting stormwater, with reinspection fee assessed.

c. Reinspection with Stop Work Order (SWO) – Escalation issued for continued non-compliance affecting stormwater through failed erosion and sediment controls. Reinspection fee assessed.

i. Effective until deficiencies are corrected.

ii. Erosion and sediment control failures which threaten life or property may result in SWO without prior reinspection or NOV.

d. Reinspection Fees

i. Applicability – applies only to reinspection due to failure to comply with site stormwater quality requirements.

ii. Amount – As established in the Water and Wastewater Rate Book.

iii. Time of Payment – Payment is due per standard City of Denton utility billing dates.

4.14 Stormwater Facility Maintenance Agreements

4.14.1 Maintenance Agreements

All drainage improvements constructed within a development and any existing or natural drainage systems shall require a maintenance agreement that identifies responsible parties for maintenance. The maintenance agreement shall be written such that it remains in force upon sale of transfer of the property.

As part of the Operations and Maintenance Plan submittal, a SWFMA must be prepared by the engineer of record for each stormwater control that will not be wholly maintained by the City. This agreement must outline preventive maintenance tasks and major repairs, identify the schedule for each task, assign clear roles to affected parties, and provide a maintenance checklist to guide future owners, including an annual self-inspection to be provided to the City. Multiple stormwater controls may be contained within a single Stormwater Facility Maintenance Agreement. When areas are identified for detention that also serve other purposes for the development (e.g. parking lots, loading docks) the requirement for a SWFMA may be waived.

4.14.2 Private Maintenance (SWFMA Required)

A. Private drainage facilities include those drainage improvements which are located on private property and which serve the needs of private development.

B. Private drainage facilities may also include detention or retention ponds, dams, and retaining walls intended to direct or contain runoff. Such facilities must be designed in accordance with sound engineering practices and reviewed and inspected by the City.

C. All SWFMA exhibits shall be reviewed and approved by the City with the civil engineering plans. The agreement for perpetual maintenance of private drainage facilities shall be executed with the City during per-construction. This agreement shall run with the land and can be tied to commercial property or to an owner's association, but not to individual residential lots.

D. The SWFMA shall provide the City with access to all private drainage facilities.

4.14.3 Maintenance Agreement Requirements

Details of the SWFMA must be set forth in a series of exhibits:

A. Exhibit A Legal Description - This includes the Metes and Bounds, a Surveyor's Drawing of the area occupied by the facility, and a copy of the preliminary or recorded plat containing the facility.

B. Exhibit B Design Plan and Specifications - These are summary documents intended for the use of future owners in conducting routine maintenance, inspections, and repairs. The documents include:

1. Design Data and Calculations - This can be in the form of a letter or statement from the engineer of record which summarizes critical design calculations related to the functionality of the facility, such as storage volume or TSS removal, and attests to the facility conforming to applicable *i*SWM standards;

2. Schematic Plan - This should be prepared by the engineer of record from construction drawings to show the general layout of the facility. Major features requiring regular or special maintenance should be shown and labeled in general terms understandable to a layman. A profile should be given showing critical elevations that control the function and capacity of the facility, and one or more cross-sections should be provided to indicate the general grading of the facility. A typical example of a schematic plan for a simple detention basin is shown in Figure 4.13 below; and

3. Landscaping - Vegetation should be shown consistent with the accepted Landscape Plan, either on the Schematic Plan or as a separate drawing.

C. Exhibit C Operations and Maintenance Plan - Specific maintenance tasks should be defined for each element of the facility. Maintenance tasks specific to the facility should be described in simple terms consistent with terminology contained in the Schematic and Landscape plans. An inspection and maintenance frequency should be established for each task.

D. Exhibit D Maintenance Checklist - A checklist consistent with the Operations and Maintenance Plan shall be provided for the use of future owners in performing routine and special maintenance tasks. This list should describe work required and frequency in language that is easy to understand and specific for the facility to be maintained. This form will be completed by the Owner and submitted to the City annually as part of a regular self-inspection program. *See* Appendix A for an example checklist for preparing a SWFMA for a simple detention basin.

Additional facility maintenance guidance for several types of stormwater controls is provided in the *iSWM Technical Manual*. The engineer of record must certify that the construction has been completed in accordance with the general plans and Schematic Plan. After approval of construction by the City, the engineer of record is expected to provide guidance to the owner's representative in implementing the accepted maintenance program and to co-sign the first annual inspection after the construction.

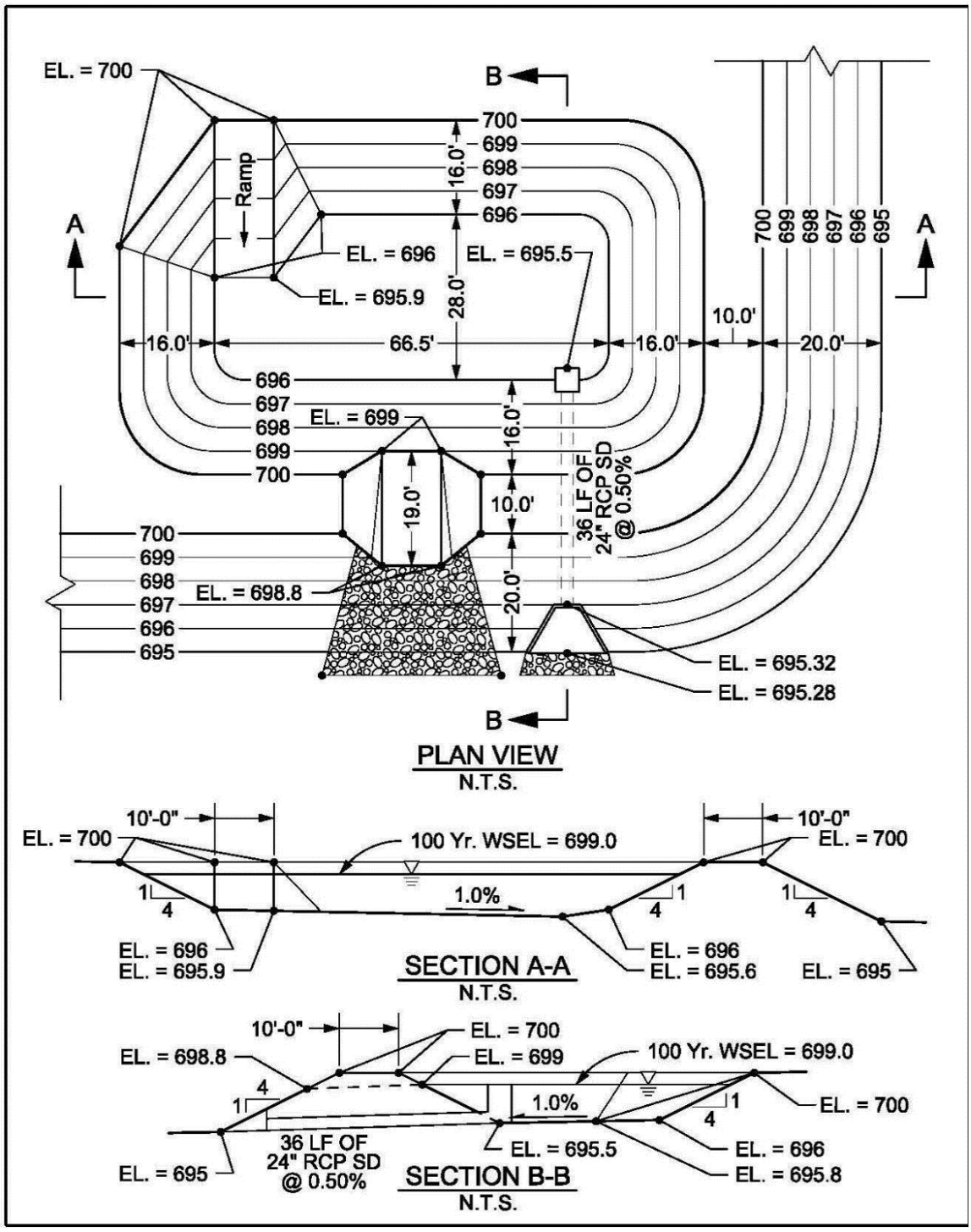


Figure 4.12 Simple Detention Basin Plan Schematic

Section 5: Transportation Design Criteria

5.1 Overview

The purpose of Section 5 – Transportation Design Criteria is to provide ***minimum guidelines*** for the design and construction of transportation infrastructure within the City of Denton, Texas and its extraterritorial jurisdictions using the complete street and context-sensitive solution approach. The goal is to create safer, more livable places that are consistent with their social, environmental and economic values.

It is the responsibility of the design engineer to ensure the final design of transportation infrastructure are in conformance with the most recently adopted versions of the following documents:

A. City of Denton Mobility Plan;

B. City of Denton Code of Ordinances, Chapter 18 – Motor Vehicles and Traffic, and Chapter 25 – Streets, Sidewalks and Public Places;

C. The North Central Texas Council of Governments (NCTCOG) Public Works Construction Standards;

D. DDC Subchapter 7.8 – Access and Circulation;

E. DDC Subchapter 7.9 – Parking and Loading;

F. DDC Subchapter 8.3 – Subdivision Design;

G. Americans with Disabilities Act (ADA) Standards for Accessible Design;

H. Public Right-of-Way Accessibility Guidelines (PROWAG);

I. The International Fire Code (IFC);

J. this Manual; and

K. relevant TxDOT, USDOT, NCHRP, FHWA, and AASHTO publications.

The criteria established in this Manual provide basic guidance for the design of transportation systems within the City of Denton. However, ***full responsibility and liability for proper design remains with the design engineer***. ***Users of this Manual should be knowledgeable and experienced in the theory and application of transportation engineering.***

Other design criteria may be warranted from applicable resources. The Federal Government, the State of Texas, NCTCOG, Denton County, Denton County Transit Authority (DCTA) and other related organizations and resources shall be consulted for additional criteria as may be deemed necessary. Along with this Design Manual, the DDC shall be consulted for additional guidance. The criteria established in this Manual do not supersede the policies contained in the DDC. Any revision to the DDC supersedes the criteria in this Manual.

5.1.1 Organization

Section 5 - Transportation Design Criteria is organized as follows:

A. Overview

B. Mobility Framework

C. Roadway Design

D. Intersection Design

E. Auxiliary Roadway Design

F. Access Management

G. Bike and Pedestrian Facility Design

H. Transit Facility Design

I. Traffic Impact Analysis Guidelines

J. Pavement Design Standard

K. Complete and Context-Sensitive Streets

5.2 Mobility Framework

The City of Denton Mobility Plan should be reviewed relative to any proposed development.

It should be noted that the City of Denton Mobility Plan is a living document and is periodically updated to reflect the changes in the characteristics of anticipated traffic flow within the City.

5.2.1 Roadway Functional Classifications

The City of Denton uses the following roadway functional classifications in guiding developments and street improvements within its jurisdiction. They are to be used in conjunction with other City of Denton documents, as well as Complete Streets, Vision Zero, and Context-Sensitive Design considerations. These classifications were established in the Thoroughfare Plan based upon expected fully developed traffic volumes.

A. Freeway

Freeways are high-capacity roadways intended to move large volumes of traffic through the region, into, and out of the City of Denton. They are typically managed and maintained by external agencies such as TxDOT and may include tolled or non-tolled facilities. Freeways are limited-access facilities as defined in Section 5.6 Access Management of this Manual.

These facilities are designed as multi-lane, high-speed roadways with on- and off-ramps to control access and support long-distance regional and interstate travel. In urban areas, freeways are often accompanied by frontage roads that provide access to adjacent properties and businesses.

This Manual does not prescribe specific design standards for freeways, as their planning, design, and construction fall under the jurisdiction of TxDOT or other applicable agencies.

B. Primary Arterial

Arterial streets are streets that serve major routes into and through the City of Denton. They are often multi-lane thoroughfares that generally include a landscaped median. Arterial streets are shown on the City Mobility Plan. These street types are to have limited access as defined in Section 5.6 Access Management section of this Manual.

Primary arterials provide regional connectivity between different areas of Denton County and the DFW region. The design of arterial can vary depending on the surrounding land use and development. In urban areas, arterials may have wider sidewalks with smaller building setbacks, while suburban areas may have limited sidewalks with a larger buffer between the edge of the street and the building fronts. Refer to City of Denton Standard Details T112A and T112C for typical cross-section requirements and design guidance.

C. Secondary Arterial

Secondary arterials provide shorter connections and carry less traffic. Secondary arterials are still significant to vehicular travel as they serve trips of moderate length and provide more land access. They have a greater role in balancing local land access with moving people and goods. Typically, they have lower travel speeds and traffic volumes than Primary arterials. They also tend to be limited in width by the built environment that they serve and often have the greatest need for accommodation of high levels of use for all travel modes. Refer to City of Denton Standard Details T110A and T110C for typical cross-section requirements and design guidance.

D. Major Collector Street

A major collector is a roadway that collects and distributes traffic between collector streets/ local streets and arterial roads, supporting moderate traffic volumes. It typically accommodates 2–4 lanes and operates at lower speeds. Major collectors balance mobility and access, featuring wider lanes, occasional medians, and turn lanes to improve flow. These roads often include sidewalks, bike lanes, or shared-use paths, making them suitable for moderate-distance trips between neighborhoods, schools, and commercial areas. Refer to City of Denton Standard Details T113A-T115A and T113C-T115C for typical cross-section requirements and design guidance.

E. Collector Street

A collector street is a street that collects associated traffic from residential streets, rural streets, commercial streets, or industrial streets as designated on the City Mobility Plan.

Collectors in the City of Denton provide local land access and traffic circulation from residential neighborhoods to arterials or major collectors. They typically experience lower traffic volumes and have lower design speeds. Collector classifications include the following:

1. Commercial Collector – Provides circulation between commercial developments and the arterial or major collector system. Refer to City of Denton Standard Details T108A and T108C for cross-section requirements and design guidance.
2. Residential Collector – Functions as a residential street but is designed to accommodate higher traffic volumes and wider pavement widths than standard residential streets. Parking may be permitted depending on the context and adjacent land uses. Refer to City of Denton Standard Details T107A and T107C for cross-section requirements and design guidance.

F. Local Streets

A local street is a public street that provides access to adjacent property and are usually contained within the neighborhood. These streets have low speeds and low volumes associated with them. Local streets may be further classified into the following two (2) types:

1. Residential Street – A residential street is a public street associated with residential development within an urban environment. The residential street may accommodate on-street parking, dependent on the context and adjacent land uses. Refer to City of Denton Standard Details T105A and T105C for cross-section requirements and design guidance.
2. Rural or Suburban Residential Street – A rural street is a public street that connects rural communities. Refer to City of Denton Standard Details T106A and T106C for cross-section requirements and design guidance.

Existing or new industrial developments on local streets shall consult with the City's Engineer.

5.2.2 Auxiliary Roadway Classifications

Roadways that cannot be classified as thoroughfare, are grouped together as auxiliary roadways and are classified here as follows:

A. Alleys

An alley (residential or commercial) is designed to provide access to the rear of or side of a lot including solid waste and fire access. These pathways are narrower than standard streets, usually measuring 20 feet wide ROW and are not intended for through traffic but rather for serving adjacent properties. Alleys will be required for residential streets prohibiting on-street parking. Alleys are required in non-residential zoning districts where necessary to provide for adequate access for service vehicles, off-street loading or unloading, access for emergency vehicles, fire access or similar reasons consistent with the intent of the DDC.

B. Drives

A drive is an unobstructed paved area providing vehicular access from a street to a developed property. Drives can be classified as follows:

1. Driveway - A driveway is located entirely on private property. It is only for a single-family or a duplex property. It connects a drive approach to a garage, carport, parking pad or the like.
2. Drive Aisle - A drive aisle is located entirely on private property. It is for every other condition other than for a single-family or a duplex property. It connects a drive approach to an area(s) that is to be accessed on the site such as, but not limited to: parking space(s); loading dock(s); loading area(s) (marked or implied - for passengers and/or goods); porte-cochere(s), and/or the like. It can also be a fire apparatus access road (in and of itself or in conjunction with other access use[s]). It can also be an access to an adjoining property (in and of itself or in conjunction with other access use[s]).
3. Drive Approach - A drive approach connects a street (city, public or private) or highway (TxDOT) with a drive aisle. Some features of the drive approach may extend into and be a part of the driveway or drive aisle. The drive approach is measured from the face of the roadway curb to the end of the curb return radius on the private property. The following provides the types of drive approaches considered within this Manual:
    a. Single-family residential: A drive approach to a single-family residential lot or one lot duplex.
    b. Multifamily residential: A drive approach to a multifamily lot such as triplexes, fourplexes, and multi-complexes. The drive approach can be either the main entrance approach or the secondary entrance approach. Each type has specific design requirements.
    c. Commercial: A drive approach to a commercial development. The drive approach can be either the main entrance approach or the secondary entrance approach. Each type has specific design requirements.
    d. Industrial: A drive approach to an industrial development. The drive approach can be either the main entrance approach or the secondary entrance approach. Each type has specific design requirements.
    e. Mixed-use approach: A drive approach that is a mixed-use development shall consider the more stringent criteria for the approach design.

4. Flag Drives - A flag drive is a private road within a private access easement, which may serve up to three (3) residential dwelling units. Flag drives shall have direct access to a public street other than an alley. They shall not, however, provide direct access to an arterial street.

C. Cul-De-Sacs, Dead-End Street, and Hammerhead Turnarounds

A cul-de-sac is a form of dead-end street that terminates with a circular or bulb-shaped turnaround, designed to accommodate fire apparatus and large vehicles for safe and efficient maneuvering.

A half cul-de-sac incorporates a 90° ± 5° bend, typically applied to residential or residential collector streets, and provides limited turnaround capability. In contrast, traditional dead-end streets share similar geometric characteristics with cul-de-sacs but terminate abruptly without a defined turnaround, restricting emergency access and vehicular circulation.

Hammerhead turnarounds are configured in a T-shaped or L-shaped layout at the end of a dead-end street, providing adequate space for large vehicles to complete a three-point turn. This option is commonly applied in constrained sites where a full cul-de-sac is not feasible.

To support overall street connectivity and circulation, the use of cul-de-sacs, dead-end streets and hammerhead turnarounds should be avoided if possible.

5.3 Roadway Design

5.3.1 Design Controls

Traffic volumes and speed are necessary for the design of roadways, and assist with the planning and design of ROW, number of lanes, turn-lanes, need of intersections, and bicycle and pedestrian facilities. Guidance on these design controls will be discussed at the pre-design meeting.

5.3.2 Street Sections

Street section standards are provided for arterial, collector, and local streets in **Error! Reference source not found.** below. Refer to the City of Denton Standard Details for cross-section details. Options for street sections are dependent upon treatment utilization within the street section. Besides defined lanes, other treatments that can be utilized within the street sections include on-street parking, bike lanes, multi-use paths, and transit facilities. The intent is to provide options in order to develop a "complete street" with "context-sensitive" design; *See* Section 5.11 of this Manual. ROW requirements may vary at intersections based upon turning movement requirements.

In general, street grades shall follow the natural contour of the property and be below the existing grade so that the parkway drains towards the street. Excessive cuts and fills solely for the purpose of balancing earthwork are not permitted.

Table 5.3-A : Geometric Roadway Standards

Criteria	Roadway Classification									
	FREEWAY	PRIMARY ARTERIAL	SECONDARY ARTERIAL	SECONDARY ARTERIAL (ONE-WAY)	MAJOR COLLECTOR	COMMERCIAL COLLECTOR	RESIDENTIAL COLLECTOR	RESIDENTIAL	RURAL OR SUBURBAN RESIDENTIAL	ALLEY [6,7]
No. of Lanes [1]	As per TxDOT standards	6	4	2-3	3-4	3	2-3	2	2	2
Min. ROW [10]		135′	110′	65′	110′	65′	65′	55′	65′	20′
Pavement Width [2] (BOC to BOC)		84′	62′	35′	48′-72′	39′	39′	33′	21′ [5]	15′ [5]
Median Width		14′	14′	NA	0′-14′	NA	NA	NA	NA	NA
Parkway Width		25.5′	24′	15′	18′-31′	13′	13′	11′	20′	NA
Min. Center Line Radius [3]		750′	575′	575′	575′	575′	400′	200′	200′	100′
Min. Horizontal Curve Separation		100′	100′	100′	100′	100′	100′	NA	NA	NA
Min. Grade (%)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Max. Grade [4] (%)		7	7	7	7	7	7	10	10	8
Design Speed (MPH)		40-45	35-40	30-35	30-35	30-35	30	30	30	10-15
On-street Parking		Prohibited	Prohibited	Permitted [8]	Prohibited [9]	Prohibited	Permitted [8]	Permitted [8]	Prohibited	Prohibited

Notes:
[1] The number of travel lanes is dependent upon TIA and/or the City's Engineer's requirements.
[2] See Table 5.4-D, Table 5.4-E, Table 5.4-F, and Table 5.4-G**Error! Reference source not found.**, for additional ROW requirements at intersections with turn lanes.
[3] The Minimum center line radius is based on the cross slope of -2% (no superelevation).
[4] The maximum grade within 60 feet of an intersection measured from the intersection curb is 2% or less.
[5] Measurement is edge-of-pavement to edge-of-pavement.
[6] If an alley is to be used for waste collection, it must meet all alleyway access requirements shown in Section 3: Solid Waste Design Criteria of this Manual.
[7] If an alley is intended to provide fire apparatus access, it must meet the design requirements of Section 5.6.3- Fire Apparatus Access Roads of this Manual.
[8] Parking is allowed unless otherwise prohibited by ordinance or by signs installed by the city.
[9] Parking is prohibited unless otherwise allowed by ordinance or by the City's Engineer, in which case only parallel parking is permitted.
[10] The developer shall dedicate from one-half of the required ROW, measured from the centerline of the existing street alignment, up to the full width of the required ROW for City-maintained facilities, in accordance with the City of Denton Mobility Plan.
[11] A 20-ft wide public utility easement is required along the property frontage where the property abuts a TxDOT-maintained roadway.
[12] The applicable standards, cross-sections, and design requirements shall be determined in coordination with the City Transportation Department.

5.4 Intersection Design

Several components of intersection design are addressed in this section. These standards are to work in concert with the Traffic Impact Analysis (TIA) requirements of this Manual. Additionally, the Pedestrian and Bicycle Facility Design, Transit Facility Design, and the City of Denton Standard drawings for accessibility should be reviewed for additional design requirements.

5.4.1 Geometry

A. Street intersections should be designed to be perpendicular; *see* tolerances shown in Table 5.4-A below. All streets shall be aligned with any existing streets by continuation of the centerline thereof.

B. The staggering of street alignment resulting in "T" intersections shall leave a minimum distance of 150 feet between the curb faces of residential streets, and 200 feet between the curb faces of collector streets.

C. Table 5.4-A and Figure 5.1 below provide requirements for ROW corner clips and curb return radius at intersections. These standards provide minimum vision clearance areas without consideration to stopping sight distance. Additional sight clearance evaluation should be performed as necessary, as per Section 5.4.3 below.

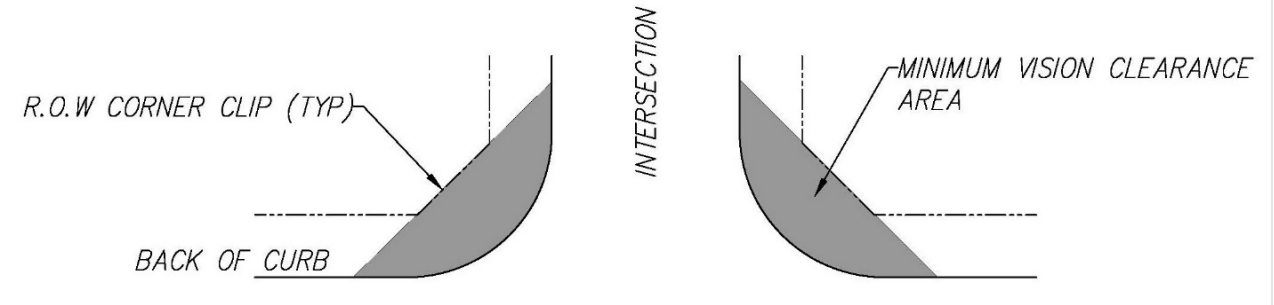


Figure 5.1 Minimum Vision Clearance

Table 5.4-A: Intersection Geometry

Intersection Classification	Intersection Angle (degrees)	ROW Corner Clip [1] (feet)	Curb Return Radius (feet)
Arterial - Arterial	90±5	30	30
Collector - Arterial	90±5	20	30
Collector - Collector	90±5	15	30
Residential Street - Arterial	90±5	15	30
Residential Street - Collector	90±10	15	20
Residential Street - Residential Street	90±10	10	20
Flag Drive - Collector	90±10	5	20
Flag Drive - Residential Street	90±15	5	10
Alley - Collector	90±10	10	30
Alley - Residential Street	90±10	15	30
Alley - Alley	90±10	25	30

Notes:
[1] Shall apply to all corners of the intersection.
[2] Fences must provide a 5-ft. corner clip adjacent to driveways.
[3] Curb Return Radius is for single lane design. Multi-lane and special considerations for truck-turning radius require turn radius analysis, as required by the City's Engineer.
[4] Major Collector shall follow the arterial street standard.

5.4.2 Visibility Standards

Table 5.4-B and Figure 5.2 below shall be used to evaluate the required unobstructed view for motorists at intersections, which are based upon the design speed approaching the intersection. Design speeds are based upon the roadway classification. The values shown in the table are minimum standards. Within the sight line area, no obstruction shall be allowed that will obstruct the view of motorists. A sight visibility easement shall be dedicated to protect and maintain sight visibility.

A. Table 5.4-B below is based upon passenger car right turn and left turn from stop. Where truck traffic warrants additional sight distance, refer to AASHTO Geometric Design of Highways and Streets for single-unit truck and combination truck design requirements, Case B1 and Case B2.

B. Refer to AASHTO Geometric Design of Highways and Streets for multi-lane considerations and other design considerations that may apply for Cases "A" through "F".

C. Lines of sight distance at all intersections shall be clear at an elevation between two (2) feet and nine (9) feet above the nearest gutter elevation.

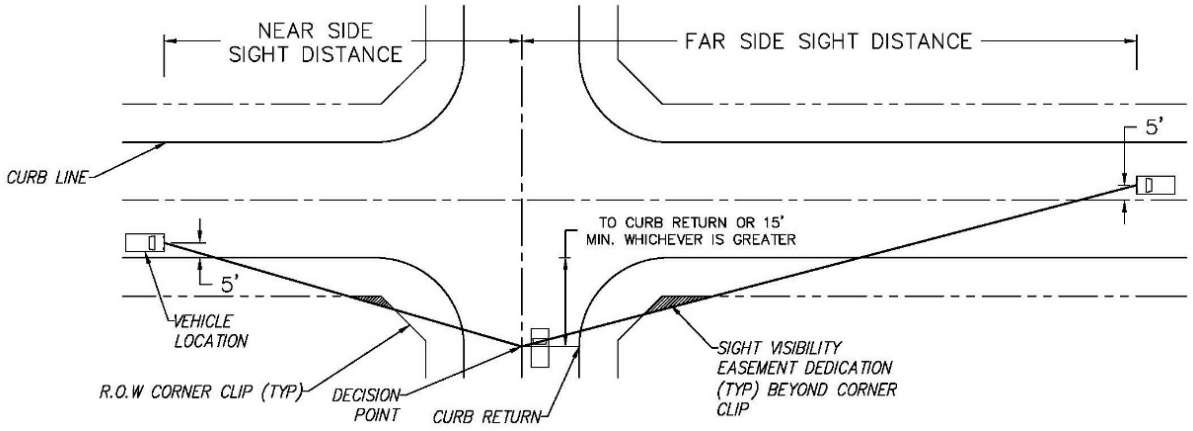


Figure 5.2 Visibility Standards

Table 5.4-B: Visibility Standards

Design Speed (mph)	Intersection Sight Distance Near Side (feet)	Intersection Sight Distance Far Side (feet)
30	290	335
35	335	390
40	385	445
45	430	500

Notes:
[1] Driveways accessing roadways shall use above table to satisfy intersection visibility compliance.

5.4.3 Vertical Curve Standards

Vertical curves are required when two (2) street grades intersect at a point of vertical intersection greater than 1%. Minimum vertical lengths for both crests or sags shall be defined by the design speed for the street and the associated stopping sight distance, as well as the minimum K value. Table 5.4-C below shows the minimum K value for various design speeds.

Table 5.4-C: Minimum 'K' Values for Vertical Curves

Design Speed (mph)	Stopping Sight Distance (feet)	Crest Vertical Curve (K Min)	SAG Vertical Curve (K Min)
30	200	19	37
35	250	29	49
40	305	44	64
45	360	61	79

Notes:
[1] Source: AASHTO Geometric Design of Highways and Streets 'US Greenbook'.

Vertical curve lengths can be calculated as shown in Equation 5.1 below:

$$L = KA \qquad \textbf{[Eqn. 5.1]}$$

Where: L = Vertical Curve Length

A = Algebraic Difference in Grade

A. No vertical curve required for "A" equal to or less than 1.0%

B. Minimum spacing between successive vertical curves shall be 50 feet for residential, and 100 feet for collectors and arterials.

C. Resultant vertical curve grade shall be no less than 0.3% for concrete pavement, and no less than 0.5% for asphalt pavement.

D. For drainage purposes, 50-ft. vertical curves are required when "A" is greater than 1.0% and less than or equal to 1.2%. Otherwise minimum vertical curve length is 100 feet.

5.4.4 Turn Lane Requirements

Turning lane requirements shall be based upon the following requirements and/or the requirements of the City's Engineer, and the tables within this section.

A. Left-Turn Lane Warrants

When designing an intersection that provides direct or indirect access to the proposed development, left-turn lanes should be provided at driveways and street intersections along major arterial and collector roads, wherever left turns are permitted. Traffic-volume-based guidelines for where left-turn lanes should be provided are presented in Tables 5.4-D (four-lane roadways) and 5.4-E (two-lane roadways) below.

Table 5.4-D: Left-Turn Warrants for Four-Lane Roadways [1] *Source: AASHTO A Policy on Geometric Design of Highways and Streets*		
Left-Turn Lane Peak-Hour Volume (veh/hr)	**Three-Leg Intersection, Major-Road Peak-Hour Volume (veh/hr/ln) that Warrants a Left-Turn Lane**	**Four-Leg Intersection, Major-Road Peak-Hour Volume (veh/hr/ln) that Warrants a Left-Turn Lane**
5	450	50
10	300	50
15	250	50
20	200	50
25	200	50
30	150	50
35	150	50
40	150	50
45	150	<50
50 or More	100	<50

Notes:
[1] These guidelines apply where the major road is uncontrolled, and the minor-road approaches are stop- or yield-controlled. Both the left-turn peak-hour volume and the major-road volume warrants should be met as shown in Figure 5.X.
[2] Major road volume shall be calculated as the total traffic volume from both approaches of the major roadway, divided by the total number of through lanes on those approaches.

Table 5.4-E: Left-Turn Warrants for Two-Lane Roadways [1] *Source: AASHTO A Policy on Geometric Design of Highways and Streets*		
Left-Turn Lane Peak-Hour Volume (veh/hr)	**Three-Leg Intersection, Major-Road Peak-Hour Volume (veh/hr/ln) that Warrants a Left-Turn Lane**	**Four-Leg Intersection, Major-Road Peak-Hour Volume (veh/hr/ln) that Warrants a Left-Turn Lane**
5	200	150
10	100	50
15	100	50
20 or more	50	< 50

Notes:
[1] These guidelines apply where the major road is uncontrolled, and the minor-road approaches are stop- or yield-controlled. Both the left-turn peak-hour volume and the major-road volume warrants should be met.
[2] Major road volume shall be calculated as the total traffic volume from both approaches of the major roadway, divided by the total number of through lanes on those approaches.
[3] Bypass lanes warrant analysis at three-leg rural intersections shall follow the TxDOT Roadway Design Manual.

Figure 5.3 below guides the left-turn lane design plan. Conditions for requesting a left-turn lane include large truck volume, high crash history, limited sight distance, and significant delay for motorists to make the turn, as determined by the City's Engineer. Further discussion and examples of left-turn lane guidance can be found in AASHTO's Policy on Geometric Design of Highways and Streets.

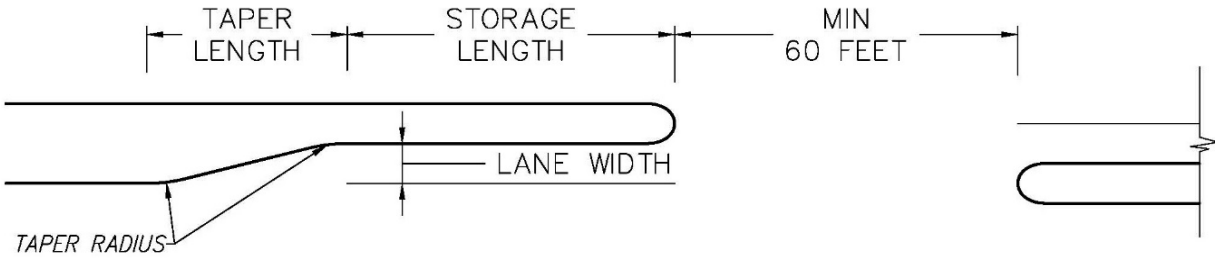


Figure 5.3 Left-Turn Lane

B. Right-Turn Lane Warrants

When designing an intersection that provides direct or indirect access to the proposed development, right-turn lanes should be provided along major arterial and collector roads at driveways when the right turns are permitted and satisfy the following criteria. Table 5.4- G below provides criteria which warrant right-turn lanes. Figure 5.4 below provides guidance on right-turn lane requirements.

Table 5.4-F: Right-Turn Warrants for Urban and Suburban Roadways

Roadway Classification	Speed Limit (mph)	Volume (Vehicles per Hour)
Arterial / Collector	45 or greater	50 or more
Arterial / Collector	Less than 45	60 or more

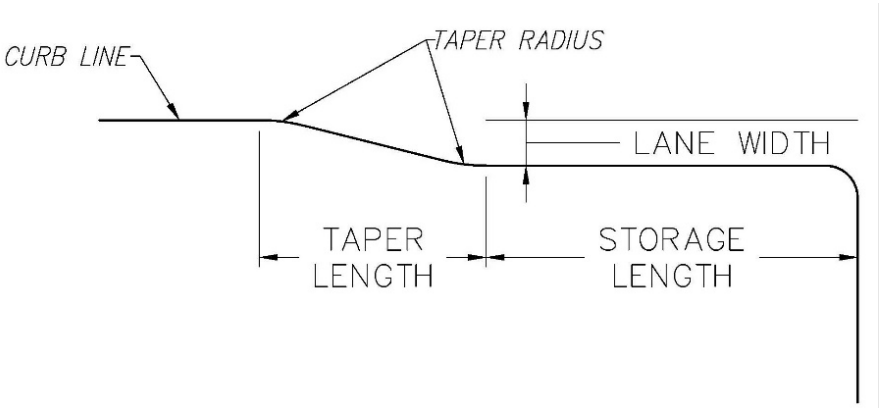


Figure 5.4 Right-Turn Lane

Conditions for requesting an exclusive right-turn lane when right-turn traffic volume projections are less than indicated in Table 5.4- G, include the following, as determined by the City's Engineer:

1. Large volume of truck traffic,
2. High crash history,
3. Roadways with limited sight distance, or
4. Heavier than normal peak flow movements on the main roadway.

C. Turn Lane Geometry

When a turn lane is required, Table 5.4- H below shall be used as the minimum criteria for the turn

lane geometry. Additional consideration shall be given for unique traffic movements such as excessive tractor trailer utilization, extended length transport vehicle movement, etc. *See* Section 5.4.5 below for additional geometry standards for Collectors and Arterials.

Table 5.4-G: Minimum Turn Lane Geometry

Intersection Type	Lane Width (feet)	Minimum Storage Length (feet)	Minimum Taper (feet)		Additional ROW Required (feet)
			LEFT TURN	RIGHT TURN	
Residential Collector	11	100	100	100	15
Major/Commercial/Industrial Collector	11	150	100	150	15
Secondary Arterial	11	150	100	200	15
Primary Arterial	11	200	100	200	15

Notes:
[1] Required turn lane storage may be greater depending upon the TIA.
[2] The Pedestrian Path shall be taken into account for access across the median by utilizing a leave-out or ramp in accordance with accessibility standards described in this manual.
[3] Cross slope of median openings or turn bays shall not be more than 2% or less than 1%.
[4] On TxDOT Roadways, TxDOT Roadway Design Manual standards shall supersede City of Denton Standards.
[5] Taper Radius shall be 200 feet minimum.
[6] Additional ROW required per turn lane bay, if ROW is not sufficient.

5.4.5 Intersection Detail for Collectors and Arterials

Figure 5.5 below provides median location details and specific turn lane radius requirements. Also refer to median details shown in the City of Denton Standard Details.

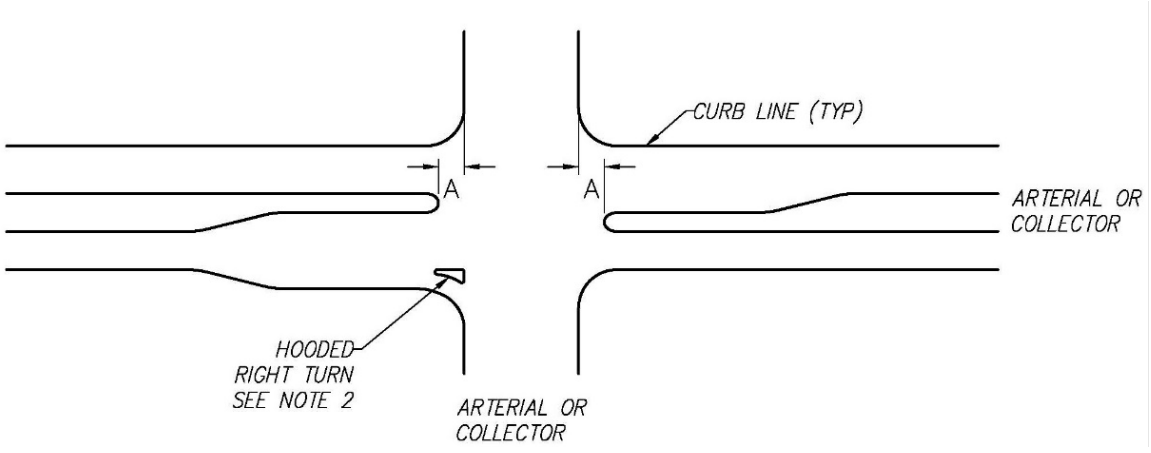


Figure 5.5 Intersection Detail for Collectors and Arterials

Notes:
1. For collector and arterial streets, A = 15 feet minimum.
2. Depending upon traffic flow requirements, the right turn may require a hooded right turn.

5.4.6 Intersection Spacing

Standards for intersection spacing are outlined below in Table 5.4- H.

Table 5.4-H: Minimum Intersection Spacing [1]

Roadway Classification	Alley	Flag Drive	Residential	Collector	Arterial
Alley	100 feet	N/A	100 feet	100 feet	N/A
Flag drive	N/A	N/A	75 feet	75 feet	N/A
Residential	100 feet	75 feet	200 feet [2]	200 feet [2]	400 feet
Collector	100 feet	75 feet	200 feet [2]	200 feet [2]	400 feet
Arterial	N/A	N/A	400 feet	400 feet	1200 feet

Notes:
[1] Spacing will be measured between face of the curbs.
[2] 100-ft. minimum to the first intersection for entrances to subdivisions off of an arterial, where lots back up to the arterial.

5.4.7 Roundabouts

Roundabouts are circular intersections that create counter-clockwise traffic movements around a central island, with entering traffic yielding to circulating traffic.

The design of a roundabout shall be in compliance with the Intersection Control Evaluation provided by the FHWA. Normally, each roundabout will be unique in some way, as such a standard roundabout is not included in this Manual. Also, the various analyses and design considerations involved in roundabout design are beyond the scope of this Manual.

A. The following resources shall be used when designing a roundabout:
   1. TxDOT Roadway Design Manual
   2. NCHRP Report 1043: Guide for Roundabouts (2023)
   3. Federal Highway Administration Roundabouts, An Information Guide
   4. Federal Highway Administration Roundabouts, Technical Summary

B. In addition to the resources provided above, the roundabout design shall include the following design review process with the City's Engineer and City Staff:
   1. Have a Pre-Application Conference on the project, which will include a separate meeting with the City's Engineer for proposed roundabout design considerations;
   2. Have a Traffic Impact Analysis (TIA) review meeting with the City's Engineer. *See* section on TIA requirements;
   3. Develop Preliminary layout of roundabout considering TIA and Pre-Development meetings;
   4. Preliminary Design review meeting with the City's Engineer;
   5. Develop roundabout design based up comments from the City's Engineer; and
   6. Submit roundabout design through the Development Review Process (DRP).

5.5 Auxiliary Roadway Design

5.5.1 Alleys

A. Alleys shall have at least two (2) direct access points to public streets and are subject to the block length criteria included in this Manual.

B. Alleys shall be a minimum of 15 feet wide, with edges sloping towards the centerline at 3% slope.

C. No drainage infrastructure will be allowed within the alley ROW. Alleys shall be designed to convey all runoff along the surface of the pavement.

D. Alleys that are intended to provide fire apparatus access must meet the design requirements of Section 5.6.3-Fire Apparatus Access Roads of this Manual.

E. Refer to City of Denton Standard Detail T103C for further details.

5.5.2 Drives

The design criteria for drives detailed in this section should be utilized in conjunction with the standards outlined in DDC 8.3 (Lot Planning). The following standards generally apply to all developments. However, there may be unique situations for which these standards may be impractical. In these situations, the City's Engineer will work with the developer to develop a mutually agreeable solution. In the event that a mutually agreeable solution is not reached, the developer may apply to the Planning and Zoning Commission for consideration of the issue.

A. Drive Approach Standards

Table 5.5-A: Drive Approach Dimensions

Development Type [1]	Drive Approach Widths		Radius
	MIN. WIDTH (FEET)	MAX. WIDTH [2] (FEET)	(FEET)
Residential – Single-family or Duplex	12	20	5 [3]
Residential – Multifamily	24	38	10 to 20
Commercial or Industrial [4]	30	38	20 to 25

Notes:
[1] Driveways on TxDOT roadways - driveway width and curb radius shall meet TxDOT Roadway Design Manual standards.
[2] Refer to Figures 5.6 through 5.10.
[3] If the drive approach is part of the fire apparatus access road, refer to Section 5.6.3 of this manual.
[4] Maximum drive approach width is a function of traffic volume.
[5] Add five (5) feet to maximum radius for significant truck traffic.
[6] For shared drive approaches, no lot shall contain less than nine (9) feet of the drive approach and driveway or drive aisle (as may apply). Drive approach shall be centered on lot line, such that maximum drive approach width equals 30 feet.

1. Residential

   a. One (1) single-family or one (1) duplex residential lot accessing a collector may be permitted to have one (1) full-width or circular drive approach (Figure 5.6 below), when alleys are not practical.

   b. Two (2) adjacent single-family or two (2) adjacent duplex residential lots accessing a

collector may be permitted to have one (1) shared full-width or circular drive approach, when alleys are not practical.

c. Three (3) or more contiguous single-family or three (3) or more contiguous duplex residential lots accessing a collector will be required to enter the collector by an alley, flag drive, or residential street.

d. One (1) single-family or one (1) duplex residential lot accessing an arterial, will be required to have an on-site facility, allowing entrance into the arterial in a forward manner.

e. For homes with a 3-car garage or greater, where the garage door is street-facing and less than 40 feet from the back of curb, the maximum drive approach width shall be 30 feet.

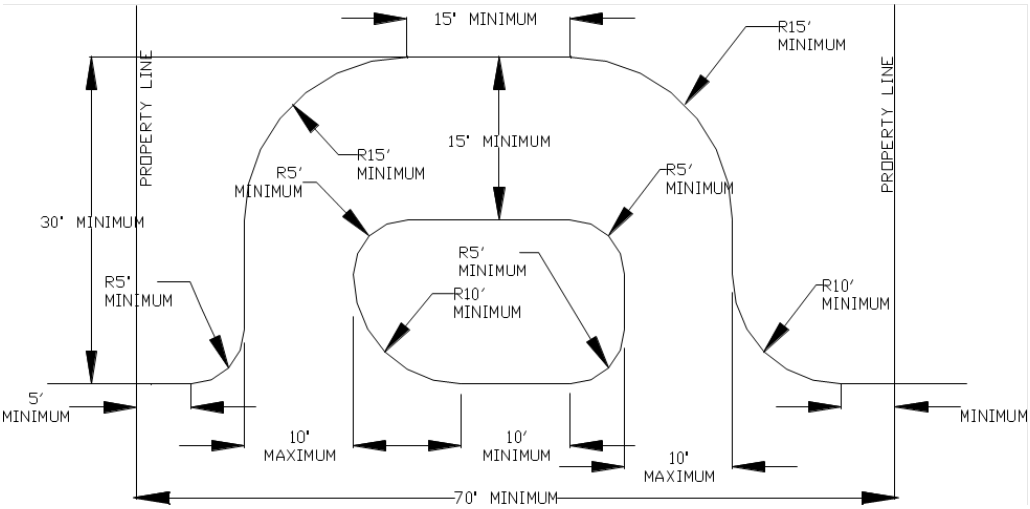


Figure 5.6 Residential Circular Drives

2. Commercial

a. All stop bar markings and stop signs when used shall be on private property, as well as upstream of any pedestrian facility crossing the drive approach and/or drive aisle.

b. All signs and markings should be consistent with TMUTCD.

c. Drive approaches with significant truck traffic may install surmountable curb with textured and colored pavement in the parkway, with a depth equal to or greater than the drive approach pavement requirement.

d. Ingress/Egress Lanes

i. Single Lane Egress/Ingress (Figure 5.7) - The outbound (towards the street) lane shall be a minimum of 12 feet wide; if the width of the driveway is greater than 30 feet, then the inbound (onto the site) lane shall be a minimum of 18 feet wide.

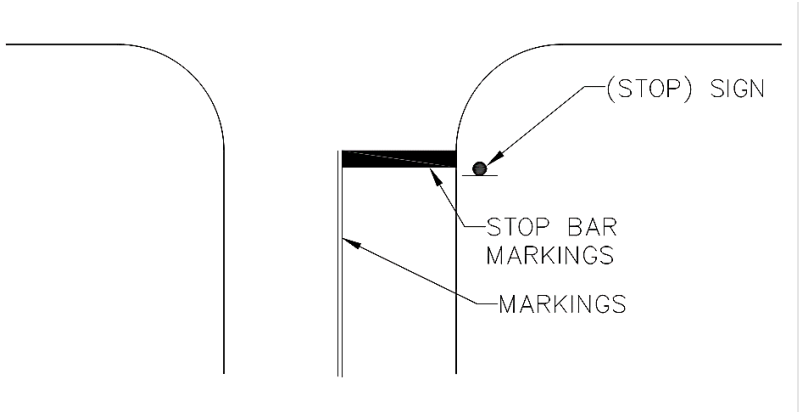


Figure 5.7 Drive Approach: Single Lane Egress/Ingress

ii. Dual Lane Egress, Single Lane Ingress (Figure 5.8) - The outbound lanes shall be 10 feet wide; if the width of the driveway is greater than 30 feet, then outbound lanes shall remain 10 feet wide while the width of the inbound lane shall be increased.

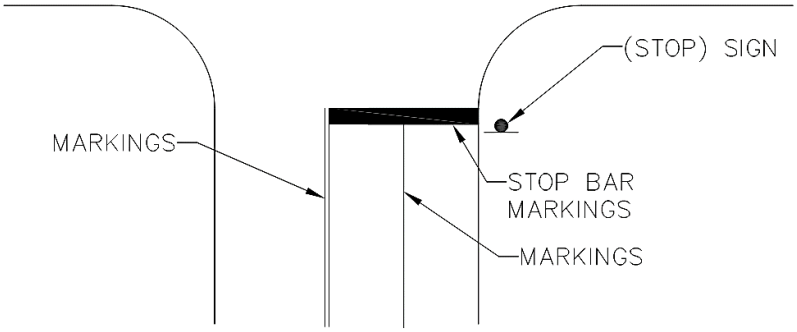


Figure 5.8 Drive Approach – Dual Lane Egress, Single Lane Ingress

iii. Multiple Lane Egress/Ingress (Figure 5.9) - Only allowed when dual left-turn lanes into the site or opposing street/driveway has two (2) or more lanes, of which two (2) are designated as being through lanes.

d) Each of the two (2) outbound and inbound lanes shall be 10 to 12 feet wide.
e) Median shall accommodate any pedestrian facility across the drive approach and/or drive aisle, as projected from both sides thereof.

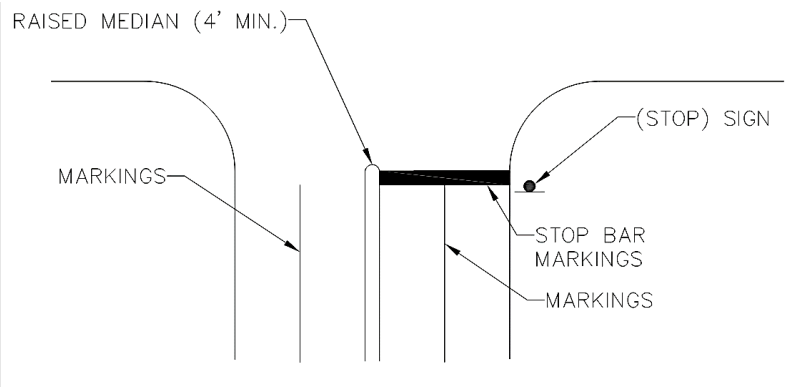


Figure 5.9 Drive Approach – Multiple Lane Egress/Ingress

iv. Right-in or Right-out Egress/Ingress - The minimum width of the drive approach/drive aisle prior to the island, each lane (inbound and outbound) at the island, and the applicable radii shall be determined by the engineer of record, based on expected vehicle type(s), as well as an auto-turn analysis provided to the City's Engineer for review and approval as part of the Civil Engineering Plan submittal.

a) Median/island shall accommodate any pedestrian facility across the drive approach and/or drive aisle as projected from both sides thereof.
b) For "one way in" or "one way out" driveways, the geometry shall be as shown in Figure 5.10 below for the respective side.
c) Through a Design Deviation request, the minimum drive approach width may be reduced based upon acceptable turning radius for emergency vehicles, and determination that truck traffic requiring the larger width will not occur.
d) When the right in/right out drive approach is part of the fire apparatus access road, the minimum width of each drive shall be 24 feet.

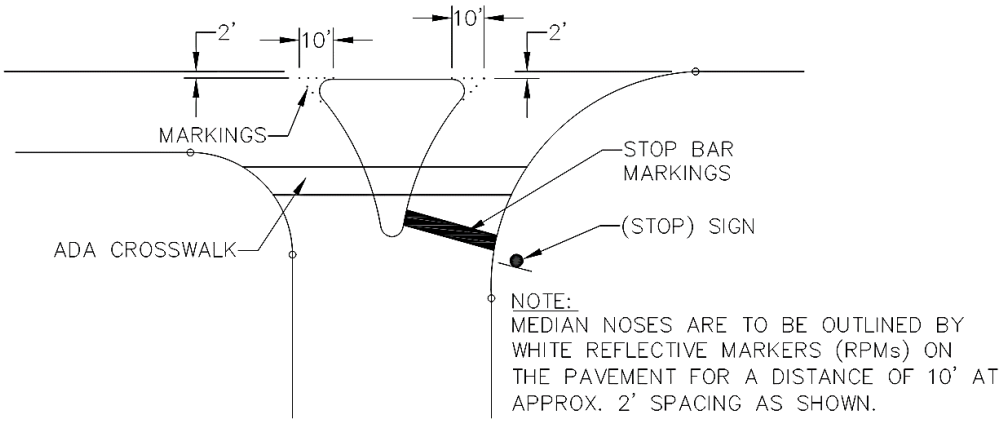


Figure 5.10 Drive Approach – Right in or Right out Egress/Ingress

v. With the exception of multi-lane egress/ingress (shown in Figure 5.9), drive approaches with a median installed in lieu of the double-yellow marking, may exceed the maximum drive approach width by the width of the median only.

vi. Right-in/right-out driveways along TxDOT frontage roads may be designed without a porkchop unless the driveway is in close proximity to exit and entrance ramps. A regular driveway approach with one-way signs is acceptable

B. Drive Approach Spacing

1. Same side of the street

Drive approach spacing shown in Table 5.5-B below applies to drive approaches on the same side of the street, and is measured between the nearest edges of each drive approach, along the back of curb, not including the radius.

Table 5.5-B: Minimum Drive Approach Spacing

Roadway Classification	Min. Spacing [1] (feet)
Primary Arterial	200 [2]
Secondary Arterial	150 [2]
Major Collector/Collector	100 [3]
Residential Street [4]	50
Flag Drive	10
Alley	10

Notes:
[1] Driveways on TxDOT roadways must meet the minimum spacing in the TxDOT Access Management Manual, Table 2-2.
[2] A maximum of two (2) drive approaches permitted. If a second point of access is required by City Fire Code official, it must be remote, meaning driveways are spaced no less than half the diagonal of the maximum overall dimension of the lot.
[3] If permitted; drive approaches are not permitted on arterial streets, unless otherwise allowed according to Section 5.6 of this Manual.
[4] If permitted; refer to Section 5.6 of this Manual for permitted access.
[5] For a T-intersection on residential streets, the drive approach shall be offset farthest from the intersection.
[6] Single-family driveways on residential streets require a minimum spacing of 10 ft.

2. Near Intersections

Drive Approach spacing shown in Table 5.5-C below applies to drive approaches near intersections and is measured between the face of the curb of the intersecting street and the nearest edge (face of curb) of the drive approach not including the drive approach radius; *see* Figure 5.11 below.

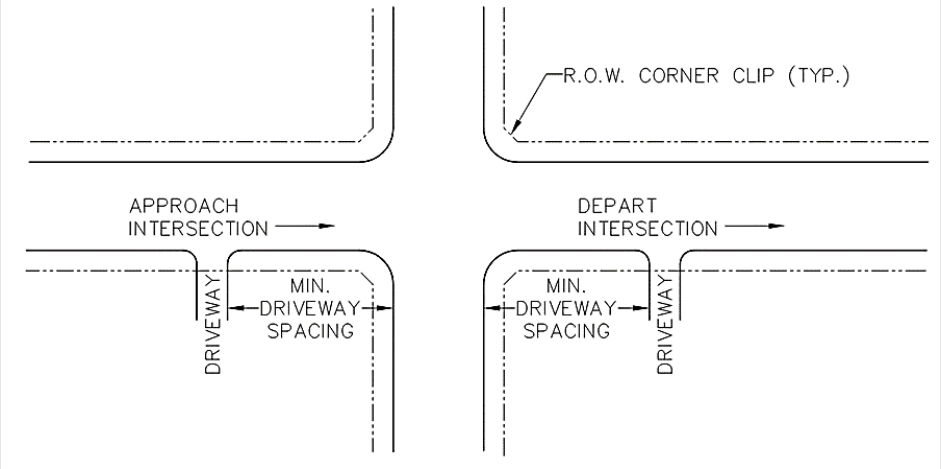


Figure 5.11 Drive Approach Spacing at Intersections

Table 5.5-C: Minimum Drive Approach Spacing at Intersections

Intersection Type	Approaching the Intersection	Departing the Intersection
Arterial - Arterial [1]	150 feet on both streets	200 feet on both streets
Collector - Arterial [1]	75 feet on collector, 150 feet on arterial	100 feet on collector, 200 feet on arterial
Collector - Collector	75 feet on both streets	100 feet on both streets
Residential - Arterial [1]	50 feet on residential, 150 feet on arterial	50 feet on residential, 200 feet on arterial
Residential - Collector	50 feet on residential, 75 on feet collector	50 feet on residential, 100 feet on collector
Residential - Residential [2]	50 feet on both streets	50 feet on both streets
Flag Drive - Collector [1]	20 feet on flag drive, 75 feet on collector	20 feet on flag drive, 100 feet on collector
Flag Drive - Residential [1]	20 feet on flag drive, 50 feet on residential	20 feet on flag drive, 50 feet on residential
Alley - Collector [1]	20 feet on alley, 75 feet on collector	20 feet on alley, 100 feet on collector
Alley - Residential [1]	20 feet on alley, 50 feet on residential	20 feet on alley, 50 feet on residential
Alley - Alley	10 feet on both alleys	10 feet on both alleys

Notes:
[1] If permitted by the City's Engineer.
[2] Driveways across T-intersections on residential streets are exempt.

3. Offset and relative to median openings (See Figures 5.12 and 5.13 below)

   a. For collector streets, drive approaches that do not align across the street from each other must be offset by a minimum of 75 feet between nearest tangent-edge to nearest tangent-edge.

   b. For arterial streets without medians, drive approaches must align across the street from each other, and must be approved by the City's Engineer. When this is not physically possible or practical as determined by the City's Engineer, drive approaches that do not align must be offset across the street from each other by a minimum of 150 feet between nearest tangent-edge to nearest tangent-edge.

   c. For arterial streets with medians, drive approaches must align with existing or proposed

median openings. Where this is not possible or practical as determined by the City's Engineer, drive approaches must be placed as far away from the existing or proposed median opening as is reasonably possible.

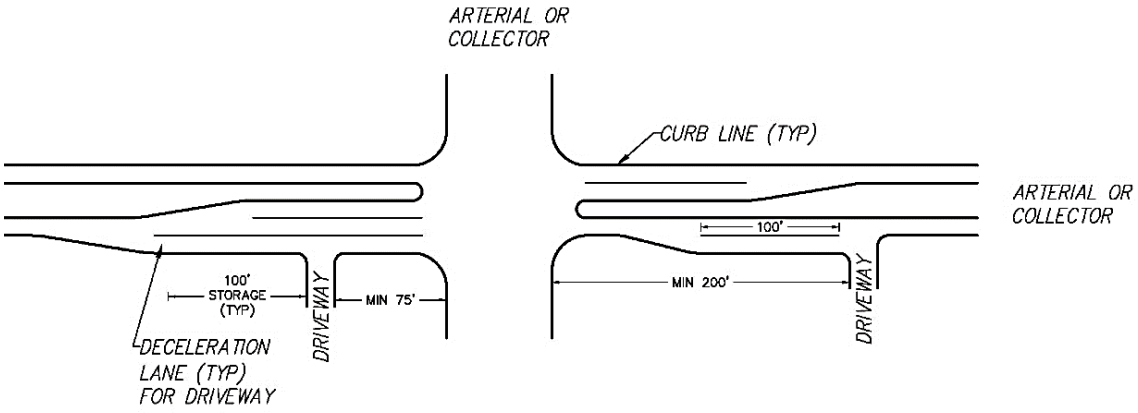


Figure 5.12 Drive Approach Near Turning Movements

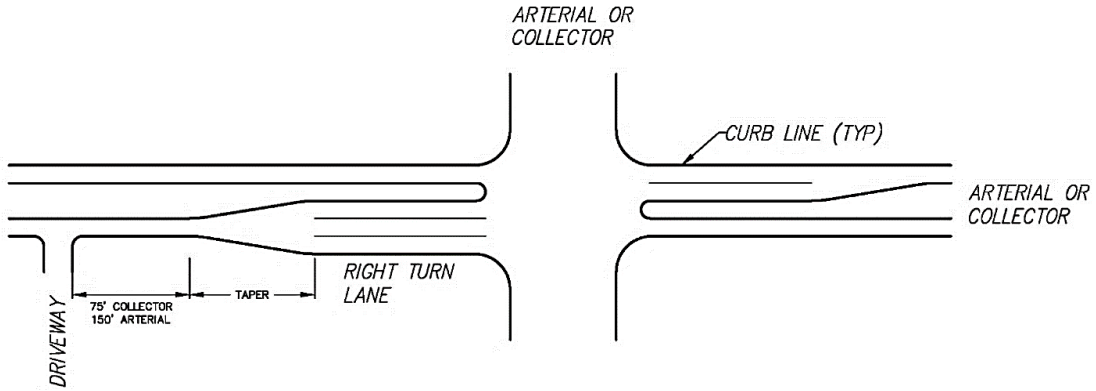


Figure 5.13 Drive Approach Near Turning Movements

C. Drive Approach Grades

1. Minimum Drive Approach Slope:

   The minimum drive approach slope shall be determined by:

   $$S = (6 + [0.02 \times W \times 12]) / (W \times 12) \quad \textbf{[Eqn. 5.2]}$$

   Where: W = the width of the parkway in feet as shown on the City of Denton Standard Details.

2. Maximum Drive Approach Slope: Unless otherwise approved by the City's Engineer through a design deviation request (Section 9), the maximum drive approach slope shall be 12%.

3. Difference in Drive Approach Grade: Driveway profiles shall not have a grade difference greater than 5%, without constructing a vertical curve. A minimum K-value of 4 is recommended for driveways accommodating low ground clearance or long wheelbase vehicles.

4. Sidewalks in Drive Approach: Maximum sidewalk cross slope within the limits of the drive approach shall be 2%.

5. Sidewalk Easement Requirement: Where the parkway width is insufficient to provide appropriate drive approach slope, a sidewalk easement will be required, equal to the balance of the sidewalk width needed outside the ROW plus two (2) feet. The additional two (2) feet requirement is for sidewalk installation and maintenance. The balance of the sidewalk width needed is based upon using the minimum drive approach slope calculated in Section 5.5.2.C.1 above. *See* Figure 5.14 below as well as City of Denton Standard Details.

6. Driveway/Drive Aisle Consideration: The drive approach slope from the bottom of the gutter to the nearest edge of the sidewalk (within the limits of the ROW) shall not exceed the driveway/drive aisle slope beginning at the furthermost edge of the sidewalk. Also, it shall not be less than the minimum slope, nor be greater than the maximum slope as noted herein.

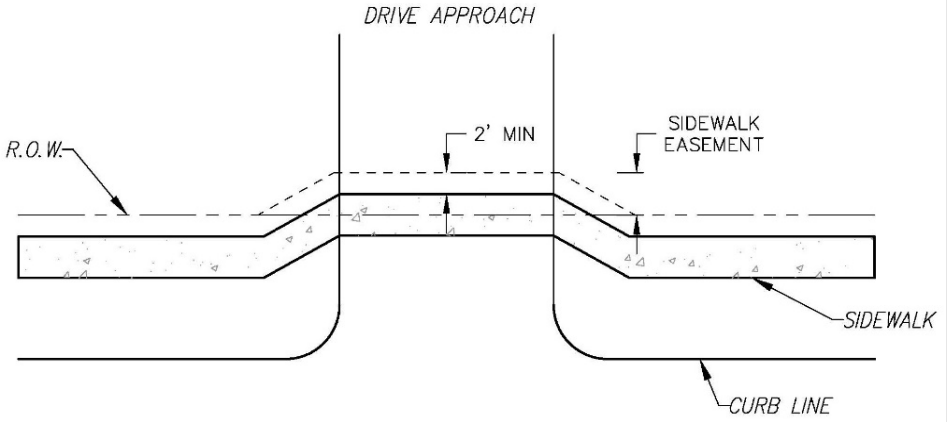


Figure 5.14 Sidewalk Easement to meet Drive Approach Slope

D. Driveway Throat Length Requirements

1. Minimum throat length requirements are shown in Table 5.5-D below. Note that throat length requirement applies to both edges of the drive approach.

2. All drive approaches that access an arterial shall be classified as a primary drive approach. If no drive approaches access an arterial, then the drive approach expected to receive the most traffic is considered to be the primary drive approach.

3. The throat length is measured between the first parking space or drive aisle and the curb line, whichever is closer to the curb line.

4. Parking lots with 10 or less parking spaces may use a minimum throat length of 10 feet for drive approaches accessing a residential or collector street.

5. For gated entries, a minimum storage of 100 feet must be provided from the travel lane face of the curb with an area for turnaround.

6. A queuing analysis shall be required for gated entrances and drive-throughs.

Table 5.5-D: Minimum Throat Length		
No. of Parking Spaces	**Min. Throat Length for Primary Drive Aisle (feet)**	**Min. Throat Length for Secondary Drive Aisle (feet)**
0 to 100	20	20
101 to 250	40	20
251 to 500	60	40
501 to 1000	80	60
1001 and above	Queuing Analysis Required	Queuing Analysis Required

E. Driveway Separation

Driveways shall be separated in accordance with Table 5.5-B to ensure that all driveways are separated by sufficient distance so as to avoid interfering with the safe movement of traffic. In interpreting and applying the separation requirements, the following shall apply:

1. The separation requirements shall be determined in reference to any proposed or existing driveways on or off the property. Where applied to a property, which is located adjacent to an undeveloped tract, the separation requirements shall account for the placement of future driveways on the adjacent undeveloped property.

2. The minimum separation specified may be reduced for currently developed property, if the amount of street frontage for the property is insufficient to allow for one (1) driveway access that would have the necessary separation from an existing driveway on adjacent property, and joint access with adjacent properties is not physically possible, as determined by the City's Engineer. If a reduction in the minimum separation specified is allowed, the separation shall be reduced only to the degree necessary to allow for the single driveway.

F. Corner Clearance Standards

Corner clearance standards shall be applied in accordance with AASHTO "Green book" to ensure that the traffic movements from driveways do not unduly conflict with the movement of traffic on intersecting public streets. In interpreting and applying the corner clearance standards, the following shall apply:

1. A reduced requirement may only be used if absolutely necessary to provide driveway access to property where no other means of access meeting the corner clearance requirement is reasonably possible, and joint access with adjacent properties is not physically possible as determined by the City's Engineer. If a reduction in the minimum corner clearance specified is allowed, the corner clearance shall be reduced only to the degree necessary to allow for the single driveway.

2. The specified distances shall be measured at the ROW line from the edge of the driveway nearest the intersecting street to the ROW line of the intersecting street. Where ROW corner clips exist or are proposed, the specified distance shall be measured from the edge of the driveway nearest the intersecting street and the end of the corner clip nearest to the subject driveway.

G. Modifications to Existing Drives

Existing non-compliant drives may be modified to comply with criteria set forth in this Manual, but may not be modified in a way that increases the non-compliance with this Manual.

H. TxDOT Drives

All drives connecting to TxDOT roadways shall meet all required TxDOT standards, in addition to meeting City of Denton standards when applicable.

5.5.3 Cul-de-sacs

A. Geometrical Standards

1. Maximum length of a Cul-de-sac shall be 600 feet measured from the centerline of the intersecting street to the Cul-de-sac radius point, and perpendicular to the intersecting street centerline.
2. Minimum length of a Cul-de-sac shall meet Fire Code requirements.
3. Residential Cul-de-sacs shall not have more than 29 residential lots.
4. The center radius of the Cul-de-sac shall be a minimum of 50 feet for residential developments, and 60 feet for commercial and industrial developments measured from the center point to the face of curb or edge of pavement where there is no curb.
5. The Cul-de-sac return radius shall be 30 feet.
6. Cul-de-sac minimum street grades shall be as shown below in Figure 5.15 and Figure 5.16 below for downward gradient and upward gradient, respectively.

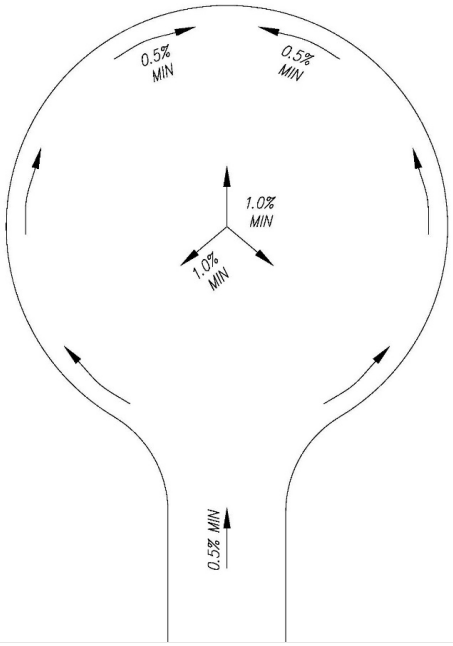


Figure 5.15 Cul-de-sac Minimum Slope - Downward Gradient

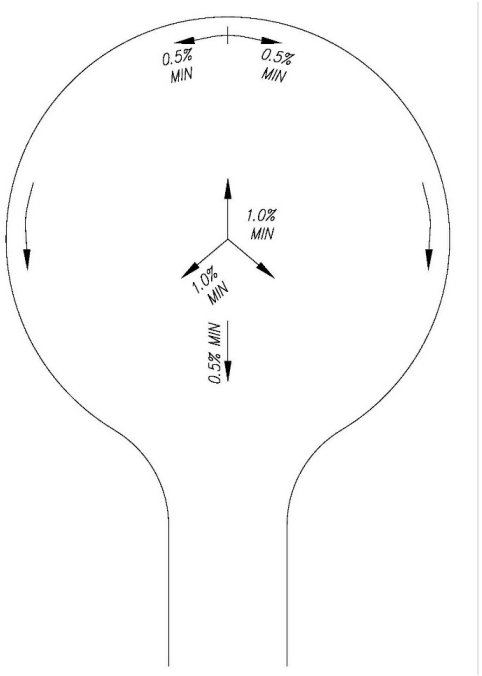


Figure 5.16 Cul-de-sac Minimum Slope - Upward Gradient

B. Offset Cul-de-sacs

1. Offset Cul-de-sacs shall have the same radius and return radius as the standard Cul-de-sac.
2. The length of the offset Cul-de-sac shall be measured from the centerline of the intersecting street to the Cul-de-sac radius point, perpendicular to the intersecting street centerline.

C. Temporary Turn-Around

1. A temporary turn-around shall be limited to approved phase developments where the street will be extended in the future.
2. A temporary turn-around shall meet the requirements of a standard Cul-de-sac for radius and return radius size.
3. The length of street associated with the turn-around shall not be any greater than 600 feet nor less than Fire Code requirements.
4. If the length of street will be greater than 600 feet, then the next block length of street and intersecting streets shall be constructed in order to provide looped traffic flow for emergency vehicles.
5. The turn-around section shall be constructed to the same structural section as the street section less curb and gutter requirements, unless drainage requirements warrant curb and gutter.

5.5.4 Hammerhead Turnarounds

A. The legs of the hammerhead (forming the "T" shape) should be at least 60 feet in length, measured from the centerline of the intersecting roadway.

B. The turnaround must be constructed to support heavy vehicles and meet all width and corner radius

standards required for emergency access.

C. No parking or obstructions are allowed within the hammerhead area to ensure full access for emergency vehicles.

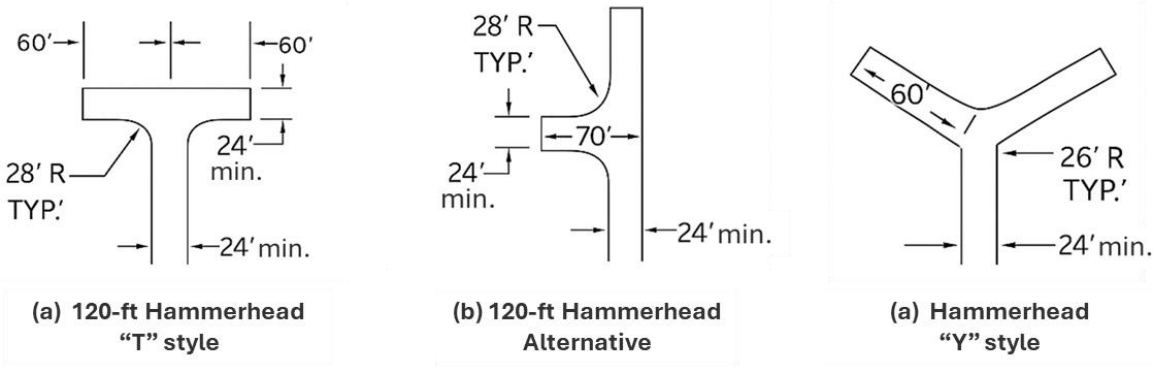


Figure 5.17 Hammerhead Turnarounds

5.5.5 Supplementary Design Elements

A. Signage and striping

Signage and pavement markings shall be as shown in the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

1. New subdivisions must include STOP signs on minor street approaches and All-Way STOP control (AWSC) where long stretches of Residential, Collector, and Arterial intersections. (Determined by the reviewer or City's Engineer) . The City's Engineer must approve AWSC signs.
2. Midblock crossings are discouraged; where it's inevitable, it must have LED- Crosswalk Signs, Ped warning, Ped crossing signs, Rectangular Rapid-Flashing Beacons (RRFBs), Pedestrian Hybrid Beacons (PHBs), or other active crossing signs as directed by the City's Engineer.
3. Crosswalk Markings - Continental style – Two (2) feet wide by 10 feet long white thermoplastic
    a. Crosswalks shall only be installed if there are Barrier-Free Ramps (BFRs) on both ends of the road.
    b. Crosswalks are required only on Collectors and above, not on residential, local streets, or alleys.
4. 'STOP' Bars – 24 inches white thermoplastic located 2 inches from the crosswalk or aligned with 'STOP' signs.

B. On-street Parking

Consistent with the requirements of Public Rights of Way Accessibility Guidelines (PROWAG), the following Americans with Disabilities Act (ADA) on-street parking requirements shall be followed:

1. General
    a. On-street parking is permitted for residential and residential collector streets, unless prohibited by the City's Engineer.

b. On-street parking should be parallel, while angled and perpendicular parking requires approval from the City's Engineer.

c. On-street parking for proposed commercial/industrial collectors or arterials is not allowed. Where on-street parking is designated, one (1) on-street parking space for each single-family unit on a block is required on the frontage street within that block.

d. Areas in front of a driveway, within five (5) feet of a driveway, within 20 feet of a street intersection, or within 15 feet of a fire hydrant shall not be counted toward the required on-street parking.

2. Parallel Parking

a. For parallel parking spaces where the adjacent sidewalk or available ROW is more than 14 feet wide, an access aisle must be provided at street level for the entire length of each accessible parallel parking space.

b. The access aisle must be a minimum of five (5) feet wide and connect to a pedestrian access route.

c. The access aisle must not encroach on the vehicular travel lane and must comply with the technical requirements for surfaces.

d. In alterations where the street or sidewalk adjacent to the parking spaces is not altered, an access aisle is not required, provided the parking spaces are located at the end of the block face.

e. Where the adjacent sidewalk or available ROW is less than or equal to 14 feet wide, an access aisle is not required, but accessible parallel parking spaces must be located at the end of the block face.

Figure 5.18 shows the acceptable parking configuration for on-street parallel parking.

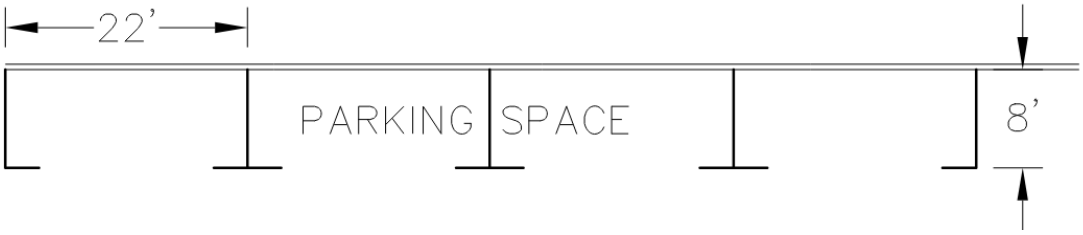


Figure 5.18 Parallel Parking

3. Perpendicular and Angled Parking

a. For perpendicular and angled parking spaces, an access aisle must be provided at street level for the entire length of each accessible perpendicular or angled parking space.

b. The access aisle must be a minimum of eight (8) feet wide to accommodate vans with lifts and connect to a pedestrian access route.

c. Two (2) accessible parking spaces are permitted to share a common access aisle.

d. The access aisle must be marked to discourage parking in the aisle and comply with the technical requirements for surfaces.

Figures 5.19 through 5.22 show the acceptable parking configurations for on-street angled parking.

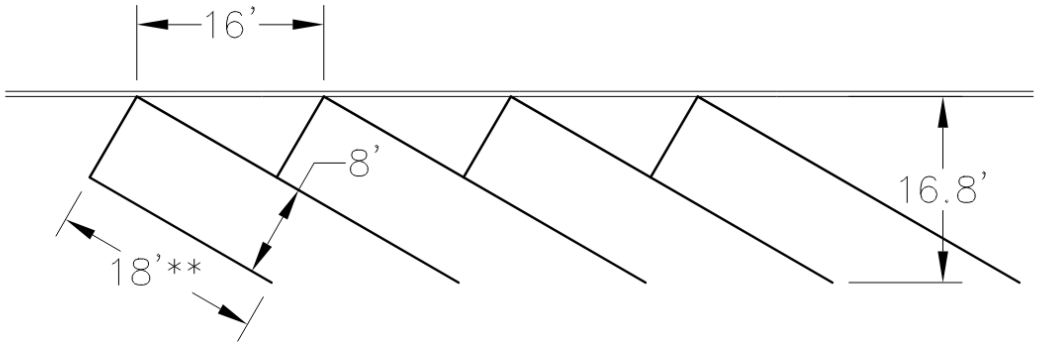


Figure 5.19 Angled Parking – 30 degrees

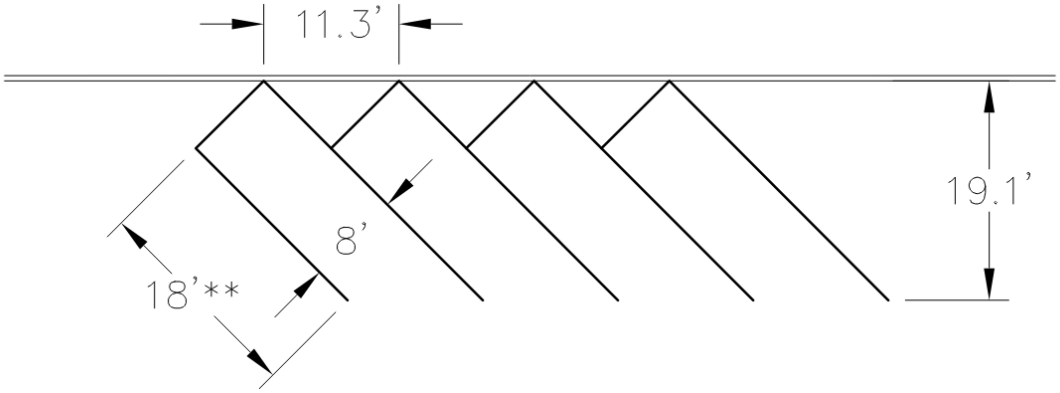


Figure 5.20 Angled Parking - 45 degrees

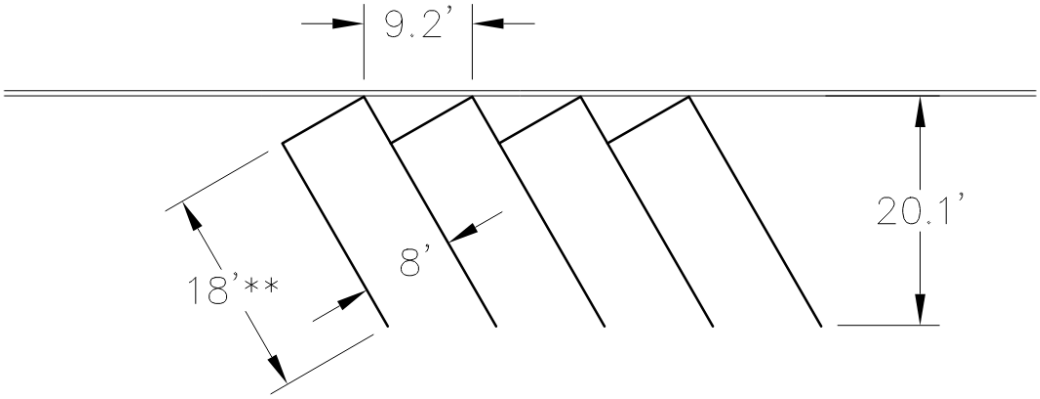


Figure 5.21 Angled Parking - 60 degrees

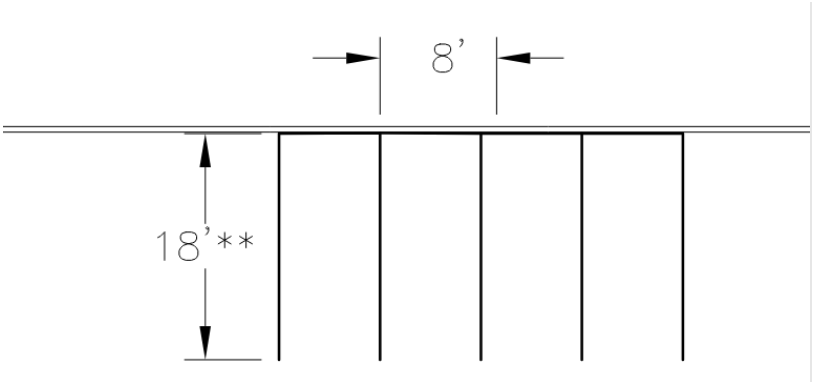


Figure 5.22 Angled Parking - 90 degrees

4. Curb Ramps and Blended Transitions
    a. Curb ramps and blended transitions must connect the access aisle serving each accessible on-street parking space to the pedestrian access route.
    b. Curb ramps are not permitted within the access aisle.
    c. Parking spaces at the end of block face can be served by curb ramps or blended transitions at the pedestrian street crossing.
    d. Detectable warning surfaces are not required on curb ramps and blended transitions that connect the access aisle to the sidewalk, including where the sidewalk is at the same level as the parking spaces, unless the curb ramps and blended transitions also serve pedestrian street crossings.
5. Other
    a. Wheel stops will be required to prevent vehicle overhang into adjacent property, ROW, structures, landscaping or sidewalk (applicable to '**' shown on above figures).
    b. Parking spaces may be reduced to 16.5 feet in length if a two (2) feet overhang is provided.
    c. All standard parking space striping shall be white in color.
    d. On-street motorcycle parking space is half the size of a vehicle parking space.

C. Median Openings

Median openings for collectors and arterials shall be as designated by the City's Engineer. Median opening allowance shall primarily consider the safety and effective flow of traffic within the collector or arterial street, then secondarily consider the effective movement of traffic to and from the development. Whether a median opening is allowed will solely be up to the City's Engineer.

When a development is allowed to have a median opening, it shall be provided in accordance with the following criteria:

1. The width of a median opening shall be 60 feet.
2. Median openings shall center on the intersecting drive.
3. Median openings shall be a minimum of 400 feet apart, measured from nose-to-nose of medians.

4. Whenever a median opening is constructed, the associated left-turn lane serving the development must be constructed at the same time. In the event that there is an existing intersecting street on the opposite side of the street, the new development constructing the median opening shall be required to install both left-turn lanes.
5. Patterned and colored median noses shall be constructed as shown on the City of Denton Standard Details.
6. For any proposed median opening on TxDOT-maintained facilities, the standards outlined in the TxDOT Roadway Design Manual shall be followed.

D. Traffic Calming

1. General Policy
   a. Traffic calming measures intended to control vehicle speeds within the public ROW are generally not permitted.
   b. Exceptions may be considered in critical areas where documented overspeeding presents a safety hazard - such as in front of schools, hospitals, parks, or other pedestrian-sensitive environments.
   c. Any installation within the public ROW must be supported by an engineering study that documents operating speeds exceeding the posted limit and must receive approval by the City Fire Code Official, ensuring compliance with the most current provisions of the IFC adopted by the City.
2. Prohibited vs. Conditional Devices
   a. Prohibited Devices:
      i. Speed humps, bumps, and other similar vertical deflection devices are prohibited on both public ROW and private property fire apparatus access roads.

         These devices have been shown to delay emergency response times by approximately 10 seconds per device and have been associated with damage to fire and EMS vehicle frames as well as injuries to emergency personnel during response operations. For these reasons, they are not permitted within the City.
   b. Conditional Devices:
      i. Speed cushions or segmented devices designed to allow emergency vehicle clearance may be considered on private property only. These devices require City Fire Code Official approval and must conform to current IFC standards and applicable AASHTO/ITE traffic calming guidance.
      ii. Horizontal traffic calming devices (including but not limited to chokers, chicanes, traffic circles, and similar geometric modifications) may be considered on a case-by-case basis within both public ROW and private property; however, their implementation must be reviewed and approved by both the City's Engineer and the City Fire Code Official.
3. Design & Installation Standards
   a. All traffic calming devices must include signage and pavement markings in compliance with the most recent TMUTCD edition, where applicable.
   b. Additional ROW dedication may be required to accommodate traffic calming devices while maintaining minimum lane widths, drainage, and pedestrian or bicycle access.

c. Devices must be constructed of durable materials (e.g., pre-molded rubber, modular plastic, or reinforced concrete) to ensure long-term performance and maintain emergency response accessibility.

4. Permitting Requirements

A separate permit is required to install any speed control device within a designated fire apparatus access road.

5.6 Access Management

5.6.1 Purpose and Goals

The purpose of the access management plan is to promote the health, safety, and general welfare of the present and future residents of the city through managing traffic flow and promoting traffic safety. In planning and designing access for proposed developments, the following documents should be utilized in conjunction with this section:

A. DDC Section 7.8.9 – Driveways and Access

B. DDC Section 7.8.10 – Cross-Access Between Abutting Developments

C. TxDOT Access Management Manual (if proposed access connects TxDOT-maintained facilities)

D. TxDOT Roadway Design Manual (if proposed access connects TxDOT-maintained facilities)

These standards collectively ensure safe, efficient, and coordinated access within the city's roadway network.

5.6.2 Access Standards

A. Compliance

1. No person shall construct, reconstruct, replace, relocate, alter, enlarge, improve or perform any work on or make use of any driveway for any property within the City or its extraterritorial jurisdiction, except in accordance with the Access Management standards provided in this Manual or the TxDOT Access Management Manual, when applicable.

2. All driveways shall be designed, installed, located, and constructed in accordance with the approved specifications, plans, conditions, and requirements of the permit issued for the property, and the requirements of this Manual.

3. No certificate of occupancy shall be issued for any building on any property for which a permit is required, until the construction, improvements, alterations or other work covered by the permit is completed in accordance with the permit issued, the requirements of this Manual, or the provisions of any other applicable ordinance.

4. Where no building permit was required in connection with the requested permit, no driveway on the property for which the permit was issued shall be used until and unless the work is completed in accordance with the permit, and this Manual.

B. Access to Freeways

Direct access from private property to freeway main lanes is prohibited; access is provided exclusively at designated interchanges and ramps. Access to adjacent frontage roads must comply with the TxDOT Access Management Manual and are , subject to the following provisions:

1. Control of Access:

   Access is prohibited in areas where TxDOT has established Control of Access. Control of Access areas are documented on current TxDOT ROW maps.

2. Direct Ramp Access:

   a. Ramps with Frontage Roads: Direct access from adjacent properties or streets is strictly prohibited for the entire length of the ramp.

   b. Interstate Ramps without Frontage Roads or Interstate Interchange Connectors: Direct access is prohibited along the full length of the ramp or connector in accordance with 23 CFR 625.3 and 625.4.

   c. Non-Interstate Facilities without Frontage Roads: Direct access is strongly discouraged. If allowed, the location must be determined based on spacing criteria and procedures outlined in this Manual and the TxDOT Access Management Manual.

3. Frontage Road Considerations:

   Direct access to frontage roads is prohibited in the vicinity of ramp connections to ensure safe merging, weaving, and adequate acceleration and deceleration of vehicles.

4. Ramp Proximity Restrictions:

   a. Exit Ramps: No access shall be permitted within the paved gore area or within 250 feet downstream of the painted gore of an exit ramp.

   b. Entrance Ramps: No access shall be permitted within the paved gore area or within 200 feet upstream of the painted gore of an entrance ramp.

   c. For further guidance, refer to the TxDOT Roadway Design Manual.

5. Design Considerations:

   The spacing of interchanges and ramps shall provide adequate distance for entering and exiting vehicles to safely accelerate, decelerate, and weave, consistent with TxDOT design standards.

C. Access to Arterial Streets

Access to an arterial street shall not be permitted unless there is no other reasonable means of providing safe access to the property. Unless designated as a freeway, all TxDOT Highways shall be considered arterials. Additionally, the geometric, hydraulic, and pavement designs of all access driveways to TxDOT roadways must be reviewed by TxDOT to ensure compliance with their standards.

1. No development shall be allowed access to an arterial street if property excluded from the development could have been used to provide reasonable access to a lesser classified street, or if the property has been previously subdivided in violation of state law or the DDC and if access could have been provided to a lesser street except for such unapproved subdivision of the property.

2. Existing commercial or industrial lots created prior to adoption of the DDC by legal subdivision procedures with exclusive frontage on an arterial street may take access to the arterial in accordance with the access standards in this Manual.

3. Existing single-family and duplex lots created prior to adoption of the DDC by legal subdivision procedures with exclusive frontage on an arterial street may be developed with

a circular drive. Such drives shall be designed and constructed in accordance with standards for circular drives provided in this Manual.

4. When drives access to an arterial street is the only reasonable means of providing safe and adequate access to the property as determined by the City's Engineer, the drive design, number of drives, location and construction shall be in accordance with this Manual.

5. Drives on an arterial shall align with existing median openings, other driveways, and "T" intersections, or be offset in accordance with this Manual.

D. Access to Collector Streets

1. Access to collector streets for commercial, office, or industrial development is required and shall be designed and constructed in accordance with the standards provided in this Manual.

2. Single-family or duplex lots shall not be designed such that there is no other means of access other than a collector street.

3. Existing single-family and duplex lots developed prior to approval of the DDC with exclusive frontage on a collector street and no alley may be developed with a circular drive. Such drives shall be designed and constructed in accordance with the standards for circular drives provided in this Manual.

4. Drives on a collector street shall align with existing driveways and 'T' intersections on the opposite side of the street, or shall be offset in accordance with this Manual.

5.6.3 Fire Apparatus Access Roads

A. Design Standards

The design of all fire apparatus access roads shall be submitted to the Fire Department for review and shall not be constructed without prior authorization from the City Fire Code Official.

1. Fire apparatus access roads shall be constructed in accordance with the City of Denton standards for the concrete pavement cross-section of a residential street.

2. They shall be designed for all-weather use and capable of supporting fire apparatus with a load rating of up to 75,000 pounds.

3. Width, Clearance, and Setback

   a. Minimum unobstructed width of 24 feet for buildings up to 30 feet in height, and 26 feet for buildings over 30 feet in height.

   b. Minimum vertical clearance of 14 feet.

   c. Setback from the building face shall be a minimum of 15 feet and maximum of 30 feet.

4. Fire apparatus access roads must have a minimum inside turning radius of 25 feet, and a minimum outside turning radius of 45 feet.

   a. Driveways less than 24 feet wide may have a minimum inside turning radius of 28 feet.

   b. Driveways wider than 26 feet may have a minimum inside turning radius of 20 feet.

5. Maximum grade for fire apparatus access roads shall not exceed 10%.

6. Proximity to Buildings

   Fire apparatus access roads shall be located so that all parts of the building are accessible within 150 feet, measured along the hose lay from the lane.

For buildings fully equipped with an approved automatic fire suppression system, this distance may be increased to 300 feet upon approval of the City Fire Code Official.

7. Dead-End Lanes must provide an IFC-approved turnaround if the dead-end exceeds 150 feet in length (IFC Appendix D). Refer to Sections 5.5.3 and 5.5.4 of this manual for further details regarding turnarounds.

8. Traffic Calming - No speed bumps or similar traffic calming devices are permitted in fire apparatus access roads (IFC 503.4.1).

B. Modification of Existing Fire Apparatus Access Roads

Modification of existing fire apparatus access roads MUST be approved by the Fire Marshal's Office.

C. Marking

1. Striping

Fire apparatus access roads shall be marked by painting 6-in. wide red traffic lines at its boundaries, as indicated on the plat. The words "NO PARKING FIRE LANE" or "FIRE LANE NO PARKING" shall be four (4) inches high.

2. Signage

Signs shall read "NO PARKING FIRE LANE" or "FIRE LANE NO PARKING" and shall be 12-in. wide and 18-in. high. Signs shall be painted on a white background with letters and borders in red, using not less than 2-in. high lettering. Signs shall be permanently affixed to a stationary post, and the bottom of the sign shall be six (6) feet and six (6) inches or 6'-6" above finished grade. Signs shall not be spaced more than 50 feet apart. Signs may be installed on permanent buildings or walls, as approved by the Fire Marshal.

5.7 Bike and Pedestrian Facility Design

The user should be aware of and utilize the DDC Section 7.8.11 Pedestrian and Bicycle Circulation, in conjunction with this section for the design of bike and pedestrian facilities.

5.7.1 Mobility Plan Component

The City of Denton Mobility Plan includes a pedestrian and bicycle component, which should be reviewed, relative to any proposed transportation improvement.

It should be noted that the City of Denton Mobility Plan is a living document and is periodically updated to reflect the changes in the characteristics of anticipated traffic flow within the City.

5.7.2 Accessibility Standards

The City of Denton considers sidewalks to be accessible routes according to Section 4.3 of Texas Accessibility Standards (TAS) and considers a public sidewalk a “facility”. Sidewalks, landings, ramps, and flares shall comply with the most recently adopted TAS, ADA, PROWAG, and FHWA standards. Also, sidewalks, landings, ramps, and flares are subject to the requirements of the Texas Department of Licensing and Registration (TDLR) for inspection purposes. Prior to construction of sidewalks, the Engineer of Record must show proof of TDLR review and approval for accessibility, if the total cost of the public improvements will exceed $50,000.00. Compliance with the regulations shall be the responsibility of the Engineer of Record for the project. Refer to the City of Denton Standard Details for additional requirements.

5.7.3 Geometric Standards

Table 5.7-A shows the standard width of sidewalks and bike lanes for the various roadway classifications. Refer to the City of Denton Standard Details for the locations of sidewalks and bike lanes within the street ROW. The Denton Mobility Plan should be reviewed for any planned bicycle and pedestrian facilities that may exceed those called for by the standard details. Any portion of the proposed facility extending past the ROW shall be contained within a pedestrian access easement. The recorded easement shall extend two (2) feet beyond the edge of the facility.

Table 5.7-A: Bike and Sidewalk Requirements

Roadway Classification	Min. Sidewalk Width [1]	Min. Bike Lane Width [1]
Freeway	N/A	
Arterials – Primary and Secondary	5	10
Major Collector	8	10
Collector – Commercial and Residential	8	10
Local – Residential	5	N/A
Local – Rural	N/A	N/A
Local – Alley	N/A	N/A

Notes:
[1] Refer to the City of Denton Standard Details street cross-sections for specific bike and pedestrian recommendations.
[2] Sidewalks must be at least 6 inches away from the ROW line.
[3] Sidewalks must have green space/parkway between sidewalk and street curb per city Standard Details.
[4] If sidewalks are provided at the back of the curb, then the minimum width must be 6 feet.
[5] Inlet covers cannot be part of the sidewalk.
[6] Existing sidewalks that do not comply with ADA and City/Mobility Plan standards should be upgraded to meet current City, Mobility Plan and ADA requirements.
[7] For sidewalks or other pedestrian facilities proposed in a TxDOT ROW, a TxDOT permit will be required to do any work.

A. On Bridges

Sidewalks on bridges shall be a minimum width of six (6) feet or wider, as required by the street classification. All street bridges shall have sidewalks on both sides of the bridge. Dependent upon vehicular and pedestrian traffic considerations, a parapet wall may be required to separate the sidewalk from the travel lane. Parapet walls shall be constructed to TxDOT standards. A pedestrian bridge rail shall be constructed on the outside of the bridge to protect sidewalk traffic. Both bridge rails and parapet walls shall meet accessibility standards.

B. On Drainage Crossings

Sidewalk at drainage crossings shall be a minimum width of six (6) feet or wider as required by the street classification. Sidewalk railing shall be provided to protect the sidewalk traffic from the outside edge of the drainage crossing. Dependent upon vehicular and pedestrian traffic considerations, a parapet wall may be required to separate the sidewalk from the travel lane. Parapet walls shall be constructed to TxDOT standards. Railing and parapet walls shall meet accessibility standards.

C. Adjacent to Screen Walls

A minimum additional sidewalk width of two (2) feet shall be required beyond the standard width of sidewalk, for sidewalks adjacent to screen walls.

D. Adjacent to Retaining Walls

A minimum greenspace width of five (5) feet between the sidewalk and the edge of a retaining wall shall be required, for sidewalks adjacent to retaining walls.

5.7.4 Intersection

A. Curb Ramps

The continuation of accessible routes through intersections shall use approved curb ramps that meet accessibility standards. Refer to the City of Denton Standard Details for curb ramps at intersections. Crosswalks through the intersections shall meet accessibility standards.

The following provisions further define requirements for sidewalk connections, proposed barrier-free ramps (BFRs), and receiving BFRs to ensure continuity, safety, and full accessibility throughout the intersection.

1. Sidewalks connecting to existing BFRs at intersections must be fully ADA-compliant.
2. Proposed BFRs at project corners must be aligned with existing or planned BFRs on the opposite corners. Plans shall illustrate the full intersection layout, including all ramps and crosswalks.
3. A receiving BFR is required in accordance with PROWAG standards for all new construction and alterations to existing facilities. If no receiving ramp exists on the opposite side of the intersection, a new receiving ramp with an appropriate landing must be constructed, regardless of whether a sidewalk is present. Any exceptions from this requirement must be approved by the City's Engineer.

B. Bike Lanes

Bike lanes at intersections shall consider other traffic movements and facilities such as turn lane movements, transit facilities, parking, and stop bar locations. The current Urban Intersection Design Guide by TxDOT can be used for bike lane design at intersections. The bike lane design at intersections requires the approval of the City's Engineer.

5.7.5 Signage and Pavement Markings

Signage and pavement markings shall be as shown on the TMUTCD Marking & Sign Drawings, and in accordance with the accessibility standards.

A. Crosswalks

Continental type-high visibility crosswalk markings are to be provided in all uncontrolled street crossings, school crossings, downtown areas, or as directed by the City's Engineer.

B. Bike Lane

Traffic control devices such as vertical flex posts, green pavement markings, and wayfinding signage may be required to enhance the proposed bicycle facility, as directed by the City's Engineer. For additional guidance, refer to Section 5.5.5.A of this manual.

5.7.6 Amenities

A. Bike Parking

1. Refer to Bicycle Parking Guideline 2nd Edition by the Association of Pedestrian and Bicycle Professionals (APBP) for general guidelines and resources.

2. All bicycle parking facilities/devices shall be constructed to meet commercial grade structural standards.
3. Location Standard:
    a. Bicycle parking must be on the same lot as the principle use.
    b. Bicycle parking must be located in highly visible and well-lit areas.
    c. Bicycle parking must not interfere with accessible paths of travel or accessible parking as required by the accessibility standards.
    d. Bicycle parking must be located within 50 feet of a main building entrance. In multiple building locations, bicycle parking must be distributed in a manner that serves all entrances.
4. Layout and Design:
    a. Bicycle rack design:
        i. Support the bicycle in at least two (2) places.
        ii. Enable the frame and at least one (1) wheel to be secured.
        iii. Designed to accommodate "U" shape locking devices.
        iv. Installed to the manufacturer's specifications.
        v. Each bike rack must be designed to accommodate at least two (2) bikes.
        vi. Each bike rack space should be a minimum of two (2) feet in width and six (6) feet in length.
    b. Bicycle Parking Space
        i. Concrete pad built to City of Denton sidewalk standards.
        ii. Must provide clearance of at least two (2) feet from closest wall.
        iii. Must provide clearance of at least three (3) feet between bike racks.
        iv. Must not interfere with pedestrian pathway.

In addition to selecting an appropriate bicycle rack type, the overall layout of bicycle parking areas shall be designed to ensure safe, efficient, and accessible use. Minimum recommended dimensions for bicycle rack areas are provided in the APBP Bicycle Parking Guidelines, as shown in Figure 5.23. For larger bicycle parking areas with high turnover rates, multiple access points are recommended to facilitate user circulation and reduce congestion. Where feasible, bicycle parking areas should be oriented and designed to provide protection from weather elements, enhancing both usability and longevity of the racks.

B. Benches

All benches shall be constructed to meet commercial-grade structural standards. Benches shall be secured to prevent displacement. Benches shall not project into any accessible route or alter an accessible route such that it will not meet the accessible route standards.

C. Lighting and Enclosures

Lighting standards and above-ground enclosures shall not extend into any accessible route or alter an accessible route such that it will not meet the accessible route standards.

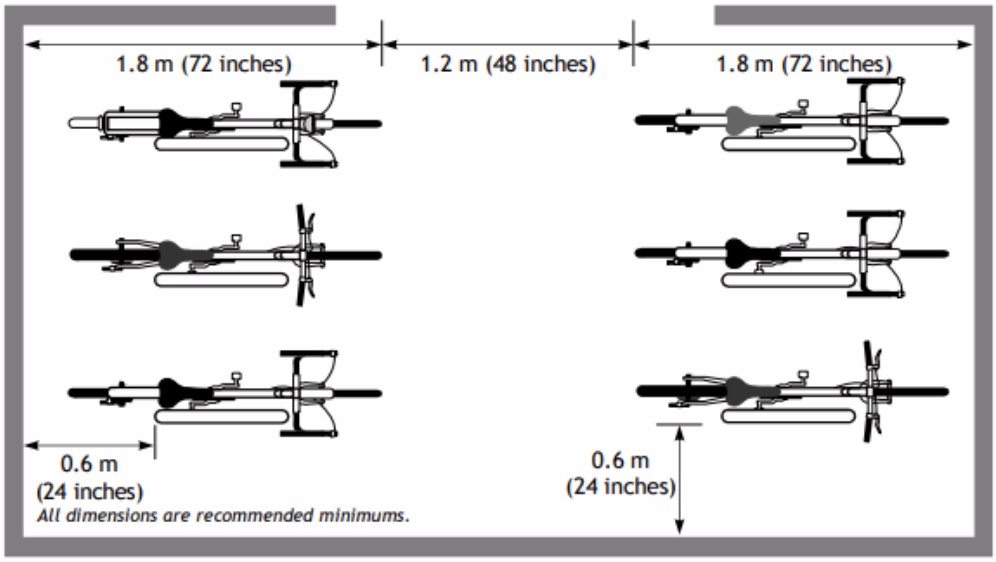


Figure 5.23 APBP-recommended design dimensions for bicycle rack areas

5.8 Transit Facility Design

5.8.1 General

Bus stops shall meet at a minimum the design standards of the Denton County Transit Authority (DCTA), and the accessibility standards of TAS, PROWAG, and ADA. Figure 5.24 show a general layout of a bus stop at an intersection. Bus stops shall be located on the departing side of a street intersection. The use of a pull-out lane may be considered where the specific site conditions warrant such an arrangement. The determination of the appropriateness of a pull-out lane shall rest with the City's Engineer.

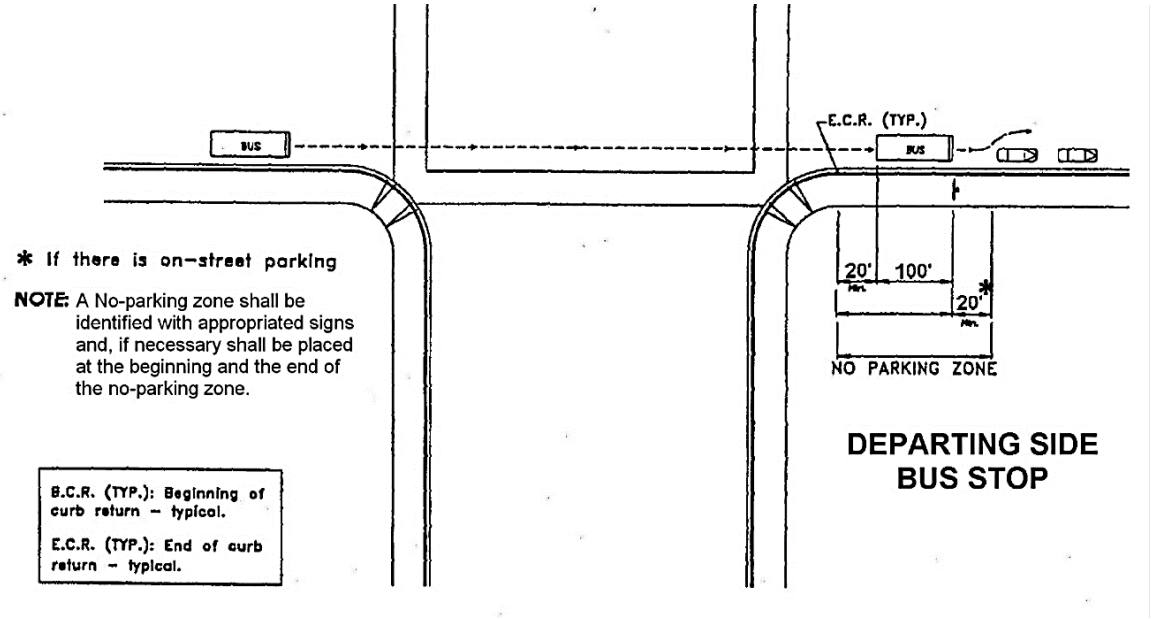


Figure 5.24 Standard Bus Stop Location at Unsignalized Intersection

Note: For signalized intersections an Approach Side Bus Stop is preferred

5.8.2 Bus Stop Placement

Bus stop placement should consider the need for the bus stop, traffic operation concerns, and passenger accessibility. A bus stop should be placed within an area that allows bus stop amenities to be located in the public ROW and where the ingress and egress of the bus does not overly impede the flow of traffic. The warrant for a bus stop shall be as required by the City of Denton in conjunction with DCTA. Elements to consider for bus stop placement include the following:

A. ADA and PROWAG compliance of all elements, including pedestrian routes, shelters, signing, etc.

B. Within Public ROW, or a dedicated access easement.

C. Proximity to major trip generators such as malls, student housing areas, retail commercial zones, park and rides, destination areas, etc.

D. Pedestrian facilities such as sidewalks or multi-use paths, marked cross walks, space provisions for accessibility standards, and curb ramps should be available at the location for a proposed bus stop.

E. Convenient passenger transfers to other routes.

F. Open and visible location for personal security and passenger visibility.

G. Acceptable street illumination or proposed street illumination with placement.

H. Ability to have restrictive parking in bus zone.

I. Adequate space for bus zone.

J. Gentle street grades at bus zone.

K. Return to traffic without overly hindering traffic flow.

L. No interference from driveways.

5.8.3 Bus Stop Amenities

The following are bus stop amenities that shall be considered during the process of design:

A. Accessibility compliant loading area. All bus stops shall have accessibility compliant loading and offloading area. This area shall be integral to the sidewalk pathway, bench area, and shelter area, if provided. The loading area shall be constructed of reinforced concrete with the same thickness as the adjacent sidewalk.

B. Bench and trash receptacle may be warranted based upon Table 5.8-A. Bench and trash receptacle type and installation shall be as required by the City of Denton.

C. A shelter may be warranted based upon Table 5.8-A The shelter type and installation shall be as required by the City of Denton and DCTA. Shelters shall provide space to meet accessibility standards.

D. Illumination shall be provided if illumination is not provided at the street corner adjacent to the bus stop, or if in the opinion of the City's Engineer the existing illumination is inadequate.

E. Bus stops that accumulate 10 points or more may be considered for shelter placement. Bus stops that accumulate six (6) points or greater may warrant a bench and trash receptacle.

Table 5.8-A: Bus Stop Amenities Warrant	
Points	**Condition**
6 points	25 people per day boarding
4 points	Special needs, i.e., Senior Center, Medical Complex, libraries, high accessibility standard usage such as group residences
4 points	High use location, i.e., Student housing area, schools, hospitals, mall
2 points	Request for improvements by citizens, i.e., multiple requests over a one-year time
6 points	15 people per day or greater boarding
4 points	Adjacent to an arterial roadway

5.8.4 Bus Stop Signage and Markings

Bus stop signage and markings shall be according to the City of Denton and DCTA. Signage shall include a "No Parking Zone" sign and a DCTA bus stop sign.

5.9 Traffic Impact Analysis Guidelines

5.9.1 General

The purpose of the traffic impact analysis (TIA) is to assess the impacts of development on the existing roadway system within the study area of the development and to assess the traffic flow needs within the development. The thoroughfare component of the Mobility Plan and the City of Denton traffic model establishes the base conditions for assessing the impacts. The current traffic model and the assessment is based on a Level of Service D according to the current Highway Capacity Manual. The TIA shall be signed and sealed by a licensed Professional Engineer (PE) in the State of Texas, and shall be valid for a period of 3 years, unless there is a significant change in the plans or surrounding conditions, as determined by City's Engineer.

5.9.2 Trip Generation Assessment

A trip generation assessment shall be required for all proposed developments. Developers shall submit the City-adopted Trip Generation Assessment Worksheet ("TGA Worksheet") as part of Traffic Scoping submittal process. Refer to City's TIA Scoping Checklist. The TGA Worksheet must reflect unadjusted trip generation projections for the proposed development, prepared in accordance with the following resources and methodologies:

A. Trip forecasts shall be based on the most recent edition of the ITE Trip Generation Manual. Developers shall utilize conservative trip estimates, specifically values falling between the Average Rate and Fitted Curve Equation, where both are provided.

B. If an appropriate ITE Land Use Code is not available, applicants may submit empirical trip generation data from comparable facilities of similar size and function within the Dallas–Fort Worth metropolitan area. Supporting documentation must include a detailed description of the data collection methodology, a demonstration of land use comparability, a description of site conditions, and verification of data reliability. If alternative data sources are used, applicants must provide justification and supporting documentation. All alternative data sources are subject to review and approval by the City's Engineer.

The City's Engineer shall evaluate the TGA Worksheet, in combination with the thresholds and criteria specified in Section 5.9.3, to determine whether a TIA is required for the proposed development.

5.9.3 When is a TIA required?

Based on the TGA Worksheet for the proposed project, unless otherwise directed by the City 's Engineer, a TIA will be required for the following conditions:

A. Development will generate equal to or more than 50 Peak-Hour Trips (PHT).

B. Development will generate equal to or more than 1,000 vehicle trips per day (VPD).

C. Project area to be developed is equal to or more than 100 acres.

D. Changes or alterations to the City Thoroughfare plan based on the Mobility Plan will be requested.

E. Access is taken from a TxDOT roadway, subject to both City and TxDOT TIA requirements.

F. Zoning changes that will negatively increase estimated traffic volumes above the current zoning estimated traffic volumes.

G. Access is taken from an existing roadway with current traffic flow congestion based upon observed conditions.

H. Development plus recently approved or pending development projects which have not been constructed located adjacent to the site and/or in proximity to the site, meet the above vehicular trip criteria or acreage criteria as determined by the City's Engineer.

5.9.4 TIA Category and Study Area

Table 5.9-A shows the number of analysis periods and study area limits for TIAs.

Table 5.9-A: Criteria for Study Requirements

Analysis Category	Site Trips Generated at Full Build-Out	TIA Analysis Periods [1]	Minimum Study Area [3]
I	50-99 total peak hour trips	1. Existing year 2. Opening year [2]	1. All site access drives
II	100-500 total peak hour trips	1. Existing year 2. Opening year [2] 3. Five years after opening	1. All site access drives 2. All signalized intersections and/or major unsignalized intersections within ½-mile to 1 mile of site boundary, depending on total peak hour trips
III	>500 total peak hour trips	1. Existing year 2. Opening year of each phase 3. Five years after initial opening 4. Twenty years after final opening with full build-out	1. All site access drives 2. All signalized intersections and/or major unsignalized intersections within 1-½ miles of site boundary and/or major intersections along access routes to/from regional corridors

Notes:
[1] Analysis periods shall include build and no-build scenarios. Assume full occupancy when each phase opens.
[2] Assume full build-out.
[3] For certain projects, the City may require an enlarged study area. Land uses within the study area should include recently approved or pending development adjacent to the site and/or in proximity to the site.

5.9.5 TIA Scoping and Report

A. TIA Scoping

If a TIA is warranted for a development under the conditions outlined in Section 5.9.3, the developers shall prepare and submit a TIA Scoping Memorandum in accordance with the City's most recently adopted TIA Scoping Checklist. The scoping process ensures consistency, transparency, and effective coordination between the developers and the City. A TIA will not be accepted for review without an approved TIA Scoping Memorandum.

The TIA Scoping Memorandum shall:

1. Establish the appropriate level of analysis for the proposed development (from Table 5.9-A);
2. Define study area boundaries and identify required intersections and roadway segments (following Table 5.9-A);
3. Identify traffic data collection requirements and study periods (following Table 5.9-A); and
4. Confirm the methodologies, assumptions, and evaluation tools to be applied in the study.

Refer to the City of Denton TIA Scoping Checklist for further details.

B. TIA Report

TIAs shall be prepared in accordance with the City of Denton TIA checklist, the approved TIA traffic scoping, the Denton Development Code (DDC), and TxDOT standards, as applicable. At a minimum, TIA reports shall address the following:

1. Project Description and Existing Conditions – Summarize the proposed development (land use, size, location, phasing) and document existing roadway characteristics, intersection control, traffic volumes, and any planned improvements within the defined study area.
2. Trip Generation, Distribution, and Future Conditions – Estimate trips per Section 5.9.2 methodology, assign them to the network, and evaluate traffic operations with and without the project, considering background growth and approved developments.
3. Operational and Access Analysis – Assess performance of key intersections and roadway segments (LOS, delay, v/c, queues), driveway spacing and sight distance, and internal circulation. School developments shall include a Traffic Management Plan.
4. Multimodal and Safety Considerations – Identify pedestrian, bicycle, and transit impacts along with any safety deficiencies.
5. Mitigation Strategy and Commitments – Identify operational or safety issues resulting from the proposed development and recommend appropriate mitigation, such as turn lanes, signal adjustments, intersection or geometric modifications, access management strategies, or multimodal enhancements. Proposed improvements should be clearly categorized by timing and responsibility, distinguishing between those required at opening day and those that may be phased or coordinated with other developments or agencies. Recommendations must form a practical implementation plan demonstrating how anticipated impacts will be effectively addressed.

It must be noted that the City's Engineer reserves the right to request additional data, analyses, or scenarios based on project scope or site-specific conditions. Refer to the City of Denton TIA Checklist for detailed formatting and submittal requirements.

5.9.6 School Traffic Management Plan

A. Purpose

Schools generate atypical traffic conditions that require special consideration. They produce higher-than-usual vehicular traffic, concentrated traffic loads at specific times, and a mix of different vehicle types. Consequently, traffic management should be given the highest priority when evaluating new school sites, upgrading existing sites, or reviewing ongoing school operations.

A School Traffic Management Plan (TMP) is a site-specific plan that addresses the school campus and adjacent street network. It provides guidelines to coordinate traffic circulation during school peak hours, ensuring that all road users are safely and efficiently guided through the site while maintaining the performance of the roadway and minimizing impacts on surrounding properties.

B. Applicability

A TMP is required for:

1. Any new school development; or
2. Developments that are expected to significantly impact traffic operations at an existing school.

The TMP must be prepared and submitted as part of the TIA to demonstrate that traffic conditions at school access points have been adequately evaluated and mitigated.

C. TMP Preparation and Certification

1. The TMP shall be prepared by a licensed Professional Engineer (PE) in the State of Texas with expertise in transportation and traffic engineering, preferably certified as a Professional Traffic Operations Engineer (PTOE).
2. Field observations of both morning drop-off and afternoon pick-up periods shall form the basis of the TMP.
3. The TMP must be signed, stamped, and dated by the licensed PE and include a statement confirming that it was developed with input from individuals familiar with the site's traffic characteristics, including contact information for the approving school administration official.
4. The TMP should be prepared in a format suitable for distribution to parents, students, and school staff.

D. TMP Content Requirements

The TMP shall include, at a minimum, the following elements:

1. Site and Roadway Description
    a. Location of the school site and description of adjacent roadways.
    b. All points of vehicular and pedestrian access (ingress and egress).
2. TMP Exhibit
    a. Scaled site diagram showing building footprints, curbs, pavement markings, parking areas, and designated student drop-off and pick-up locations.
    b. Aerial images are not acceptable due to replication challenges.

3. Traffic Operations
    a. Summary table indicating school schedule, student enrollment by grade, maximum vehicular accumulation, on-site storage capacity, and surplus during dismissal periods or at designated loading zones.
    b. On-site traffic circulation plan, including any temporary traffic control devices.
    c. Proposed coordination system for student drop-off and pick-up (e.g., passenger identification, separation of transportation modes, and staggered arrival/dismissal times).
4. Staffing and Supervision
    a. Number and location of school staff assisting with loading/unloading students, with roles and responsibilities clearly defined.
    b. Number and location of adult crossing guards or off-duty law enforcement personnel.
5. Pedestrian and Bicycle Considerations
    a. Identification of pedestrian routes up to 0.5 miles from all school access points.
    b. Strategies to encourage walking and biking.
6. Parking and Parent Communication
    a. Parking management strategies for on-site and nearby public areas.
    b. Communication plan to inform and engage parents, students, staff, and neighbors regarding the TMP.
7. Additional Considerations (if applicable)
    a. School bus loading and unloading operations.
    b. Methodology for projected maximum vehicular accumulation.
    c. Traffic control plan showing signage on public rights-of-way.
8. High-Speed Roadway Considerations: For schools adjacent to roadways with posted speed limits of 35 mph or greater, the TMP shall include:
    a. Turning movement counts at all major intersections adjacent to the school.
    b. Stopping and intersection sight distances at all school driveway approaches.

5.9.7 Safety Assessment

Consistent with the recently adopted Mobility Plan, safety is the number one priority for the City of Denton and as such, all new developments will be required to conduct a safety assessment as part of their TIA. The safety assessment will include a review of safety for all road users (vehicles, pedestrians and bicycles) within the project site as well as along existing public ROWs in the vicinity of the project. The assessment will include a review of the following:

A. Within the project site (Site Circulation).

B. All new intersections including project driveways.

C. Evaluation of Historic Crash Data at all existing intersections and roadways included in the TIA.

5.9.8 Queue Analysis for Drive Through Facilities

A review of proposed drive through operations must be included in the TIA. The evaluation must include:

A. Illustration of proposed operations (i.e. access points and queue formation).

B. Anticipated maximum demand/queue (preferably based on observations of other existing sites with similar characteristics or using service rate queue analysis).

C. Maximum queuing capacity on-site.

D. Mitigation plan (Exhibit showing site plan) for if/when traffic ever exceeds design capacity to prevent queues blocking sidewalks or travel lanes of adjacent roads. The plan needs to show how the operator would have to manage longer queues without compromising safety (e.g. double queue, cones, pavement markings, signs, etc.). The plan needs to be signed by the traffic engineer whom the City would contact if/when needed to resolve back up problems once the tenant is in operations - same as the traffic study.

E. The following information must also be included:

1. Peak hour turning movements at intersections with driveway during AM & PM peak hours of adjacent street.
2. Average Daily Traffic on abutting street.
3. Show adjacent street traffic lane configuration, dedicated turning lanes, traffic control.
4. Site plan showing all dimensions of all driveways, sidewalks, crosswalks.

5.9.9 TIA Submission and Review Procedures

A. Trip Generation Assessment

The Trip Generation Assessment, as described in Section 5.9.2 of this Manual, must be completed and submitted as Part A of Traffic Scoping submission to see if a TIA is required.

B. TIA Scoping

1. If a TIA is required (as determined in the TGA worksheet), or clearly warranted under conditions in Section 5.9.3, TIA Scoping must be submitted following the direction provided in section 5.9.4, 5.9.5.A & the City's TIA Scoping Checklist Past B section.
2. The TIA scope must be reviewed and approved by the City prior to TIA application submittal.

C. TIA Report Submission

TIA Report Submission must follow Section 5.9.5.B and the City's TIA checklist.

D. TIA Updates

If the development's proposed land use or traffic generation characteristics change after TIA approval, the TIA must be updated and resubmitted to the City for approval.

5.10 Pavement Design Standard

5.10.1 Streets

The minimum pavement section requirements for each classification of roadway are contained within the City of Denton Standard Details for pavement cross-sections.

A. A geotechnical report shall be prepared that documents the existing soil characteristics of the proposed roadway subgrade for any proposed street improvements. Soil testing shall be performed whenever the soil characteristics change or every 500 feet, whichever is less. The report shall include recommendations for the type and treatment level of subgrade stabilization based upon ultimate traffic conditions.

B. Flex-base may be used as an option for subgrade treatment. Depth of flex-base required shall be based upon the geotechnical report for the street improvements based upon ultimate traffic conditions.

C. Alternative pavement sections may be proposed only if supported by a geotechnical report that provides sufficient evidence to demonstrate that the alternate section shall meet the ultimate traffic loading requirements.

5.10.2 Drive Approach

Refer to the City of Denton Standard Details for drive approach section requirements.

5.11 Complete and Context-Sensitive Streets

Complete streets are transportation facilities that are planned, designed, operated and maintained to provide safe mobility for all users (including bicyclists, pedestrians, transit vehicles, truckers and motorists) appropriate to the function and context of the facility. Context-sensitive solutions formulate a complete street design considering contextual applications. Contextual applications can be of geographical nature such as Urban Core, General Urban, Suburban, University Core and other typical service areas that require unique components to address the overall transportation facilities.

Within the geometric standards are options that relate to developing a complete street that accounts for all transportation facilities within the context of the associate area. Connectivity and context-sensitive solutions are essential to meeting the goals of the standards. Refer to the City of Denton Standard Details for cross-section details, and the pedestrian and bicycle components of the 2022 Mobility Plan for planned facilities, or as required by the City of Denton during development review.

BIKE LANES – Bike lanes shall be six (6) feet wide unless otherwise approved by the City's Engineer. Buffered or separated bike lanes are generally preferred to increase level of comfort in the bicycle facility.

OFF-STREET MULTI-USE PATH – Some development areas will warrant the use of off-street multi-use paths for pedestrian and bicycle traffic connectivity to other facilities as identified by the City of Denton. Multi-use paths shall be 10 feet wide, unless otherwise approved by the City's Engineer.

TRANSIT – Bus stop locations may be required by the City of Denton for connectivity of the transit system. *See* Section 5.8 of this Manual for details.

MEDIAN VS. CONTINOUS LEFT TURN LANE – Selection of a median or continuous left turn lane shall be based upon the TIA, connectivity, adjacent uses, and other factors required by the City's Engineer. Medians shall be 24 feet back of curb to back of curb, unless otherwise approved by the City's Engineer. Continuous left turn lanes shall be 11 feet wide.

MODIFICATIONS TO STANDARDS – Modifications to the standards may have to be considered in some instances based upon context-sensitive use. An example of context-sensitive use which may require the standards to be modified is a roadway corridor restriction that creates limitations that cannot be altered. An example of a roadway corridor restrictions would be existing infrastructure and/or buildings that must

remain. Another example is infill development. Modifications to the standards based upon context-sensitive use shall be at the sole discretion of the City's Engineer.

Section 6: Water and Wastewater Design Criteria

6.1 Overview

The purpose of Section 6 - Water and Wastewater Design Criteria is to provide minimum, non-exhaustive criteria for the design and construction of water distribution and wastewater collection systems within the City of Denton, Texas and its extraterritorial jurisdictions.

It is the responsibility of the design engineer to ensure the final design of water distribution and wastewater collection systems are in conformance with the most recently adopted versions of the following documents:

A. Texas Administrative Code (TAC) Title 30, Part 1, TCEQ – Ch. 290;
B. Texas Administrative Code (TAC) Title 30, Part 1, TCEQ – Ch. 217;
C. Texas Administrative Code (TAC) Title 16, Part 2, PUCT – Ch. 24;
D. City of Denton Code of Ordinances and the DDC;
E. The City of Denton's Standard Details and Standard Specifications for Construction;
F. City of Denton Water Distribution System Master Plan;
G. City of Denton Wastewater Master Plan;
H. American Water Works Association (AWWA) Standards;
I. The International Building Code (IBC);
J. The International Plumbing Code (IPC);
K. The International Fire Code (IFC); and
L. This Manual.

The criteria established in Section 6 of this Manual provide basic guidance for the design of water and wastewater systems. However, ***full responsibility and liability for proper design remains with the design engineer.*** Users of this Manual should be knowledgeable and experienced in the theory and application of water and wastewater engineering. If criteria established in Section 6 overlap with state statutes, rules, or regulations, –the more stringent requirement shall apply. The criteria established in this Section do not supersede the criteria contained in the DDC. In the case of conflict between this Section, City of Denton Standard Details, or other cited City regulations and standards, the more stringent requirement shall apply.

The General Manager of Water Utilities and Street Operations reserves the right to require extended review, direct the design, location specifications and details of vertical water utility infrastructure, and large horizontal infrastructure including, but not limited to, water treatment plants (WTPs), elevated storage tanks (ESTs), booster pump stations, water mains 16 inches in diameter or greater, wastewater reclamation plants, peak flow detention facilities, sewer lift stations and sewer interceptors over 12 inches in diameter. The General Manager of Water Utilities and Street Operations reserves the right to deny proposals at his or her discretion.

6.1.1 Organization

Section 6 - Water and Wastewater Design Criteria is organized as follows:

6.2 Water Design Criteria

6.2.1 Distribution System Extensions

A. General

Water mains shall be sized to meet the calculated water demand, fire flow protection requirements, and to conform to the City of Denton's Water Distribution System Master Plan (Water Master Plan or WMP). All residential, commercial, industrial, and any other development connecting to the City's water distribution system shall use the following guidelines:

1. The design engineer shall obtain the record drawing water maps from the Capital Improvement Projects & Engineering Division and use the following criteria, based on the City's WMP, for sizing the water lines.
    a. Average daily demand in gallons per capita per day = 160 GPCD
    b. Maximum daily demand / Average daily demand = 2.0
    c. Peak hour demand / Maximum daily demand = 1.5
    d. For Single-Family Residential – Use 3.2 people/unit
    e. For Multifamily Residential – Use 2.5 people/unit
    f. Refer to 30 TAC § 290.45 (d)(1) Table A - Non-community water systems
2. Water distribution systems extensions shall provide sufficient connections to the City's existing water system, integrating existing main extensions to the development (including dead-end mains) from adjacent properties to the system extension, for the demand of the proposed extension and shall be extended to neighboring properties for subsequent system extensions. System extensions shall be of sufficient size to furnish adequate domestic, irrigation and fire protection water supply to all lots within the development and conform to the City WMP. Every new water system extension shall include two (2) or more connections to the existing City water system when feasible, to ensure an adequate and reliable water supply in the event of a water main break or routine system maintenance. The City may require two (2) or more meter connections, particularly for large and/or densely developed lots. Good engineering judgement is required to ensure reliability is considered in the design of all proposed water systems
3. Every development shall provide adequate water capacity for fire protection purposes. Fire flow capacity requirements are in addition to daily demand requirements. The procedure for determining fire flow requirements for buildings or portions of buildings shall be in accordance with the version of the IFC adopted by the City. For any platted lot where the end use is not defined, the standards in Table 6.2-A shall apply
4. The cost for modeling a project's impact with the City's distribution system model will be the responsibility of the developer and paid to the City.

B. Distribution System Operational Limits

The City observes the following operational limits for the distribution system under normal usage:

1. Maximum velocity for mains (16 inches or more): 3 fps, with up to 5 fps on case-by-case basis
2. Maximum velocity for mains (16 inches or less) under non-fire flow conditions: 5 fps
3. Maximum velocity for mains (12 inches or less) under maximum day demand + fire flow scenario: 10 fps
4. Maximum head loss (12 inches or less): 5 feet per 1,000 feet
5. Maximum head loss (16 inches or more): 3 feet per 1,000 feet
6. Hazen-Williams Roughness Coefficient (C): 130

Proposed impacts to the City's system determined to, or likely to, cause (through hydraulic modeling or other analysis) these limits to be exceeded, are prohibited without additional improvements to the public system to allow proper operation of the system.

Table 6.2-A: Water Capacity for Fire Flow

Area	GPM
One (1) and two (2) family dwellings - less than 3,600 sq. ft.	1,000
Buildings other than one (1) and two (2) family dwellings - less than 3,600 sq. ft.	1,500
Medium-intensity commercial and light industrial	3,000
High-intensity commercial and industrial	4,000

Notes:
[1] All fire flows to be calculated with 20 psi residual pressures.
[2] In addition to the fire flow requirements specified above, all developments shall provide adequate water capacity to satisfy the greater of: (a) Peak Hour demand for the Peak Day, or (b) Average Hour demand plus fire flow for the Peak Day.
[3] Special exceptions to the above standards may be made by the City's Engineer for unique situations.

C. Public Fire Hydrants

Fire flow requirements shall be in accordance with the IFC as adopted by the City of Denton or Denton County, as appropriate.

D. Private Fire Mains

In addition to the requirements of Section 6.2.1.B of this Manual above, private fire protection water mains shall be installed in accordance with NFPA 24 and the adopted IFC requirements. Private fire protection mains and associated hydrants shall be permitted by the Fire Marshal's Office with jurisdiction.

E. Fire Flow Tests

Fire flow tests are normally requested by the design engineer, the Mechanical, Electrical and Plumbing (MEP) engineer, and other engineers to determine available water system capacity at or near the point of interest. If a fire flow test on the existing water system is necessary, contact Water Distribution at FireFlowTesting@cityofdenton.com.

F. Pressure Planes

The City of Denton's Water Distribution System is divided into several water pressure planes to ensure even water-pressure gradients. Prior to the design of connection points between a

proposed main and any existing main, the design engineer shall investigate and determine if the proposed water main crosses the boundary between different pressure planes.

Even though physical connections of water pipes exist between pressure planes, they are designed with valves which are closed at the boundary points so that each pressure planes is isolated. Proposed mains that approach pressure planes boundaries shall be designed to loop within their designated pressure planes and with no or minimum lengths of dead-end mains.

Connections between pressure planes must be approved by the General Manager of Water Utilities and Street Operations and may require pressure-reducing valve stations. The design engineer can determine the pressure planes boundaries by consulting the record drawings which show the designated closed valves between pressure planes and by contacting Water Utilities. *See* Figure 6.1 below for the 2025 Water System Pressure Plane Map.

The Central pressure plane operates at a Hydraulic Grade Line (HGL) of 826 feet and includes service elevations between 540 feet and 700 feet. It is recommended that any areas above 700 feet be served from the West pressure plane, if possible. An alternative to connecting new development to the higher-pressure plane includes grading sites at or below 700 feet. Areas at elevations below 600 feet may experience high pressure. Individual Pressure Reduction Valves (PRVs) may be needed to maintain an acceptable pressure range.

Eastern pressure planes (i.e. East and Southeast) have a HGL of 745 feet are supplied from the Central pressure plan by reducing pressure via system pressure-reduction valves. Service elevations for the eastern pressure planes range from 515 feet and 615 feet.

The West pressure plane operates at an HGL of 900 feet at the Northwest EST, 905 feet at the Southwest EST and includes service elevations between 670 feet and 770 feet. The boundary between the West and Central pressure plane generally follows the 670-foot contour. Any areas at elevations greater than 770 feet will not be able to be served by the existing distribution system due to low static pressures. Areas near the suction side of the Southwest Boost Pump Station should be served from the West pressure plane due to the decreased residual pressure in the Central pressure plane in this area.

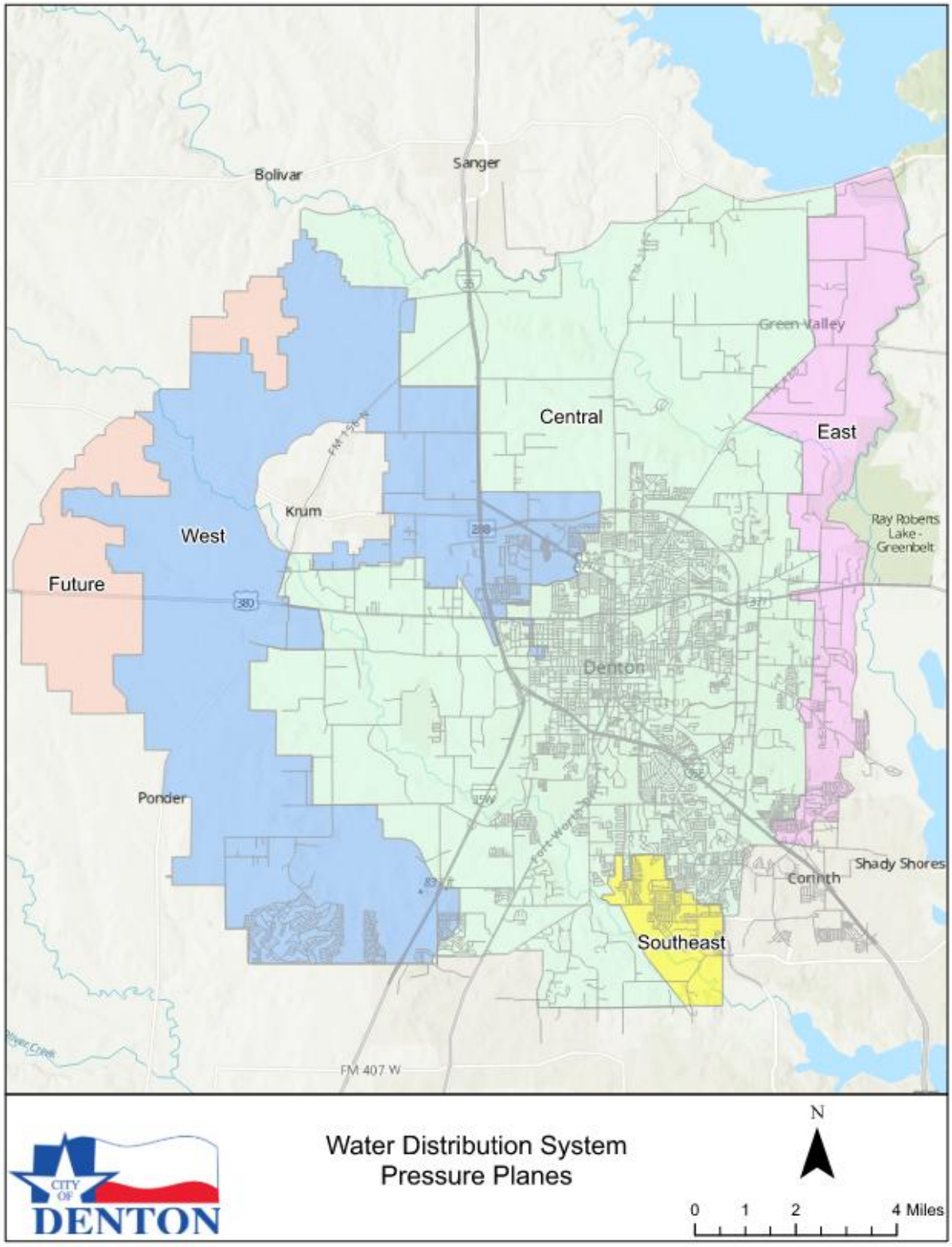


Figure 6.1 2025 Water Master Plan Pressure Plane Map

6.2.2 Water Main Horizontal and Vertical Alignment

The following guidelines should be followed by the design engineer in placement of water lines:

A. In existing streets, water lines shall be placed in the pavement four (4) feet from back of curb. For new residential development, water lines shall be placed on the north and east sides of the streets, where possible, four (4) feet from back of curb. See the City of Denton Standard Details.

B. All water lines shall be laid as straight as possible. Avoid excessive number of high points and low points between cross street connections, as they trap air pockets. See Section 6.2.6.B of this Manual for placement of air release valves.

C. Minimum radius of curvature and maximum deflection angle of pipe joints are restricted to the manufacturer's recommendation, after which, horizontal or vertical bends are required. Deflection of pipe shall only be permitted through joint deflection; no bending of pipe is allowed.

D. Vertical bends shall be no greater than 45 degrees.

E. Except for transverse pipe crossings, no other utility shall be installed over, under or within five (5) feet horizontally of a water line.

F. There shall be at least two (2) feet of vertical separation between a water line and any utility or storm drain crossing it.

G. Water lines shall not be located closer than 10 feet to any building or structure, or located where the excavation of which could place the stability of another structure in jeopardy.

H. Where distribution mains run parallel to transmission mains 16 inches or larger, a non-standard cross-section detail will need to be coordinated with the Water Utility and accommodate the ROW width, gravity and pressurized wastewater mains, reuse water mains and storm drainage mains.

I. The WMP is a guide for transmission main alignment and subject to formal and informal updates.

6.2.3 Depth of Cover for Water Mains

The following table shall govern depth of cover for water main installations:

Table 6.2-B: Minimum Depth of Cover for Water Mains

Pipe Size	From Surface to Top of Pipe	
	UNDER UNPAVED AREAS	UNDER PROPOSED OR EXISTING PAVEMENT
12-in. and smaller	5 feet	42 inches
16-in.	-	5 feet
16-in. and larger	6 feet	-
20-in. and larger	-	6 feet

Notes:
[1] Additional depth of cover shall be required for low-lying areas where future drainage improvements are anticipated.

6.2.4 Pipe and Fittings

A. Specifying the appropriate pipe material is the responsibility of the design engineer, based on the analysis of specific site and loading conditions, and pressure requirements. The minimum requirements in this Section are based on pipe size only, and in no way relieve the design engineer

of the responsibility of specifying the pipe material applicable to the specific project. Pipe gasket material shall be that recommended by the manufacturer for the specified pipe. Special attention shall be given by the design engineer for unique pipe fitting and pipe assembly situations.

B. Water pipe shall be a minimum of eight (8) inches in diameter. The standard pipe sizes that shall be used for water main lines are 8-in., 12-in., 16-in., 20-in., 24-in., 30-in., 36-in., and 42-in. pipes. Pipe sizes of 6-in., 10-in., 14-in., 18-in., 21-in., and 33-in. are considered non-standard by the City and may not be used for water main lines. A 6-in. pipe may be used for fire hydrant connections.

C. Water mains 16 inches and greater in diameter shall have preplanned points of connection of no less than 12 inches in diameter for distribution extensions. Tees with branch valves shall be used for preplanned connections.

D. See Table 6.2-C below for the City's minimum pipe materials, fittings, polywrap, thrust restraint, and embedment requirements, as a function of pipe size.

E. All fittings for pipe sizes less than 30 inches in diameter, including vertical and horizontal bends, shall have concrete thrust blocking. *See* City of Denton Standard Details.

F. All vertical and horizontal fittings and valves shall require restrained joints in addition to concrete thrust blocking. The joint restraints shall be designed as though there is no concrete thrust blocking, and the concrete thrust blocking shall be designed as though there are no joint restraints. Flanged tees should be used to secure all branch valves to fittings. Table 6.2-C below includes the minimum lengths of pipe to be restrained for 8-inch and 12-inch PVC water mains. For water lines greater than 12 inches in diameter, additional restrained joints may need to be installed beyond the fitting (i.e., may need to be installed on several pipe joints on each side of the fitting), depending on the required restrained length calculated. Restrained length calculations shall be included in the lay schedule in the material submittal package and shall use approved methods of joint restraint. *See* City of Denton Standard Details, specific product listings and Table 6.2-C below.

G. Geotechnical reports detailing soil conditions, that may affect the design, operation or maintenance of water infrastructure are required. Corresponding corrosion protection systems are to be provided for metallic pipe materials including reports detailing the operation and maintenance of the corrosion protection systems. Corrosion system design reports must be included with record drawings.

Table 6.2-C: Restraint Lengths for Fittings and Bends

Pipe Size (inches)	Plugs, Tees, and Valves [1]	Bends [1]			
		90°	45°	22.5°	11.25°
8	88 ft	33 ft	14 ft	7 ft	4 ft
12	126 ft	45 ft	19 ft	9 ft	5 ft

Notes:

[1] Length to be restrained on each side of the bend or fitting. Assumptions: 1.5 safety factor, SP soil type, Type 4 trench.

Table 6.2-D: Minimum Requirements for Pipe and Fittings

Pipe Size and Material	Ductile Iron Fittings	Corrosion Protection	Thrust Restraint	Embedment
8-IN. TO 12-IN.				
PVC (AWWA C900, DR – 14)	Mechanical joint; Compact or Full-Body	8-mil V-Bio Enhanced Polywrap (fitting only)	Wedge-action mechanical joint restraint glands, at fittings.	See drawings U201, U202, U203A, U203C in City of Denton Standard Details
16-IN. TO 20-IN.				
Ductile Iron, AWWA C151, Special Thickness Class 52, push-on-joints (where unrestrained; e.g.: American Flex-Ring joint)	Mechanical joint; Full-Body	8-mil V-Bio Enhanced Polywrap (inner layer), plus 4-mil cross-linked (outer layer) Bonded joint and Cathodic Protection (CP) System required	Wedge-action mechanical joint restraint glands, at fittings. Boltless Restrained connections (Example: American Flex-Ring joint), at several pipe joints either side of each fitting, depending on the required restrained length calculated.	See drawings U201, U202, U203A, U203C in City of Denton Standard Details
Reinforced Concrete Steel Cylinder, AWWA C303 Bar Wrapped	N/A	Bonded joint and Cathodic Protection (CP) System required	Full Circle Welded Joints required for thrust restraint	Contact Water Utilities Dept.
24-IN.				
Ductile Iron, AWWA C151, Special Thickness Class 52, push-on joints (where unrestrained; e.g.: American Flex-Ring joint)	Mechanical joint; Full-Body	8-mil V-Bio Enhanced Polywrap (inner layer), plus 4-mil cross-linked (outer layer) Bonded joint and Cathodic Protection (CP) System required	Wedge-action mechanical joint restraint glands, at fittings. Boltless Restrained connections (Example: American Flex-Ring joint), at several pipe joints either side of each fitting, depending on the required restrained length calculated.	Crushed Stone
Reinforced Concrete Steel Cylinder, AWWA C303 Bar Wrapped	N/A	Bonded joint and Cathodic Protection (CP) System required	Full Circle Welded Joints required for thrust restraint.	Contact Water Utilities Dept.
30-IN. AND LARGER				
Ductile Iron, Pressure Class 350; push-on joints (where unrestrained; e.g.: American Flex-Ring joint)	Mechanical joint; Full-Body	8-mil V-Bio Enhanced Polywrap (inner layer), plus 4-mil cross-linked (outer layer) Bonded joint and Cathodic Protection (CP) System required	Wedge-action mechanical joint restraint glands, at fittings. Boltless Restrained connections (Example: American Flex-Ring joint), at several pipe joints either side of each fitting, depending on the required restrained length calculated.	Crushed Stone
Reinforced Concrete Steel Cylinder, AWWA C303 Bar Wrapped	N/A	Bonded joint and Cathodic Protection (CP) System required	Full Circle Welded Joints required for thrust restraint.	Contact Water Utilities Dept.

6.2.5 Connections

A. Methods of Connection

1. Tapping Sleeve and Valve

   Tapping sleeves with tapping valves shall be used whenever possible for connections to existing mains to avoid interruption of water services. *See* Figure 3.1 in Drawing PIAZ13 of the City of Denton Standard Details.

   a. As per AWWA C223, size-on-size taps are allowed up to 12 inches (e.g.: 12-in. x 12-in.)

   b. Taps on pipes 16 inches and larger must be approved in writing in advance by the City's Engineer after demonstrating the demand is greater than the availability from the distribution existing system. Taps to mains 16 inches and greater must be a minimum of 12 inches and utilize an isolation valve of the same size as the tap. Extensions may be reduced by fittings after the tapping valve. *See* Figure 3.2 in Drawing PIAZ13 of the City of Denton Standard Details.

   c. Connections to fire hydrant leads on existing mains 16 inches and larger may be allowed on a case-by-case basis after consultation and written approval by the City's Engineer.

   d. All water service lines, two (2) inches and smaller, require taps as per City of Denton Standard Details.

2. Cut-in Connection

   Cut-in connections are only allowed to existing mains larger than 12 inches, where a size-on-size connection is needed. *See* Figure 3.4 in Drawing PIAZ14 of the City of Denton Standard Details.

3. Main Extensions

   A new valve shall be installed at the point of connection for water main extensions. This will facilitate the testing and chlorination of the new main prior to its placement into service. *See* Figure 3.5 in Drawing PIAZ14 the City of Denton Standard Details.

   Note that the developer is responsible for all surface rehabilitation associated with connecting to the City's Water Utilities. Surface rehabilitation must match existing site conditions or better.

B. Flushing and Disinfection

Refer to all current City specifications and TCEQ requirements for Flushing and Disinfection.

6.2.6 Valves

A. Isolation Valves

1. Location

   Isolation valves shall be provided to allow for the proper operation and maintenance of the water distribution system, and to ensure water quality can be maintained for each individual water customer connected to the system.

   The location of valves needs to properly address the ability of the Department of Water Utilities to remove a water line from service to perform necessary repairs, while critically minimizing the interruption of service for fire protection and to customers. Isolation of any given section of water line should generally be able to be accomplished by closure of the

least number of valves, as would generally be expected under good engineering design practices and utility engineering standards. The Department of Water Utilities reserves the right to require changes to proposed designs to satisfy these objectives.

The design engineer shall place valves on proposed water mains so they may be easily located in the future by operations and maintenance crews.

The following guidelines should be used by the design engineer in placement of isolation valves on proposed water mains:

a. Two (2) valves are to be installed at every main branch tee location, one (1) flanged to the branch of the tee and the other a mechanical joint connection on one (1) of the two (2) runs of the tee. *See* Figure 3.6 in Drawing PIAZ15 of the City of Denton Standard Details. Three (3) valves are to be installed at every cross location, each a mechanical joint connection.

b. Valves for line sizes 12 inches in diameter or less should not be spaced any farther apart than 1,000 feet. For city blocks that are longer than 1,000 feet between street intersections, placement of a valve will be required between street intersections.

c. Valves should be generally located so that no more than four (4) valves are required to isolate a section of main. *See* Figure 3.7 in Drawing PIAZ15 of the City of Denton Standard Details. For mains larger than 12 inches in diameter, valve spacing and placement shall be subject to alternate criteria approved by the City's Engineer.

d. All fire hydrant leads must be designed with a valve that is flanged to the main line. *See* Drawings W401A and W401B of the City of Denton Standard Details.

2. Specifications

Refer to Table 6.2-L and Standard Specifications 33 14 20 Resilient Seated (Wedge) Gate Valves and 33 14 21 AWWA Rubber-Seated Butterfly Valves.

Table 6.2-E: Isolation Valve Requirements

Size	4-in. to 12-in.	16-in. to 20-in.	24-in.	30-in.	36-in. or larger
Type	Gate Valve (AWWA C509 resilient-seat)	Gate Valve (AWWA C515 resilient-seat)	Gate Valve (AWWA C515 resilient-seat)	Gate Valve (AWWA C515 resilient-seat)	Gate Valve (AWWA C515 resilient-seat) or butterfly, to be determined by City on a case-by-case basis
Orientation	Vertical	Vertical	Vertical	Vertical or horizontal; to be determined by City on a case-by-case basis	Vertical or horizontal; to be determined by City on a case-by-case basis
Gear Operator Required	No	No	Yes	Yes	Yes
Vault Required	No	No	Yes	Yes	Yes
Bypass Required	No	No	No	Yes	Yes

3. Details

   Refer to Drawings W104, W105, W106A, W106B, and W601 of the City of Denton Standard Details.

B. Air Release Valves and Air/Vacuum-Air Release Valves

For water mains less than 16 inches in diameter in certain situations where the topography, remoteness, or some other hydraulic factor necessitates it, air release valves are required at local high points to facilitate automatic release of accumulated air.

For water mains 16 inches and larger, the City requires air/vacuum-air release valves at local high points to facilitate automatic release of accumulated air and to facilitate automatic prevention of vacuum conditions within the line. *See* Drawings W801 and W802 of the City Standard Details.

Manholes shall not be placed in sidewalks, pedestrian ramps, driveway approaches, or in the bottom or on the slopes of a drainage channel or drainage structure. Manholes shall be kept a minimum of 40 feet from any railroad track.

C. Pressure Reduction Valves and Pressure Sustaining Valves

Public pressure reduction valves and pressure sustaining valves are to be coordinated with and written approval obtained from the City's Engineer in consultation with the Field Operations division. Valves shall be located where they are accessible to City staff and located in a vault sized for the valve assemblies and staff access in unpaved areas of ROW and/or PUE. PUEs shall be sized considering the size of the vaults, depth of the water main, and site constraints, including, but not limited to, highways, creeks, railroads, existing and proposed structures, ingress and egress availability, topography, and ESAs.

D. Blowoff Valve Assemblies

Water mains 16 inches and larger shall be equipped with blowoff valve assemblies sized to facilitate 3 fps scouring velocities within the main, flushing and draining of the water main for maintenance. Assemblies are to be located at low points where sediment can accumulate and to ensure complete drainage of the main to allow for repairs to be completed on empty mains.

The discharge piping of the blowoff assembly must direct flushed water towards drainage infrastructure without causing flooding. Erosion prevention must be included in the design of the assembly and direction of discharged water. The location of the assemblies must be in a public ROW or utility easement in an unpaved area large enough for operation of the assembly.

6.2.7 Dead-End Mains

A. Dead-end main situations should be avoided whenever possible, except for main extensions to neighboring property for future extension.

B. In lieu of dead-end mains, the design should loop through public ROW or a dedicated public utility easement (with adequate assurance of access and fencing prohibited) to another nearby water main using the same size pipe.

C. If a dead-end main situation is unavoidable, it shall be designed so that it may be periodically flushed of stagnant water by locating a fire hydrant or other flushing device near the main's end and past the last service connection. *See* City of Denton Standard Detail W603.

6.2.8 Fire Hydrant Locations and Coverage

A. The design engineer should locate fire hydrants as close as possible to street intersections, but outside of the curb radius. This positioning of fire hydrants provides coverage along several streets. When spacing requirements necessitate the installation of fire hydrants between street intersections, they should be placed at the projection of lot lines between property owners. For main replacement projects in established neighborhoods, fire hydrants should be designed as close as possible to the old fire hydrant location, provided coverage is adequate. Neighborhood residents are familiar with the fire hydrant being at that location and normally expect a replacement fire hydrant to be placed at the same location. Fire hydrants are not to be installed closer than nine (9) feet to any wastewater main, manhole, or appurtenance.

B. Fire hydrant spacing shall comply with the 2021 IFC Appendix C Fire Hydrant Locations and Distribution, and be easily accessible by City staff and First Responders. *See* City of Denton Standard Details W401A and 401B, and Standard Specifications 33 14 40 Fire Hydrants. Fire hydrants shall be placed at a maximum of 500 feet apart in single-family residential areas and a maximum of 300 feet apart in all other areas, unless a closer spacing is required by the IFC.

6.2.9 Meters and Meters Cans/Vaults

The City allows the following water meters, depending on the volume and nature of the customer flow demands:

Table 6.2-F: Allowable Water Meters

Service Size	Meter Size	Type	AWWA Standard
1-in.	⅝-in. x ¾-in.	Positive Displacement	AWWA C700
1-in.	¾-in. x ¾-in.	Positive Displacement	AWWA C700
1-in.	1-in.	Positive Displacement	AWWA C700
2-in.	1½-in.	Positive Displacement	AWWA C700
2-in.	2-in.	Positive Displacement	AWWA C700
4-in.	3-in. Tru/Flo	Compound	See City Standard Specification 33 14 18
4-in.	4-in. Tru/Flo	Compound	See City Standard Specification 33 14 18
6-in.	6-in. Tru/Flo	Compound	See City Standard Specification 33 14 18
6-in.	6-in. Protectus III Fire Service (Shall be used for combination of domestic and fire service)	Compound	See City Standard Specification 33 14 18
8-in.	8-in. Protectus III Fire Service (Shall be used for combination of domestic and fire service)	Compound	See City Standard Specification 33 14 18

Notes:
[1] Turbine meters shall be allowed for irrigation meters; not for domestic meters.
[2] Venturi meters shall be allowed when recommended by City Water Utilities based on Single-Family Equivalent calculations.
[3] Fire hydrant meters shall only be used for non-potable purposes.
[4] Vaults are required for all meters greater than two (2) inches.
[5] *See* Section 6.2.9.D for Furnishing and Installing meters.
[6] Non-standard sized water services are not allowed. Refer to the water service connection drawings on the City of Denton Standard Details.
[7] Sites that require an irrigation meter shall have two (2) separate service line connections onto the main; one (1) for the domestic meter, and the other for the irrigation meter.

A. Number of Meters

One (1) meter is required for each residential, commercial, or industrial service connection, in accordance with the Code of the City of Denton, Texas, Chapter 26, Article I, Sec. 26-9. An apartment building, condominium, manufactured housing community, or mobile home park may be considered a single commercial facility for the purpose of this section. The City's standard policy is that only one (1) meter for domestic use will be furnished to each lot. Exceptions to that policy are:

1. Multifamily, commercial, industrial, or institutional sites shall have a separate irrigation meter from the domestic meter with a separate service line to the distribution main;
2. Multifamily developments with greater than 200 units shall be required to have two (2) domestic meters for redundancy and reliability of water service, where each meter is located on a different water main or separated by an inline valve. Note that Fire Code may require redundant (secondary) fire suppression connections;
3. Multi-building sites where the configuration or size of the site makes a single meter location impractical or infeasible;
4. Institutional Group I-2 Facilities as per IBC Sec. 308.3 and IPC Sec. 609; and
5. Submetering by the property owner to tenants of multifamily developments with a minimum of five (5) units per building (or by condominium associations to member) shall be done at the owner's expense, with privately purchased and maintained meters, and in accordance with the Public Utilities Commission 16 TAC Chapter 24 Subchapter I, as amended.

B. Sizing

In commercial and industrial projects, the design engineer shall consult with the owner or the MEP engineer to identify proposed sizes and locations for domestic water meters, fire sprinkler connections, and irrigation meters.

During Building Permit review, the City evaluates adequacy of meter size using Table E201.1, "Minimum Size of Water Meters, Mains and Distribution Piping Based on Water Supply Fixture Unit Values (w.s.f.u.)" of the version of the International Plumbing Code (IPC) as adopted by the City (copy included herein as Table 6.2-G). The City's Building Permit Plans Review uses the version of the International Residential Code as adopted by the City, Table P2903.6, "Water-Supply Fixture-Unit Values for Various Plumbing Fixture and Fixture Groups" (see Table 6.2-H) to estimate w.s.f.u. To facilitate review of the proposed meter size, the design engineer shall submit a tabulation of w.s.f.u.; a sample tabulation is provided herein in Table 6.2-J.

Contact the Water Utilities Department regarding criteria for sizing fire-rated master meters.

For commercial or industrial sites that utilize large amounts of water in their production process, the developer shall provide estimated peak daily demand. Meter to be sized to 1.25 times (1.25x) the peak daily demand.

The total service units for multifamily apartment projects with eight (8) or more units shall be determined by multiplying the total number of bedrooms in the multifamily apartment project by 0.26 Single-Family Equivalents (SFEs).

Table 6.2-G: Minimum Size of Water Meters, Mains, and Distribution Piping based on water-supply fixture-unit (w.s.f.u) values

Meter and Service Pipe (inches)	Distribution Pipe (inches)	Maximum Development Length (feet)									
PRESSURE RANGE 30 TO 39 PSI		**40**	**60**	**80**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
3/4	1/2[1]	2.5	2	1.5	1.5	1	1	0.5	0.5	0	0
3/4	3/4	9.5	7.5	6	5.5	4	3.5	3	2.5	2	1.5
3/4	1	32	25	20	16.5	11	9	7.8	6.5	5.5	4.5
1	1	32	32	27	21	13.5	10	8	7	5.5	5
3/4	1-1/4	32	32	32	32	30	24	20	17	13	10.5
1	1-1/4	80	80	70	61	45	34	27	22	16	12
1-1/2	1-1/4	80	80	80	75	54	40	31	25	17.5	13
1	1-1/2	87	87	87	87	84	73	64	56	45	36
1-1/2	1-1/2	151	151	151	151	117	92	79	69	54	43
2	1-1/2	151	151	151	151	128	99	83	72	56	45
1	2	87	87	87	87	87	87	87	87	87	86
1-1/2	2	275	275	275	275	258	223	196	174	144	122
2	2	365	365	365	365	318	266	229	201	160	134
2	2-1/2	533	533	533	533	533	495	448	409	353	311
PRESSURE RANGE 40 TO 49 PSI		**40**	**60**	**80**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
3/4	1/2[1]	3	2.5	2	1.5	1.5	1	1	0.5	0.5	0.5
3/4	3/4	9.5	9.5	8.5	7	5.5	4.5	3.5	3	2.5	2
3/4	1	32	32	32	26	18	13.5	10.5	9	7.5	6
1	1	32	32	32	32	21	15	11.5	9.5	7.5	6.5
3/4	1-1/4	32	32	32	32	32	32	32	27	21	16.5
1	1-1/4	80	80	80	80	65	52	42	35	26	20
1-1/2	1-1/4	80	80	80	80	75	59	48	39	28	21
1	1-1/2	87	87	87	87	87	87	87	78	65	55
1-1/2	1-1/2	151	151	151	151	151	130	109	93	75	63
2	1-1/2	151	151	151	151	151	139	115	98	77	64
1	2	87	87	87	87	87	87	87	87	87	87
1-1/2	2	275	275	275	275	275	275	264	238	198	169
2	2	365	365	365	365	365	349	304	270	220	185
2	2-1/2	533	533	533	533	533	533	533	528	456	403
PRESSURE RANGE 50 TO 60 PSI		**40**	**60**	**80**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
3/4	1/2[1]	3	3	2.5	2	1.5	1	1	1	0.5	0.5
3/4	3/4	9.5	9.5	9.5	8.5	6.5	5	4.5	4	3	2.5
3/4	1	32	32	32	32	25	18.5	14.5	12	9.5	8
1	1	32	32	32	32	30	22	16.5	13	10	8
3/4	1-1/4	32	32	32	32	32	32	32	32	29	24
1	1-1/4	80	80	80	80	80	68	57	48	35	28
1-1/2	1-1/4	80	80	80	80	80	75	63	53	39	29
1	1-1/2	87	87	87	87	87	87	87	87	82	70
1-1/2	1-1/2	151	151	151	151	151	151	139	120	94	79
2	1-1/2	151	151	151	151	151	151	146	126	97	81
1	2	87	87	87	87	87	87	87	87	87	87

Table 6.2-G: Minimum Size of Water Meters, Mains, and Distribution Piping based on water-supply fixture-unit (w.s.f.u) values

Meter and Service Pipe (inches)	Distribution Pipe (inches)	Maximum Development Length (feet)									
1-1/2	2	275	275	275	275	275	275	275	275	247	213
2	2	365	365	365	365	365	365	365	329	272	232
2	2-1/2	533	533	533	533	533	533	533	533	533	486
PRESSURE RANGE OVER 60 PSI		**40**	**60**	**80**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
3/4	1/2[1]	3	3	3	2.5	2	1.5	1.5	1	1	0.5
3/4	3/4	9.5	9.5	9.5	9.5	7.5	6	5	4.5	3.5	3
3/4	1	32	32	32	32	32	24	19.5	15.5	11.5	9.5
1	1	32	32	32	32	32	28	28	17	12	9.5
3/4	1-1/4	32	32	32	32	32	32	32	32	32	30
1	1-1/4	80	80	80	80	80	80	69	60	46	36
1-1/2	1-1/4	80	80	80	80	80	80	76	65	50	38
1	1-1/2	87	87	87	87	87	87	87	87	87	84
1-1/2	1-1/2	151	151	151	151	151	151	151	144	114	94
2	1-1/2	151	151	151	151	151	151	151	151	118	97
1	2	87	87	87	87	87	87	87	87	87	87
1-1/2	2	275	275	275	275	275	275	275	275	275	252
2	2	365	368	368	368	368	368	368	368	318	273
2	2-1/2	533	533	533	533	533	533	533	533	533	533

Notes:

[1] Minimum size of building supply is ¾-in. pipe.

[2] User shall follow the most recently adopted code; above table was the most recent version at the time of publication of this Manual.

Source: 2021 International Plumbing Code – Table E201.1

Table 6.2-H: Water-supply fixture-unit (w.s.f.u) values for Various Plumbing fixtures and Fixture Groups

Type of Fixtures or Group of Fixtures	Load in w.s.f.u. values		
	HOT	COLD	COMBINED
Bathtub (with/without overhead shower head)	1.0	1.0	1.4
Clothes washer	1.0	1.0	1.4
Dishwasher	1.4	—	1.4
Full-bath group with bathtub (with/without shower head) or shower stall	1.5	2.7	3.6
Half-bath group (water closet and lavatory)	0.5	2.5	2.6
Hose bibb (sillcock)[1]	—	2.5	2.5
Kitchen group (dishwasher and sink with/without garbage grinder)	1.9	1.0	2.5
Kitchen sink	1.0	1.0	1.4
Laundry group (clothes washer standpipe and laundry tub)	1.8	1.8	2.5
Laundry tub	1.0	1.0	1.4
Lavatory	0.5	0.5	0.7
Shower stall	1.0	1.0	1.4
Water closet (tank type)	—	2.2	2.2

Notes:

[1] The fixture unit value 2.5 assumes a flow demand of 2.5 GPM, such as for an individual lawn sprinkler device. If a hose bibb/sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

[2] Supply loads in the building water-distribution system shall be determined by total load on the pipe being sized, in terms of w.s.f.u., as shown in Table P2903.6, and gallons per minute (GPM) flow rates [see Table P2903.6(1)]. For fixtures not listed, choose a w.s.f.u. value of a fixture with similar flow characteristics.

[3] For SI units: 1 GPM = 3.785 Liters per minute (L/m).

[4] User shall follow the most recently adopted code. The above table was the most recent version at the time of publication of this Manual.

Source: 2021 International Residential Code – Table P2903.6

Table 6.2-I: Load Values assigned to Fixtures [1]

Fixture	Occupancy	Type of Supply Control	Load in w.s.f.u values		
			COLD	HOT	COMBINED
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flushometer-valve	6.0	3.0	8.0
Bathtub	Private	Faucet	1.0	1.0	1.4
Bathtub	Public	Faucet	3.0	3.0	4.0
Bidet	Private	Faucet	1.5	1.5	2.0
Combination fixture	Private	Faucet	2.25	2.25	3.0
Dishwashing machine	Private	Automatic	—	1.4	1.4
Drinking fountain	Offices, etc.	⅜-in. valve	0.25	—	0.25
Kitchen sink	Private	Faucet	1.0	1.0	1.4
Kitchen sink	Hotel, restaurant	Faucet	3.0	3.0	4.0
Laundry trays (1 to 3)	Private	Faucet	1.0	1.0	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2.0
Service sink	Offices, etc.	Faucet	2.25	2.25	3.0
Shower head	Public	Mixing valve	3.0	3.0	4.0
Shower head	Private	Mixing valve	1.0	1.0	1.4
Urinal	Public	1-in. flushometer-valve	10.0	—	10.0
Urinal	Public	¾-in. flushometer-valve	5.0	—	5.0
Urinal	Public	Flush tank	3.0	—	3.0
Washing machine (8-lb.)	Private	Automatic	1.0	1.0	1.4
Washing machine (8-lb.)	Public	Automatic	2.25	2.25	3.0
Washing machine (15-lb.)	Public	Automatic	3.0	3.0	4.0
Water closet	Private	Flushometer valve	6.0	—	6.0
Water closet	Private	Flush tank	2.2	—	2.2
Water closet	Public	Flushometer valve	10.0	—	10.0
Water closet	Public	Flush tank	5.0	—	5.0
Water closet	Public or private	Flushometer tank	2.0	—	2.0

Notes:

[1] For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads and for total load. The separate hot and cold water loads are three-fourths of the total load for the fixture in each case.

[3] For SI units: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

[4] User shall follow the most recently adopted code. The above table was the most recent version at the time of publication of this Manual.

Source: 2021 International Plumbing Code – Table E103.3(2)

Table 6.2-J: Sample w.s.f.u Tabulation

Fixture	Quantity	Load Values, in Total w.s.f.u (each)	Total Fixture Units
Water Closet (Public; Flush Valve)	9	10.0	90
Water Closet (Public; Flush Tank)	3	5.0	15
Urinal (Public; ¾-in. Flush Valve)	5	5.0	25
Lavatory (Public)	10	2.0	20
Kitchen Sink (Hotel, Restaurant)	2	4.0	8
Service Sink	1	3.0	3
Shower Head (Private)	1	1.4	1.4
		Total	**162.4**

Table 6.2-K: Land Use and Service Units/SFE Equivalencies

Meter Type	Meter Size	Typical Land Use	Single-Family Equivalents (SFEs)
Positive Displacement	⅝-in. x ¾-in.	Residential – Single-Family (Building less than 1,300 sq. ft. per lot size less than 6,000 sq. ft.)	0.5
Positive Displacement	⅝-in. x ¾-in.	Residential – Single-Family	1.0
Positive Displacement	¾-in. x ¾-in.	Residential / Commercial	1.5
Positive Displacement	1-in.	Residential / Commercial	2.5
Positive Displacement	1½-in.	Commercial	5.0
Positive Displacement	2-in.	Commercial	8.0
Compound	3-in.	Commercial / Industrial	22.5
Compound	4-in.	Commercial / Industrial	50.0

Notes:
Source: City of Denton Approved Meter Manufacturer's Specifications;
City of Denton Code of Ordinances Section 26-218 - Water and Wastewater Facilities - Exhibit F

C. Location

Water meters and meter cans and vaults shall be placed within a City ROW, Public Utility Easement or Public Water Easement. Placement shall also satisfy the following requirements:

1. Located as close as possible to the public water main;
2. Easily accessible to City of Denton employees; and
3. Located in an unpaved area that does not conflict with vehicular or pedestrian traffic.

D. Furnishing and Installing

All meters two (2) inches and smaller, shall be furnished and installed by City Water Utilities for fees per the current Fee Schedule. All meter assemblies three (3) inches and larger and their associated vaults, shall be furnished and installed by Contractor at their expense and inspected by Public Works Inspection and City Water Utilities.

E. Details

Details of the meter can assemblies for meter sizes two (2) inches and smaller are shown in the City

of Denton Standard Details.

Details of the meter vault assemblies for meter sizes three (3) inches and larger are shown in the City of Denton Standard Details.

F. Backflow Prevention

Note that this section of the DCM, 6.2.9.F-Backflow Prevention will be superseded and void upon the adoption of a formal City Ordinance governing backflow prevention assembly requirements in the near future.

Backflow Prevention Assemblies are required in accordance with the International Plumbing Code, 2021 IFC, 30 TAC § 290.44. Backflow Prevention Assemblies must be utilized as follows:

1. At each dedicated fire line connection. A flanged fire line valve shall be required to connect to the tee located on the main line and a fire line valve shall be required outside the downstream side of the vault or ROW line whichever applies;
2. After each meter of any site served by redundant domestic meters;
3. At facilities supporting Recreational Vehicle (RV) connections for the purpose of flushing waste tanks;
4. At all services outside City limits, in accordance with 30 TAC § 290.47(f)); and
5. At all properties that have an auxiliary water source. These properties must protect connections to the public water system using a reduced pressure backflow assembly (RPBA).

Backflow prevention devices shall be placed at the ROW or an easement line adjacent to the connection to the public water system.

6.2.10 Underground Utility Crossing

Water mains shall be separated from wastewater mains as set forth in 30 TAC § 290.44(e) - Location of Waterlines, as amended.

Where water mains are laid under or over another buried utility line or underground facility (i.e., storm drain, culvert boxes, franchise utilities, etc.), special requirements may be necessary for the protection of the water main. Table 6.2-L provides requirements for different crossing situations. This table is not a replacement for separation requirements for sewer and water lines as governed by 30 TAC §§ 217.53 and 290.44, respectively.

Table 6.2-L: Utility Crossing Requirements

Water Utility	Crossing	Utility Line Size (in.)	Separation (feet)	Special Requirement
New/existing Water	Under	< 24	≥ 2	None
New/existing Sewer	Under	< 24	≥ 2	None
New/existing Water	Under	24 to 42	≥ 2	None
New/existing Sewer	Under	24 to 42	≥ 2	None
New Water	Under	> 42	≥ 2	Encased in 150±psi pressure class pipe
Existing Water	Under	> 42	≥ 2	Encased in split steel casing
New Sewer	Under	> 42	≥ 2	Encased in 150±psi pressure class pipe
Existing Sewer	Under	> 42	≥ 2	Encased in split steel casing
New Water	Under	≥ 10	≥ 2	Cased in steel pipe
Existing Water	Under	≥ 10	≥ 2	Cased in split steel pipe
New Sewer	Under	≥ 10	≥ 2	Cased in steel pipe
Existing Sewer	Under	≥ 10	≥ 2	Cased in split steel pipe
New/existing Water	Over	< 24	≥ 2	None
New/existing Sewer	Over	< 24	≥ 2	None
New/existing Water	Over	≥ 24	≥ 2	None
New/existing Sewer	Over	≥ 24	≥ 2	None

A. To minimize crossing impacts, crossings must be perpendicular, if possible.

B. Utility crossings with less than two (2) feet of separation require a design deviation request (which will include special requirements) after providing a thorough analysis detailing physical and economic factors involved.

C. Pursuant to the Code of the City of Denton, Texas, Chapter 25, Article II, Sec. 25-80-Facility Size and Locations, all ROW user facilities are required to maintain a minimum separation of 24 inches from all City utility system facilities. If a ROW user may encounter a hardship due to this requirement, the ROW user may request a design deviation as detailed in Section 9 of this Manual.

D. Split-steel casing shall follow sizing requirements of pressure-rated casing.

E. See City Standard Specification Section 33 05 07 Steel Casing Pipe.

F. Casing spacers shall be placed not more than five (5) feet apart.

G. Encasement shall be extended a minimum of three (3) feet beyond the edge of the utility or facility to be crossed. Water mains that cross utility lines in private easements must adhere to the requirements of the easement owner, as well as those listed above.

6.2.11 Fence or Wall Crossings

A. Water mains should be routed to avoid entering private property. In circumstances where it is impractical to avoid doing so, provisions are required to allow City staff to inspect, maintain, and repair its infrastructure. Water mains crossing fences will require a design deviation request as per Section 9 of this Manual, to be reviewed by the City's Engineer, after thorough consideration of the physical and economic factors involved. Design deviations may require additional provisions beyond this Manual.

B. Water mains crossing under privacy fencing (wood, chain-link, or plastic) shall not require any

special protection.

C. Water mains crossing under other types of fencing will require the fence to be constructed of easily removable panels or have gates that can be removed from the easement.

D. Water mains may not cross under retaining walls.

E. There must be at least two (2) feet of vertical separation between a water line and any utility or storm drain crossing it.

6.2.12 Highway Crossings

Crossings of State or County-controlled roads shall require the review and approval of the appropriate regulatory agency after consultation with the City's Engineer regarding crossing location. Crossings shall meet the requirements provided by the controlling agency and by the City of Denton Standards. In the event of different requirement levels for the same item, the more stringent standard shall apply. Crossing locations must be easily and directly accessible on each side of the highway. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of highway crossings considering access, maintenance and repairs.

6.2.13 Railroad Crossings

The design engineer shall, prior to the design of any railroad crossing, contact the appropriate railroad company and regulatory agency to determine if there are any special requirements. Crossings shall be discussed with and must be approved in writing by the City's Engineer. In the event the City of Denton Design Criteria are more stringent than those of the Railroad Company or regulatory agency, the City's standards shall apply. Crossing locations must be easily and directly accessible on each side of the railroad. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of railroad crossings considering access, maintenance and repairs.

6.2.14 Creek Crossings

Where a water main is laid under any flowing stream or semi-permanent body of water, such as a marsh or pond, or an identified ESA (*See* DDC 7.4) the water main shall be installed in a separate watertight encasement pipe, with valves on each side of the crossing to allow for the isolation and testing of that portion of the water main to determine if there are any leaks, and to facilitate future repairs after consultation with the City's Engineer.

A primary consideration in the design of creek crossings is the prevention of soil erosion in the areas of trench backfill. The design engineer shall determine the need and limits of any special embedment, and determine and specify the limits for specialized backfills. Crossing locations must be easily and directly accessible on each side of the creek. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of creek crossings considering access, maintenance and repairs.

6.2.15 Elevated Crossings

Elevated crossings are not permitted for water mains except for special cases approved by the City's Engineer. Design requirements for approved elevated crossings shall be tailored to the specific project characteristics.

6.2.16 Tunneling, Boring, Jacking and Casing

Tunneling, boring, jacking and casing are methods used for water line placement under restrictive conditions when open-cut construction is not allowed. Only straight pipe alignments for both horizontal and vertical alignment are allowed.

Design engineers should consider the location, size, and depth of boring, tunnelling and receiving pits when choosing the beginning and ending stations for boring or tunnelling. A typical bore pit is between 35 and 40 feet in length to accommodate the boring machine and one (1) joint of pipe. Width of the bore pit can vary depending on the depth and size of pipe, with the narrowest width being approximately 15 feet. Tunnelling pits can vary greatly in size depending on the depth and size of the tunnel to be excavated. Additional size and spacing requirements may be required as outlined in DDC 7.4 when working adjacent to confirmed ESAs. The preferred location for the bore or tunnel pit is the lower elevation end of the bore or tunnel; allowing any groundwater and/or boring slurry to drain from the tunnel into the bore or tunnel pit. The water can then be removed by pumping.

A. Steel casing pipe, where required for open-cut or other than open-cut installation, shall conform to City Standard Specification 33 05 07 Steel Casing Pipe, and be subject to the following guidelines:
    1. Within Railroad ROW – the casing pipe size shall be sufficient to accommodate the outside diameter (OD) of the carrier pipe bell of at least one City standard size greater than what is required (see 6.2.4.B). Additionally, the casing pipe size must accommodate any external joint restraint fittings required to restrain the carrier pipe. The annular space between the carrier pipe and casing pipe shall not be grouted.
    2. All other situations – the casing pipe size shall be sufficient to accommodate the OD of the carrier pipe bell plus an additional four (4) inches of clear space. The carrier pipe shall be restrained through grout applied to the annular space between the casing and carrier pipe so external pipe restraints are not required.

B. Carrier pipes through casing shall be restrained as follows:
    1. Segmented PVC and DIP shall be restrained with either external restraint fittings applied to push-on bell and spigot pipe or by utilizing manufactured restrained joint pipe.
    2. HDPE shall be restrained through fused joints.
    3. Concrete steel cylinder pipe shall be restrained through welded joints.

All carrier pipes shall be supported with approved spacers and casing end seals. Refer to City of Denton Standard Detail U208A and the current City approved Materials Submittal List.

Large diameter (48 inches or greater) or long length bores or tunnels (200 feet or greater) may require tunnel liner plate instead of steel casing. These situations shall require design calculations to identify the type and gage of tunnel liner plate to be utilized per Specification 33 05 08 Tunnel Liner Plate.

6.2.17 Existing Water Main Replacement

A. Whenever an existing main is to be replaced by a new main, use the following guidelines for alignment and design:
    1. The new line should be located as near as possible to the existing line; while allowing the existing line to remain in service, until the new line is ready to be put into service.
    2. If the existing line is in or next to a roadway, the new line should be placed under existing pavement, not behind the curb in the parkway area.

3. The new line should be designed to utilize the existing metering locations where possible.

B. The size of the new line should match the size of the existing line. If the existing line is a non-standard size (i.e., 6-in. or 10-in.) then the new line should be sized for the next larger standard size. The design engineer shall perform field investigations to determine pavement condition over the existing main. The pavement may have been patched due to breaks in the existing main over the years. Based on field investigations, the design engineer shall include additional quantities for pavement replacement, if necessary.

6.2.18 Requirements for Abandoning Water Mains

The design engineer should note the limits and appropriate conditions for the abandoning of existing water mains which are to be replaced by the construction of any proposed water mains.

The design engineer should also make allowances in the design to provide for the existing and proposed mains to be in service simultaneously, until all customer services are transferred from the old main to the new main with minimum interruption of service. If the construction of a proposed main necessitates the abandoning of the existing main prior to the new main's placement into service, then provisions for a temporary water main with services must be addressed by the design.

6.2.19 Water Treatment Plants, Ground Storage Tanks, ESTs, Pressure Tanks, and Booster Pump Stations

If new public water treatment plants (WTPs), ground storage tanks (GSTs), ESTs, pressure tanks and/or Booster Pump Stations are needed to support a development, the design shall be directed by the Water Utility considering the needs of the development and the Water Utility System.

6.3 Wastewater Design Criteria

6.3.1 Estimated Wastewater Flows

For sewers in new developments, sewer lines and lift stations shall be designed to accommodate the projected buildout flows from all residential, commercial, industrial, or institutional sources upstream of the proposed sewer improvement. Figure: 30 TAC § 217.32(a)(3) Table B.1. - Design Organic Loadings and Flows for a New Wastewater Treatment Facility (*see* excerpted information in Table 6.3-A) shall be used as a guide to generate wastewater flows. However, minimum flow capacity for sizing of sewers for peak flow condition shall not be less than the results of the following calculation procedures:

A. Delineate the wastewater drainage area that will drain into the sewer main or lift station. Include all upstream offsite areas.

B. For the development site, use the following design parameters:

1. Table 6.3-A to generate the wastewater loading by type of use.
2. 3.2 capita per lot for single-family.
3. 2.5 capita per unit for multifamily.
4. Apply a 4.0 multiplier to the average daily flow to determine the peak flow.

C. For undeveloped upstream areas, use the following design parameters:

1. 4 lots per acre.

2. 3.2 capita per lot.
3. Average daily flow of 90 GPCD.
4. Apply a 4.0 multiplier to the average daily flow to determine the peak flow.

D. For developed residential upstream areas, use the following design parameters:
1. Count number of single-family lots.
2. Obtain number of multifamily units (available through DCAD)
3. 3.2 capita per lot for single-family.
4. 2.5 capita per unit for multifamily.
5. Average daily flow of 90 GPCD
6. Apply a 4.0 multiplier to the average daily flow to determine the peak flow

E. For developed non-residential upstream areas, use the following design parameters:
1. Average daily flow of 1,500 GPD per acre.
2. Apply a 4.0 multiplier to the average daily flow to determine the peak flow.

For replacement of existing sewers and construction of parallel sewers for additional capacity, wastewater flow data may be provided by the City from data generated by City sewershed computer models. The cost for modeling a project's impact with the City's collection system model will be the responsibility of the developer and paid to the City.

Proposed impacts to the City's system determined to, or likely to, cause (through hydraulic modeling or other analysis) these limits to be exceeded, are prohibited without additional improvements to the public system to address the capacity deficiency.

Table 6.3-A: Design Flows for a New Wastewater Treatment Facility

Source	Remarks	Daily Wastewater Flow (Gal. per person)[1]
Municipality	Residential	75 - 100
Subdivision	Residential	75 - 100
Trailer Park [2] (Transient)	2½ Persons per Trailer	50 - 60
Mobile Home Park [2]	3 Persons per Trailer	50 - 75
School	Cafeteria & Showers Cafeteria/ No Showers	20 15
Recreational Parks	Overnight User Day User	30 5
Office Building or Factory	Facility must be designed for the largest shift	20
Hotel/Motel	Per Bed	50 - 75
Restaurant	Per Meal	7 - 10
Restaurant with bar or cocktail lounge	Per Meal	9 - 12
Hospital	Per Bed	200
Nursing Home	Per Bed	75 - 100
Alternative Collection Systems, e.g., septic tanks	Per Capita	75

Notes:
[1] City of Denton requires usage of the highest number of the TCEQ ranges.
[2] At the time of updating this Manual, the TCEQ is evaluating criteria for tiny homes, and should be consulted as appropriate.
Source: TCEQ Rules - 30 TAC §217.32(a)(3), Table B.1

6.3.2 Size and Slope of Sewers

After the design engineer has determined the wastewater flows per Section 6.3.1 of this Manual, the sewer size can be determined using the following criteria. However, no sewer, other than service laterals and force mains, shall be less than eight (8) inches in diameter.

The size and grade of the proposed sewer shall be evaluated using Manning's formula

$$V = 1.49/n\ (R)^{0.67}\ (S)^{0.50} \qquad \textbf{[Eqn. 6.1]}$$

Where:

V = velocity (in fps)

n = Manning's coefficient of roughness; minimum 0.013

R = hydraulic radius (feet)

S = slope of energy grade line (feet per foot)

Proposed sewers shall be designed with slopes sufficient for velocity of three (3.0) fps, with a minimum required velocity of two (2.0) fps. The minimum acceptable Manning's "*n*" factor for design shall be 0.013, which takes into consideration the slime, grit and grease layers that will affect hydraulics or hinder flow as the pipe matures. The sewer pipe grades shown in Table 6.3-B are based on an "*n*" value of 0.013 and are the minimum acceptable slope for sewer lines.

Table 6.3-B: Minimum and Maximum Pipe Slopes

Size of Pipe - ID (inches)	Minimum Slope (%)	Maximum Slope (%)	Capacity Flowing Full at Min. Slope (MGD)
8	0.335	8.40	0.45
10	0.25	6.23	0.71
12	0.20	4.88	1.03
15	0.15	3.62	1.62
18	0.115	2.83	2.25
21	0.095	2.30	3.07
24	0.08	1.93	4.14
7	0.07	1.65	4.91
30	0.06	1.43	6.23
33	0.055	1.26	7.66
36	0.045	1.12	9.17

The capacity of the sewer pipe flowing full shall be computed by the following equation:

$$C = 0.299/n\ (D)^{2.67}\ (S)^{0.50} \qquad \textbf{[Eqn. 6.2]}$$

Where:

C = capacity (million gallons per day-MGD)

n = Manning's coefficient of roughness; minimum 0.013

D = inside diameter (feet)

S = slope of the energy grade line (feet per foot)

Sewer mains shall be designed to convey peak flow at no more than 80% of full pipe capacity at system buildout.

A. High Velocity Protection

Where velocities greater than 10 fps will occur when a pipe flows full, based on Manning's Equation and an "n" value of 0.013, restrained joint pipe or external restraint systems must be utilized.

6.3.3 Sewer Alignment

Design engineers shall be guided by the following in the alignment of wastewater lines:

A. Collection system extensions must follow topographical depressions and extend to the upstream drainage shed, considering storm drainage improvements. Crossing into other drainage sheds require written approval from City's Engineer;

B. For new construction in areas not served, sewer mains shall be laid straight between manholes. No horizontal or vertical bends are allowed between manholes;

C. Avoid shifting mains from one side of the ROW to the other side of the ROW between street intersections;

D. Where the bypass of existing flows is feasible, it is recommended that replacement mains be constructed horizontally in the same trench;

E. Except for pipe crossings, no franchise utility shall be installed within five (5) feet of a sewer main; and

F. Vertically parallel wastewater mains require written approval from the City's Engineer. Details regarding main access must be planned out including but not limited to the dedicated of easements or City ROW to ensure ability to access the mains, calculations and details showing distances from the main that other utilities may not be placed to preserve ability to access.

6.3.4 Sewer Main Depth and Recommended Cover

A. Minimum depth for the design of sewer mains shall be determined by providing a 2% grade for the lateral from the center of the house or building to the center of the proposed main and including an additional two (2) feet drop. Therefore, for a house 100 feet from the proposed sewer main, the designed depth of the main shall be at least four (4) feet below the FFE of the house since:

2 feet + (2% of 100 feet) = 4 feet **[Eqn. 6.3]**

The lateral also must have at least two (2) feet of cover at its shallowest point. The design engineer is responsible for ensuring sufficient depth and grade is maintained to serve all building sites in the sewer shed.

B. Recommended cover for all sewer mains is four (4) feet to six (6) feet. Minimum cover shall be three (3) feet and six (6) inches or 3-½ feet. Any main approved to have less than minimum cover shall be encased in Class "B" embedment per City Standard Specifications. *See* Drawing U204 of the City of Denton Standard Details.

When establishing depth for proposed wastewater mains, design engineers shall consider the impact of proposed water and drainage improvements especially on service laterals that cross those improvements to connect to the wastewater main.

C. The maximum depth of sewer mains is 30 feet.

6.3.5 Gravity and Force Main Sewer Pipe Material

Gravity and Force Main sewer pipe shall meet the following criteria unless special circumstances require an alternative and is approved by the City's Engineer. Slope of grade across cover shall be a maximum of 4H:1V.

Table 6.3-C: Minimum and Maximum Pipe Slopes

Pipe Diameter	Application	Pipe Material
8-in. to 12-in.	Gravity	PVC – ASTM D3034, SDR 26; HDPE – ASTM D3350, DR-17
15-in.	Gravity	PVC – ASTM D3034, SDR 26
18-in. to 24-in.	Gravity	PVC – ASTM F 679, PS115; Fiberglass Reinforced Plastic – ASTM D3262
6-in. to 60-in.	Force Main	HDPE – ASTM D3350, DR-13.5; DIP – AWWA C150/C151, CL52 or PC 350,

A. For gravity sewer pipe sizes over 24 inches in diameter, design calculations and pipe selection shall be submitted by the development design engineer for review. Approvals will be provided on a project specific basis.

B. Force main sewer pipe shall be designed to meet the working and surge pressure requirements of the specific application. Design calculations and pipe selection shall be submitted by the development design engineer for review.

C. Different pipe materials shall not be mixed between manholes. If it is anticipated that a mixing of materials will occur, the design engineer shall design a manhole at the point of transition of pipe materials. For previously placed stub-out of a material other than PVC pipe, design engineer shall add a note to the plans calling for removal of the stub-out or change the material of the proposed pipe for that section of pipe between manholes.

6.3.6 Sewer Pipe Embedment

The types of embedment and backfill for sewer mains are shown in Drawings U201, U202, U203A, and U203C of the City of Denton Standard Details. Embedment requirements shall be based on sewer mains under proposed pavement, unpaved areas and existing pavement.

6.3.7 Manholes

Manholes constructed on existing or proposed sewer lines shall be sized as follows:

Table 6.3-D: Manhole Sizing

Pipe Diameter	Manhole Diameter
8-in. to 12-in.	4.0 feet (For depths greater than 12 feet, use 5.0 feet)
15-in. to 27-in.	5.0 feet
30-in. to 36-in.	6.0 feet

Notes:

[1] Special manholes shall be designed for mains larger than 36-in. diameter pipe.

The types of manholes allowed by the City are shown in Drawings S101, S102, S103, and S107B of the City of Denton Standard Details. Additionally, connections to manholes must comply with City Standard Specifications.

Generally, manholes shall be stationed on the main run, and where known, the stations of the side mains should also be indicated. When connecting a proposed main to an existing main at a manhole, the connection shall have the top inside elevation of the outfall main level with the top inside elevation of the proposed main. Connections to brick manholes are prohibited.

At the discretion of Water Utilities, Field Operations, or Planning and Engineering Department staff, manholes with known deficiencies will be required to be replaced.

Manholes deeper than 20 feet must be of monolithic construction, such as Glass-fiber Reinforced Polyester.

A. Manhole Locations

Manholes shall be provided at the following locations to facilitate maintenance, cleaning, and inspection:

1. At the location of lateral connections that are 8-in. diameter or larger;
2. At 500 feet intervals on sewer mains 15-in. diameter or smaller; at 800 feet internals on mains 18-in. diameter through 30-in. diameter; at 1,000 feet intervals on mains 36-in. diameter through 48-in. diameter; and at 2,000 feet intervals for 54-in. diameter and larger;
3. At all locations where pipe diameter or pipe material changes;
4. At all locations where the horizontal or vertical alignment of the sewer main changes;
5. At the ends of all mains with service connections. Two main upstream ends may not be combined in one manhole;
6. At the end of any pipe segment at least 150 feet long;
7. At the end of every end-of-line (EOL);
8. Sewer service laterals are to be connected to the sewer main line and not into a manhole unless it is a size-on-size connection;
9. Manholes shall not be placed in sidewalks, pedestrian ramps, driveway approaches, or in the bottom or on the slopes of a drainage channel or drainage structure;
10. At a minimum of 40 feet from any railroad track; and
11. Separation of utilities around manholes shall be a minimum distance of five (5) feet , to allow for maintenance and repair.

6.3.8 Sewer Laterals

A. Water Utilities, Field Operations, or Engineering and Planning staff reserve the right to permit utility-supervised connections to the collection system by non-City staff. Note that the developer will be responsible for all surface rehabilitation associated with connecting to the City's Water Utilities. Surface rehabilitation must match existing site conditions or better.

B. Laterals may not serve more than one (1) lot.

C. Minimum lateral sizes from the sewer main to the public cleanout are:

1. 4-in. minimum for single-family;

2. 6-in. minimum for residential duplex, triplex, and quadplex; and
3. 6-in. minimum for local retail, light commercial, apartment, manufacturing and industrial

D. Single-way clean-outs shall be provided on laterals at the public easement or ROW line. Double-way cleanouts are not allowed. *See* Drawings S403 and S404 of the City of Denton Standard Details.

E. Manholes shall be provided for lateral connections when the lateral pipe diameter is equal to the main sewer pipe diameter or if the lateral is eight (8) inches in diameter or larger.

F. Laterals shall be constructed to the property line and shall be located at a point five (5) feet downstream from the center of the lot on unimproved property. For improved property, design engineers should use technical judgement in lateral placement.

G. Preferred grade for lateral construction within the ROW/PUE is 2%. Laterals within ROW/PUE shall not be designed with less than 1% grade.

6.3.9 Underground Utility Crossings

Wastewater mains and manholes shall be separated from water mains as set forth in 30 TAC §217.53(d) - Separation Distances and 30 TAC §290.44 - Water Distribution.

The requirements of Section 6.2.10 of this Manual shall govern the crossing of underground utility lines by wastewater mains.

6.3.10 Fence or Wall Crossings

The requirements of Section 6.2.11 of this Manual shall govern the crossing of fences or walls by wastewater mains.

6.3.11 Highway Crossings

Crossings of State or County-controlled roads shall require the review and approval of the appropriate regulatory agency after consultation with the City's Engineer regarding crossing location. Crossings shall meet the requirements provided by the controlling agency and by the City of Denton Standards. In the event of different requirement levels for the same item, the more stringent standard shall apply. Crossing locations must be easily and directly accessible on each side of the highway. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of highway crossings considering access, maintenance and repairs.

6.3.12 Railroad Crossings

The design engineer shall, prior to the design of any railroad crossing, contact the appropriate railroad company and regulatory agency to determine if there are any special requirements. Crossings shall be discussed with must be approved in writing by the City's Engineer. In the event the City of Denton Design Criteria are more stringent than those of the Railroad Company or regulatory agency, the City's standards shall apply. Crossing locations must be easily and directly accessible on each side of the railroad. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of railroad crossings considering access, maintenance and repairs.

6.3.13 Creek Crossings

When a sewer main crosses a creek or channel, the design engineer must evaluate the condition of the creek bed and ensure erosion control is provided. Backfill material and minimum construction criteria are shown in the City of Denton Standard Details S701 and S702. These criteria include creek bed soil and condition, as well as presence of exposed rock. When working in these areas, minimize storage of soil, materials, and equipment near floodways and waterways. Crossing locations must be easily and directly accessible on each side of the creek. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of creek crossings considering access, maintenance and repairs.

A. Siphons

For creek or channel crossings where a Low-Water Channel Crossing is not feasible, design of an inverted siphon crossing is permissible when approved by the City's Engineer through a design deviation request. Inverted siphons shall not have less than two (2) barrels, with a minimum pipe size of eight (8) inches, and shall be provided with necessary appurtenances for convenient flushing and maintenance. Access structures are required at each end of the siphon, with adequate clearance for maintenance and cleaning purposes. Bank and channel stabilization may be required to protect the crossing lines and casing of the carrier pipe may be required to meet environmental or other restrictions. Siphon locations must be easily accessible on each side of the creek by heavy equipment for maintenance. Additional access easements and installation of all-weather road surface may be required. The City of Denton shall have final say in the location, criteria and standards of creek crossings considering access, maintenance and repairs.

6.3.14 Tunneling, Borings, Jacking, and Casing

Force main tunnels and bores shall follow the same requirements as are laid out for water mains in Section 6.2.16 of this Manual.

6.3.15 Abandonment of Sewer Mains

A. The design engineer should note the limits and appropriate conditions for the abandoning of existing wastewater mains which are to be replaced by the construction of any proposed wastewater mains.

B. The design engineer should also make allowances in the design to provide for the existing and proposed mains to be in service simultaneously until all customer services are transferred from the old main to the new main with minimum interruption of service. If the construction of a proposed main necessitates the abandoning of the existing main prior to the new main's placement into service, then provisions for a temporary wastewater main with services must be addressed by the design.

C. Typically, abandoned lines may be left in place with only the ends being plugged with grout or concrete. However, the City may require special abandonment actions including, but not limited to, filling the abandoned wastewater main with grout, removal and proper disposal of all above ground appurtenances, and removal and proper disposal of the abandoned pipe. In situations where a manhole is being left in service even though one (1) or more lines into the manhole are being abandoned, the abandoned line shall be cut and plugged outside of the manhole. However, if the City determines that the pavement is in good condition the City may allow the abandoned line to be plugged from inside of the manhole.

6.3.16 Abandonment of Manholes

If a manhole as well as the sewer main is to be abandoned, the method described in ***Abandonment of Sewer Mains***, above, along with the minimum guidelines shown in Drawing S105 of the City Standard Details, shall be used.

6.3.17 Lift Stations

The need to construct a lift station should be determined only after a thorough analysis of the physical and economic factors involved. A Preliminary Engineering Report is required, which lists all factors and adheres to current state regulations. The City reserves the right to review each proposal and determine whether there is enough merit to justify a lift station. Any lift station located in the City of Denton CCN must adhere to these requirements.

A. Preliminary Design Submittal

A preliminary design submittal is required for each lift station proposed. The submittal shall include a written report and a map prepared by a Professional Engineer, licensed by the State of Texas.

1. The plans submitted shall contain the following information, at a minimum:
    a. Be to scale, with the scale indicated;
    b. A north arrow;
    c. A location map;
    d. Delineation of the boundary of the proposed development;
    e. Delineation of the boundary of the sewershed in which the development lies;
    f. The area in acres of the development;
    g. The area in acres of the sewershed contributing to the lift station;
    h. The proposed land use or uses for the development;
    i. The proposed land use or uses for the sewer basin;
    j. The proposed lift station site, along with the GPS coordinates;
    k. The proposed force main routing and size;
    l. Delineation of the 100-year flood plain and ESAs;
    m. Location and size of the existing collection system at the tie-in point;
    n. Contour lines (2-ft. intervals);
    o. Show how storm drainage is taken off site; and
    p. Property lines.
2. The written report shall include the following information:
    a. A general narrative about the proposed development and the circumstances that warrant a lift station, including a phasing plan detailing the utilization and station limitations from initial flow to buildout;
    b. Influent hydraulic calculations showing:
        i. Area in acres of the sewer basin and the development;
        ii. The area of each proposed land use for the development and for the projected land use(s) for the basin;

iii. The design flow for the basin and the development;

iv. The peak flow for the basin and the development;

v. Elevation of the proposed lift station site; and

vi. The elevation of the proposed discharge point of the force main.

c. Preliminary wet well volume calculations;

d. Preliminary force main size;

e. Cost estimates for proposed lift station(s) and force main(s), and cost estimates for a gravity line in lieu of the lift station if possible;

f. Ground water levels included in a comprehensive geotechnical report for the proposed site areas; and

g. A copy of the summary transmittal letter to TCEQ showing agency approval of proposed plans.

B. Site Layout

1. Station Siting:

The following are the minimum criteria for station sites:

a. The station shall be protected from the 100-year flood and shall be accessible during a 100-year flood;

b. The station should be located as remotely as possible from populated areas. The entire station site shall be completely enclosed with an 8-ft. high, opaque concrete or masonry wall, with an opaque sliding gate with a minimum width of 16 feet on track flush with the ground. All shall be of an architectural style and colors blending with the development architecture, as approved by the city;

c. The lift station site shall be large enough to allow the construction of the lift station to serve the upstream basin(s), and its replacement while maintaining active service without a bypass;

d. The station site must have verified radio communication ability with the City's central Supervisory Control and Data Acquisition (SCADA) antenna location;

e. The station shall have a minimum 16-ft. wide drive approach and be accessible by City of Denton service trucks, without requiring vehicles to turn after entering the drive approach to the station;

f. The station will include an approved odor-control system;

g. The station site and its access shall be dedicated as a separate lot to the City, as City property;

h. The station site cannot be located within the boundaries of any private entity intended to regulate property including, but not limited to, HOAs, COAs, and POAs;

i. The station site shall be located so it may serve as much as the entire sewer basin as possible. This may require the station to be located off-site of the development. When it is required that the station serve a larger area than the proposed development, the developer may enter into a pro-rata contract with the City to be reimbursed the cost of excess capacity as other developments tie to the system; and

j. The on-site generator must have an unobstructed 36-in. buffer on all sides and be accessible by City service vehicles.

2. Wet Well/ Dry Well Arrangement

a. Orientation shall consider the routing of incoming sewers and force main;

b. Orientation shall allow at least a 2-ton vehicle to directly access the wet well or the dry well, forwards and backwards or larger vehicle as appropriate;

c. Wet wells and dry wells shall be separate structures;

d. Wet wells shall have sloped bottoms to avoid excess sludge deposits;

e. The wet well shall have a lockable aluminum door with an aluminum frame and safety grating. The minimum opening size shall be 4-ft. x 6-ft. with two (2) doors large enough to adequately maintain the wet well. Door and frame shall be Bilco Type K, KD or an approved equal;

f. The dry well or valve vault shall have a lockable aluminum door with an aluminum frame and safety grating. The minimum opening size shall be 2-ft. x 3-ft. or large enough to adequately maintain the dry well or meter vault. Door and frame shall be Bilco Type K, KD or an approved equal;

g. The wet wells, dry wells, manholes, valve vaults and meter vaults, including decks, shall all be cast-in-place concrete only. No other materials are acceptable. *See* City Standard Specification 33 05 64 Concrete Wet wells, Valve Vaults, and Appurtenances for Lift Stations;

h. The coating for the wet well exterior and interior walls shall be coated as specified in Specification 33 05 64 Concrete Wet wells, Valve Vaults, and Appurtenances for Lift Stations;

i. The wet well shall be hydrostatically tested to the top of the wet well for 48 hours prior to placing the lift station into service. Only losses due to evaporation will be acceptable; and

j. Provisions shall be made to remove water from the dry well, valve vault or without allowing gas or water from the wet well into these structures.

3. Site Access

a. Access will be provided by concrete entrance and pad for aesthetics and ease of maintenance;

b. Access shall be functional during a 100-year flood. The road surface shall be above the water level caused by a 100-year return period storm;

c. Every station more than 100 feet from a public street requires a turn-around adjacent to the lift station, sized large enough to accommodate a City service truck with generator;

d. The equipment rack shall not obstruct vehicle access to the wet well or the dry well; the location must be approved during the review process. It shall be placed at an easily accessible elevation and include a canopy; and

e. Site inside the fence shall be an all-weather surface, such as ¾-in. crushed rock or flex-base.

4. Passive Ventilation

   a. Passive ventilation shall be screened to prevent insect access to the wet well or any vaults where ventilation is required. Minimum diameter of air vents shall be four (4) inches. Vent outlet shall be at least one (1) foot above the 100-year flood elevation. The passive ventilation system must be sized to vent at a rate equal to the maximum pumping rate of a lift station, but not to exceed 600 fpm through a vent pipe.

C. Hydraulic Design

For influent flow, the preliminary design report shall include the design flow and the peak flow for the development and the sewer basin. The design flow shall be calculated in accordance with TCEQ rules. Refer to Section 6.3.1 - Estimated Wastewater Flows herein for peak flow calculations.

1. Pump Capacity

   a. Firm pumping capacity is the pumping capacity of the station with the largest pump out of service.

   b. The firm pumping capacity shall be greater than the peak flow for the entire sewer basin. If the sewer basin is significantly larger than the proposed development and it is not feasible to design for this flow, the firm pumping capacity may be designed to handle a portion of the basin with approval from the City's Engineer.

   c. The pump curves shall be selected so the pumps will run near the best efficiency point during normal operating conditions. The selected curves shall also be such that the pumps do not approach shut-off head when they are running simultaneously.

   d. System head curves, pump curves and head calculations shall be submitted. Calculations and pump curves at both minimum (all pumps off) and maximum (last normal operating pump on) static heads, for a C value of both 100 and 140, must be provided for each pump and for the combination of pumps with modified pump curves.

2. Wet Well Volume

   a. Wet well volume for a submersible pump station is the volume contained above the top of the motor, or as specified by the pump manufacturer, to the bottom of the influent pipe. TCEQ Rule §217.60(b)(4) (d) A gravity pipe discharging to a wet well must be located so that the invert elevation is above the liquid level of a pump's "ON" setting.

   b. Wet well volume for all other non-submersible pump stations is the volume contained in an area from a minimum of two (2) feet above or distance at which vortexing does not occur above the top of the intake of the pump.

   c. High level alarm elevation shall be a minimum of 48 inches below the top of the wet well or 48 inches below the flow line elevation of the lowest influent pipe, whichever elevation is lower. Wet well volume shall be calculated by the following method:

$$\mathbf{T = V/(D - Q) + V/Q} \qquad \mathbf{[Eqn.\ 6.4]}$$

Where: T = Total time between successive pump starts in minutes (operating cycle)
D = Rated pump capacity (in GPM)
V = Storage volume between lead pump on and pump off elevations (in gallons)
Q = Inflow to wet well (in GPM)

Note: The operation cycle 'T' shall not be less than 10 minutes for Average Flow and not more than 60 minutes for Minimum Flow conditions.

d. Per TCEQ Rules, 30 TAC § 217.63:

i. Systems for preventing the discharge of wastewater must operate for a duration at least equal to the longest power outage on record for the past 60 months, or at least 20 minutes, whichever is longer. The design must be based on peak flows, inflow, and infiltration. If the longest power outage on record for the past 60 consecutive months is greater than 48 hours and generators will be used to provide backup power, then the owner must have a contract in place that guarantees fuel supply during an emergency. The owner must also have sufficient storage capacity at the wastewater treatment facility for the fuel required for the duration of the emergency.

ii. For calculation purposes, the owner must assume that the lift station wet well is full to the pump activation level when the power outage period begins.

3. Force Main Capacity

a. Force main capacity shall be sized to meet the capacity of the entire sewer basin. The force main may be designed to handle a portion of the basin with approval from the City's Engineer.

b. The minimum force main size shall be four (4) inches in diameter, except for Grinder Pump lift stations.

c. The minimum recommended velocity is three (3) fps, and the velocity shall not be less than two (2) fps when only the smallest pump is in operation.

d. The maximum velocity through a force main shall not be more than six (6) fps and will require confirmation per 30 TAC §217.67 that the pipeline will not fail.

D. Pumps

Pump specifications are listed in the City of Denton Specification 33 25 02 Sewage Pumps. Substitutions or deviations from the list of acceptable pumps requires the approval of the City's Engineer. The number of pumps must comply with 30 TAC § 217.61(e). If pumps are to have a variable capacity, Variable Frequency Drives (VFDs) are to be specified. Stations requiring three pumps must be equipped with VFDs on at least two of the pumps.

E. Mechanical

1. Force Mains

a. Force mains shall be laid to City of Denton Standard Specifications.

b. Plans shall include plan and profile for the force main, including valves every 2,000 feet per 30 TAC § 217.67.

i. Valves must be resilient wedge gate valves and conform to the Section 33 14 20 Resilient Seated (Wedge) Gate Valves of the City of Denton Standard Specifications;

ii. Valves must be in a manhole and conform to Section 6.3.10 of this criteria manual and Section 33 05 61 Cast-In-Place Concrete Manholes of the City Standard Specifications; and

iii. The force main shall have an isolation valve immediately downstream of the flow meter vault.

2. Lift Station Interior Piping

   a. Piping inside the lift station shall be ductile iron meeting AWWA C-150 and C-151. All fittings shall be ductile iron meeting AWWA C-110 or C-150. Interior of the pipe and fittings shall be lined with American Polybond Plus, which consists of a primer layer of 5 mils thick fusion bonded epoxy and 55 mils thick of modified DuPont Fusabond Polyethylene, or approved equal.

   b. All nut and bolt assemblies potentially exposed to sewer gases shall be ASTM 316 stainless steel.

3. Isolation Valves

   a. Each pump shall have one (1) isolation valve downstream of the pump, in a separate vault.

   b. Isolation valves shall be resilient seat gate valves or plug valves meeting the City of Denton Standard Construction Specifications.

4. Check Valves

   a. Check valves shall be controlled closing swing check valves with a lever arm or a ball check. There must be at least 15 feet of vertical head downstream in order to use a ball check valve.

   b. A check valve shall be located upstream of the isolation valve in a separate vault.

   c. All nuts and bolts shall be stainless steel.

5. Air Release / Vacuum Valves

   a. Air release valves of a type suitable for wastewater service shall be installed along the force main where the force main would be prone to trapped air.

   b. The type of valve shall be a combination of air release and vacuum breaker (see Drawing S803 on Sheet 6 of the City Standard Details). The design engineer shall determine the type and location, subject to approval of the City's Engineer.

   c. Calculations for valve type and valve sizing shall be provided to the City.

   d. Locations of the air release/vacuum valves shall be shown on the plan and profile sheets for the force main.

   e. Air release valves along the force main outside of the lift station site must be located in a vault as shown in Standard Details.

   f. Air release valves within the lift station valve vault shall have air vents plumbed to the vault drain.

6. Generators

   a. On-site generators shall be installed to serve as the source of back-up power for lift stations. They must be sized for 125% of the largest pump motor, plus 100% of the additional pump motors and other loads.

   b. Generators shall be mounted on a concrete foundation designed to handle the weight of the generator.

   c. Generators shall use diesel for fuel unless explicit written permission is granted to use a

different fuel.

d. Electrical receptacles for a mobile load bank shall be provided in the electrical design.

e. Generators rated for 500KW or more shall be provided with a permanent load bank situated to adequate dissipate the heat generated on the lift station site.

f. Generators shall be furnished with sound attenuation appropriate for the location.

7. Hoists

Station designs that exceed or are likely to exceed the lifting capabilities of the existing City Water Reclamation service trucks are to provide permanent onsite hoists rated for the lifting of the heaviest assembly in the wet well, considering rag accumulation.

F. Electrical, Instrumentation, and Supervisory Control and Data Acquisition (SCADA) Requirements

1. In accordance with the Lift Station Instrumentation and Control Panel Build Agreement, the contractor building the lift station is required to utilize a pre-approved vendor from the City's current list to perform the specified Instrumentation and Controls (I&C) and SCADA work. The selection of the vendor for a specific project will be made during the pre-construction phase and will be based on vendor availability and project requirements.

2. Provide a radio pathway study showing line of sight from the lift station to the receiver at Pecan Creek Water Reclamation Plant.

3. Sites equipped with Variable Frequency Drives (VFDs) shall provide a climate-controlled building for housing all electrical and electronic equipment.

4. Adequate lighting of the lift station wet well, valve vault, pump control equipment, electrical and instrumentation equipment shall be included with the station design. All lighting provided should be LED lighting.

6.3.18 Low-Pressure or Alternative Collection Systems

Low pressure collection systems may be allowed with specific approval by the City's Engineer.

6.3.19 Wastewater Treatment Plants, And Peak Flow Detention Facilities

If wastewater treatment plants or peak flow detention facilities are needed to support a development, the design shall be directed by the Water Utility considering the needs of the development and the Wastewater Utility System.

6.3.20 On-Site Sewage Facilities

A. General

Planning, design and operation of on-site sewage facilities within the City of Denton must comply with the current 30 TAC Ch. 285 for On-Site Sewage Facilities, as amended. The property owner proposing to use an on-site sewage facility shall comply with the criteria listed in this Section, and Section 7.6.16 of the City of Denton DDC, as amended.

B. Permits Required

Any owner of a residential, commercial, or institutional building who utilizes an on-site sewage facility is required to secure a permit from the City of Denton to construct, alter, repair, or extend

an on-site sewage facility regardless of the size of the lot or tract of land. Contact the Environmental Services Department at the Pecan Creek Water Reclamation Plant for details on permit fees and maintenance requirements.

C. Site Evaluations

A Professional Engineer or a professional sanitarian, licensed by the State of Texas, must perform site evaluations.

D. Planning Requirements

A Professional Engineer or a professional sanitarian, licensed by the State of Texas, must prepare on-site sewage facility plans.

E. On-Site Sewage Facility Land Use Requirements

Lots or tracts of land where an on-site sewage facility is proposed must have the following minimum area size.

1. A minimum of one (1) acre when a public water system serves the tract or lot; and
2. A minimum of two (2) acres when a private water well is located on the tract or lot.

6.3.21 Pretreatment Device: Grease Interceptors / Grit Traps / Oil Separators

A. General

Planning, design, and operation of pretreatment devices within the City of Denton must comply with the most current City of Denton Plumbing Code, Chapter 28; Article VII; Section 28-56, as amended. The property owner proposing to use and operate a grease trap shall comply with the criteria listed in this Section and abide by required responsibilities outlined in City of Denton Code of Ordinances Chapter 26; Article XII – Liquid Waste.

Definitions can be found in the City of Denton Code of Ordinance, Chapter 26, Article XII, Section 26-306 and Chapter 26, Article V, Section 26-154.

B. Applicability

Any user of the publicly owned treatment works (POTW), as defined by Section 26-154, and meeting the definition of "generator," as defined by Section 26-306, shall be required to install a pretreatment device in accordance with locally adopted plumbing codes as amended. Food service establishments shall not share grease interceptors unless specifically authorized by the City's Engineer.

These requirements are applicable to all commercial food service establishments, including those that are undergoing:

1. New construction
2. Interior remodeling to accommodate expansion or operational modifications
3. Changes of ownership/occupancy
4. Facilities which fail to meet limitations outlined in article V, Chapter 26 of the Code of the City of Denton, Texas
5. When discharges which may cause blockages in the wastewater collection system

C. Review Required

Plumbing plans for new facilities must be prepared by a plumber or a Professional Engineer, licensed by the State of Texas, and submitted as a part of the development process. These plans

must show the fixtures draining into the pretreatment device. Plans must also include the flow-through rating of the pretreatment device as well as the grease or solids retention capacity and, the location of the down-stream sampling port. Plumbing plans for existing facilities must be submitted when applying for a certificate of occupancy. These plans must show the fixtures draining into the pretreatment device and indicate the flow through rating and grease and solids capacity of the pretreatment device.

D. Construction/Installation

All permitting, construction, and inspection activities must be completed in accordance with the City of Denton Plumbing Code Chapter 28. Additionally, the following specifications must be incorporated into grease trap design.

1. The grease interceptor shall be constructed with a minimum of two baffles. Each manhole access shall be minimum 20-in. diameter clear opening.
2. Grease traps are to be installed at a minimum distance of 10 feet from sinks and dishwashers to allow for adequate cooling of the wastewater. Water temperatures must be less than 120 degrees prior to entering grease trap.
3. Pretreatment devices shall be constructed of a material that is compatible with the type of waste generated by the Facility and treated by the device.
4. All grease bearing waste streams should be routed through an appropriate grease trap/interceptor, including: three-compartment sinks, pot/pan sinks, soup kettles, hand-washing sinks, automatic dishwashers, mop sinks and floor drains.
5. Any pretreatment device must have a sample port allowing for the instantaneous grab sampling of the effluent of the device. The sample port must be solely representative of the process wastewater and sanitary tie-ins must be done down-stream of the sampling port. The proposed sampling port must allow for a wide-mouthed 250-mL amber glass bottle to be submerged or partially submerged into the effluent. Interior, above-ground hydromechanical grease interceptors with a liquid capacity of 100 gallons or less may install a sample spigot with a ball valve in leu of a sample port due to space constraints with city approval. The sample spigot must be solely representative of the process wastewater and sanitary tie-ins must be done down-stream of the sample spigot. Sample wells will have a minimum 12-in. diameter access cover. Mechanical Traps and Interceptors that are installed above ground must be equipped with an influent flow regulator and an effluent valve assembly that allows for sample collection.

Unless otherwise approved in writing by the City's Engineer, all fixtures, equipment, and drain lines located in the food preparation, alcohol service, clean-up, and food service areas of a food service establishment shall be connected to a grease interceptor. Fixtures required to connect to a grease Interceptor shall include but are not limited to pot sinks, pre-rinse sinks, hand sinks, prep sinks, dishwashers, soup kettles, braising pans, wok ranges, mop sinks, floor sinks, floor drains, and wastewater generated from exhaust fan hood cleaning operations.

E. Grease Interceptor Sizing Requirements

Sizing methods described herein are intended as guidance in determining grease trap/interceptor sizes that will afford the City's sanitary sewer system a minimum degree of protection against grease and other obstructing materials. Sizing determinations are based on operational data provided by business owners or their contractors. In approving a customer's plumbing or grease interceptor design, the City does not accept liability for the failure of a system to adequately treat wastewater

to achieve effluent quality requirements specified under City of Denton Code of Ordinance Chapter 26. It is the responsibility of the generator and/or contractors to insure the appropriate level of treatment necessary for compliance with environmental and wastewater regulations.

1. Gravity Grease Interceptors (GGI) shall meet the requirements of ASME A112.14.6 and IAPMO/ANSI Z1001. The required capacity of gravity grease interceptors shall be determined by multiplying the peak drain flow into the interceptor in GPM by a retention time of 30 minutes as required by the International Plumbing Code.

2. Hydromechanical Grease Interceptors (HGI) shall be designed and tested in accordance with ASME A112.14.3 and/or CSA B481.1. Sizing shall be in accordance with HGI Sizing and Selection, as shown in the following two-step process:

   a. Step 1: Size by Flow Rate

      The minimum flow rate for HGIs may be calculated by either using pipe diameter or fixture volume using either a one-minute or two-minute drainage period. Use a one-minute drainage period when the interceptor will be installed inside of the building and has indirectly connected fixtures. When the interceptor will be installed outside of the building, use a two-minute drainage period.

      i. Fixture Volume Sizing

         Use the following formula for sizing fixtures by volume with a 75% fill factor:

         Fixture Capacity Gallons = [(L x W x H) / 231] x 0.75 [Eqn. 6.5]

         Note that,

         Fixture Capacity Gallons x 1 = one-minute drainage period (GPM)

         Fixture Capacity Gallons x 0.5 = two-minute drainage period (GPM)

         Example calculations are shown below for a three-compartment sink with each compartment dimensions being 18 x 24 x 12 inches:

         18 x 24 x 12 = 5184 cu. in.

         5184 / 231 = 22.44 fixture capacity gallons

         22.44 x 3 = 67.3 total fixture capacity gallons (three bowls)

         67.3 x 0.75 = 50.4 total fixture capacity after loading factor (75%)

         50.4 x 1 = 50 GPM one-minute drainage period

         50.4 x 0.5 = 25 GPM two-minute drainage period

         To determine the minimum required flow rate for the HGI, calculate the capacity of each fixture that will be connected and add the volumes together and use the appropriate drainage period. An appropriate HGI must be certified to meet the minimum flow rate as calculated.

   b. Step 2: Calculate Grease Capacity

      Once the minimum flow rate has been established as detailed in Step 1, the minimum grease storage capacity for the HGI required for the desired pump-out frequency is calculated as follows:

      Grease Capacity Needed = Meals per day x GPV x DPC [Eqn. 6.6]

      Where: GPV = Grease Production Values (See Table 6.3E below)

      DPC = Days per Pumpout Cycle [Recommended 90 days]

Table 6.3-E: Grease Productions Values for Typical FSEs

Menu	w/o Fryer, No Flatware	w/o Fryer, Flatware	w/ Fryer, No Flatware	w/ Fryer, Flatware
Bakery	0.035	0.0455	0.035	0.0455
Bar - Drinks Only	0.005	0.0065	0.025	0.0325
Bar and Grille	0.035	0.0455	0.035	0.0455
BBQ	0.035	0.0455	0.035	0.0455
Buffet	0.035	0.0455	0.035	0.0455
Burger Joint	0.025	0.0325	0.035	0.0455
Cafeteria - Full Serve	0.035	0.0455	0.035	0.0455
Cafeteria - Heat & Serve	0.025	0.0325	0.035	0.0455
Chinese	0.035	0.0455	0.035	0.0455
Coffee Shop	0.005	0.0065	0.025	0.0325
Continental breakfast	0.005	0.0065	0.025	0.0325
Convenience Store	0.005	0.0065	0.025	0.0325
Deli	0.005	0.0065	0.025	0.0325
Donut Shop	0.005	0.0065	0.035	0.0455
Don't know yet	0.035	0.0455	0.035	0.0455
Family Restaurant	0.035	0.0455	0.035	0.0455
Fast Food - Limited Prep	0.025	0.0325	0.025	0.0325
Fast Food - Full Prep	0.035	0.0455	0.035	0.0455
Fried Chicken	0.035	0.0455	0.035	0.0455
Greek	0.035	0.0455	0.035	0.0455
Grocery Store	0.035	0.0455	0.035	0.0455
Ice Cream/Yogurt/Smoothies	0.005	0.0065	0.025	0.0325
Indian	0.035	0.0455	0.035	0.0455
Italian	0.035	0.0455	0.035	0.0455
Mexican	0.035	0.0455	0.035	0.0455
Pizza Restaurant	0.025	0.0325	0.035	0.0455
Pizza Carryout	0.005	0.0065	0.025	0.0325
Multi-unit dwelling	0.005	0.0065	0.025	0.0325
Salads / Healthy Bowls	0.025	0.0325	0.025	0.0325
Sandwich Shop	0.005	0.0065	0.025	0.0325
Seafood	0.035	0.0455	0.035	0.0455
Snack Bar	0.005	0.0065	0.025	0.0325
Steak House	0.035	0.0455	0.035	0.0455
Sushi	0.005	0.0065	0.025	0.0325

Notes:
[1] To determine the correct grease factor, select the menu type, then the correct column for whether there is a fryer and whether the establishment uses disposable or washable plates, glasses, knives, forks, and spoons (flatware).
[2] FSEs that are not open every day, may calculate the number of days open in a 90-day period and use that to calculate the total amount of grease capacity required and must submit calculation for review.

Source: Brown Grease Supply Study, 2011, Kennedy/Jenks Consultants.

Example calculations are shown below for a Fast Food – Full Prep, with fryer, with disposable flatware, serving 300 meals per day:

Grease factor from Table 6.3E = 0.035 pounds per meal
Meals per day = 300
Days between pump-outs = 90
Grease Capacity Needed = 0.035 x 300 x 90 = 945 pounds

The correctly sized and selected grease interceptor will have the minimum flow rate determined in Step 1 and the grease storage capacity calculated in Step 2. Grease interceptors certified to meet the minimum requirements of ASME A112.14.3 or CSA B481.1 shall have the flow rates and minimum grease storage capacities as listed in Table 6.3-F below:

Table 6.3-F: Minimum Grease Storage Capacity for Grease Interceptors

HGI Flow Rate (GPM)	Minimum Grease Storage Capacity[1] (lbs.)
20	40
25	50
35	70
50	100
75	150
100	200

Notes:
[1] Minimum grease capacity as required by ASME A112.14.3, PDI G101 and CSA B481.

Grease interceptors claiming grease capacities exceeding the minimum requirements in Table 6.3-F, shall be reviewed and approved by the City when the manufacturer can demonstrate by third-party test reports, including the incremental test data, that the interceptor(s) has the capacity claimed. Upon approval from the City, the grease interceptors proven grease storage capacity may be used in selecting the sizes and required number of units to satisfy the requirements of the two-step sizing method in Section 6.3.21.E.2 of this Manual.

F. Laundries

Commercial Laundries, laundromats, and dry cleaners shall be equipped with an interceptor to reduce the quantity of lint and silt that enter the collection system. The system must be of adequate size and design to allow for cool-down of wastewater so that separation can be more readily achieved. The interceptor must be installed with a wire basket or similar device, removable for cleaning, that prevents passage into the drainage system of solids ½-inch (12.7 mm) or larger in size, string, rags, buttons or other materials detrimental to the public sewerage system.

G. Car Washes

Where automobiles are washed (including detail shops utilizing hand-wash practices), separators shall have a minimum capacity of 1000 gallons for the first bay, with an additional 500 gallons of capacity for every other bay.

H. Automotive Repair Facilities (Garages and Service Stations)

Where automobiles are serviced, greased, or repaired or where gasoline is dispensed, oil or water separators shall have a minimum capacity of 500 gallons for the first 1000 sq. ft. of area to be drained, plus 250 gallons for each additional 1000 sq. ft. of area to be drained into the separator.

6.3.22 Inspections Required

New installations or existing pretreatment devices must be inspected by the City of Denton Pretreatment Program prior to the issuance of a Certificate of Occupancy for new businesses.

6.4 Construction Plans

6.4.1 General

Before any public works construction relative to a development may begin, City staff will verify the construction plans have been approved. Construction may not begin until the construction plans have been approved, all materials used for public improvements have been submitted and approved, all fees (including review and inspection fees) have been paid, all necessary agreements and bonds have been provided, and a Pre-Construction Conference has been held by the City.

6.4.2 Responsibility

The sealing engineer is responsible for the accuracy, completeness, and conformance of the submitted plans to City standards. The purpose of the City review is to ensure conformance to City policies and standards. The City review is limited to facts as presented on the plans submitted. The City has no project engineering design or quality control review responsibility. The engineer of record certifying the plans is responsible for the accuracy and completeness of the plan documents. The City reserves the right to require plan corrections to fit actual field conditions or meet City standards requirements, which are found to be contrary to or omitted from the plans.

6.4.3 Format

Construction plans shall be digitally drawn on 24-in. x 36-in. size sheets with borders of 22-in. x 34-in., so half-size reproduced plans will be to half-scale fitting 11-in. x 17-in. sheets. Each sheet shall be legible when reduced to half-size. Digital copies of the plans shall also be provided.

6.4.4 Plan Requirements

Construction Plans must contain, as a minimum, information listed in the following sections before they can be approved:

A. General

North arrow, scale, date, and mean sea level elevations of all improvements, based on North America Vertical Datum 1988 (NAVD 88). Only NAVD 88 shall be used for plan elevations; no assumed or NGVD 29 elevations. Plans shall be drawn with a horizontal scale of one (1) inch equals 40 feet as a minimum, and appropriate corresponding vertical scale. The plans shall provide a reference to the elevation benchmark or monument used in the development of the plans. Show all crossings of existing and proposed underground utilities. Plans shall account for future changes in topography. The construction plans shall be signed and sealed by a Professional Engineer, licensed by the State of Texas, prior to bidding the project for construction.

B. Water Systems

Plan sheets must show the horizontal alignment of the proposed water system within street ROWs and easements, with horizontal control points for location of the ROWs and easements and for

location of the water system within the ROWs and easements. Sizing of pipe, valves, fittings and appurtenances must be shown on the plan view. All valves, fittings, fire hydrants, and other appurtenances must be stationed and given GPS coordinates (with an accuracy of ± six (6) inches) based on the City of Denton's grid coordinate system. Profile views of water mains shall be provided showing proposed grade, pipe material, casing pipe size and thickness (if any), and the location, elevation and size of any underground conduit or facility to be crossed. Deflections (if any) must be shown on the plan and profile views, as applicable, with stationing and the degree of deflection. Approved design deviations (if any) from City Standard Details must be provided. Show all service lines up to and including the meter can/vault. Service lines do not need to be stationed or have GPS coordinates. Adequate detail of other planned and existing improvements shall be shown to indicate planned crossings of utilities, storm drains, and stormwater facilities and potential conflict points.

C. Sanitary Sewer Systems

Plan sheets must show the horizontal alignment of the proposed sanitary sewer system within street ROWs and easements, with horizontal control points for location of the ROWs and easements and for location of the sanitary sewer system within the ROWs and easements. Sizing of pipe, manholes, fittings and appurtenances must be shown on the plan view. Manhole rim elevations, and pipe "IN" and "OUT" elevations must be shown. All manholes, fittings, and other appurtenances must be stationed and given GPS coordinates (with an accuracy of ± six (6) inches). based on the City of Denton's grid coordinate system. Every sanitary sewer line shall be profiled. Profile views shall show proposed grade, pipe material, casing pipe size and thickness (if any), manhole information, and the location, elevation and size of any underground conduit or facility to be crossed. Approved design deviations (if any) from City Standard Details must be provided. The plan view shall include arrows indicating direction of flow in pipe. Show all service lines to and including the public cleanout. Service lines do not need to be stationed or have GPS coordinates. Adequate detail of other planned and existing improvements shall be shown to indicate planned crossings of utilities, storm drains, and stormwater facilities and potential conflict points.

D. Grading

For situations involving proposed grading over existing water or sanitary sewer systems, provide a grading plan and profile showing the existing and proposed topography in 2-ft. contours. The grading plan shall consist of contours and spot elevations with water directional arrows to define the flow patterns.

Section 7: Streetlight Design Criteria

7.1 Overview

The purpose of Section 7 – Streetlight Design Criteria is to assist developers and engineers in creating an aesthetic, consistent, and safe lighting plan for our streets, sidewalks, and neighborhoods. This section outlines the process for design, review, and approval of new lighting projects, as well as criteria for modernizing existing lighting infrastructure. Streetlights are usually owned by Denton Municipal Electric (DME) which is a part of the City of Denton (the City), however they may be installed, operated, and maintained by DME, other electric utilities, or private owners depending on the location. This section of the DCM has been created to help navigate the process for selecting, permitting, placing, and maintaining streetlighting throughout the city. This manual does not apply to security, area, pathway, private, or other lighting not associated with a public road.

This manual cannot cover all the situations that might be encountered, required, or requested in the construction and installation of streetlighting. Any apparent discrepancy, omission, error, or requirement necessitating further explanation or interpretation should be referred to DME Engineering (940-349-7117 or 940-349-4173) for further clarification.

The goal of the criteria laid out in this Section 7 is to implement the following guiding principles into the application of street designs in the City of Denton:

A. Enhance safety of the community for pedestrians and drivers alike

B. Conserve energy by prioritizing efficient lighting design

C. Minimize impact to the environment including light pollution

D. Minimize impact to neighborhoods and residences by reducing light trespass

E. Provide for a uniform and aesthetic look throughout the city

F. Be fiscally responsible through effective application of design principles

7.1.1 Applicability

The existing streetlight installations throughout the City of Denton have been accepted as is at the time of approval of this manual. Retro-active replacements and upgrades solely for the purpose of bringing existing lighting up to the standards of this manual are not required. This manual is intended to apply to all new projects in the City beginning July 1, 2024. (This means the project has been approved/permitted by Development Services on or after July 1, 2024).

7.1.2 Organization

Section 7 – Streetlight Design Criteria is organized as follows:

A. Overview

B. Requirements

C. Developer & DME Responsibilities

7.2 Requirements

7.2.1 General

The City adheres to the guidance of ANSI RP-8 Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting for all highways and streets *except for local residential streets with speed limits of 30 mph or less*. ANSI RP-8 acknowledges that vehicle headlights may provide adequate illumination for slower speeds when the driver has sufficient time for reaction and stopping. As per ANSI RP-8, Section 11.6.3.1 – 'When Residential Street Lighting May Not be Needed', for local residential streets (e.g., within a residential development) with speed limits of 30 mph or less, street lighting shall be placed no more than 250 feet apart. A photometric (lighting) study will be required for all new installations except for local residential streets with speed limits of 30 mph or less.

These standards shall apply to all new streetlight installations, upgrades, replacements, and conversions from the date of the adoption of these standards onward.

Easement, ROW, and permitting regulations that are not listed in this manual still apply to streetlights. The developer is responsible for knowing and adhering to any laws and regulations governing development and construction relating to the work being done.

Developers are responsible for the design, materials, and installation costs of all streetlighting on public streets within and adjacent to their project. *See* the Developer and DME Responsibilities Section of this manual for more specific descriptions of responsibilities. DME will only energize new streetlights after the installation has been approved by DME. For most lighting installations, following energization, DME will accept ownership and maintenance of streetlights unless the lighting is located on a private drive (i.e. the City has not taken ownership of the street / streetlights) or the lighting is non-standard and will not be owned or maintained by DME.

Streetlights are not normally metered. The City (or customer in certain cases) is charged a monthly usage and maintenance fee per light according to the Denton Municipal Utility Rates Manual. This does not apply to private drives and other private properties where the developer or customer chooses to install lighting other than the standard city approved options. In such cases, DME will provide a metered service point only and the customer will be responsible for all installation, maintenance, and fees associated with the lighting installation in accordance with applicable city codes, ordinances, and utility service standards for the life of the installation.

City streets and street projects will not be considered complete until adequate streetlighting has been installed, approved, and energized. For example, for the streets in a new development to be accepted by and turned over to the City, street lighting must be complete.

7.2.2 Roadway Lighting Requirements

A. Roadway Designations

To determine the proper lighting for a roadway, it is important to determine what type of vehicle and pedestrian traffic the roadway is meant to accommodate. Roadways may be classed into several different categories based on these two variables. The lighting requirements are then applied to provide adequate lighting to mitigate the risks of collision by a vehicle with another object, vehicle, or pedestrian.

Roadways may be classified as *highways and freeways, arterials, collectors,* and *local roads*. In this section of the DCM, local roads may also refer to auxiliary roadways such as *alleys, drives, dead-ends,* and *cul-de-sacs*. Local roads may be residential streets (providing direct access to homes) or other local roads providing access to businesses and connecting larger roads together. Local roads

generally have speed limits of 30 mph or less, while highways, arterials, and collectors will have higher speed limits. *Local roads* are further broken down into *residential* and *non-residential streets* in portions of this section to allow flexibility in managing light levels in residential neighborhoods. Specific road classification and design information may be found in Section 5 – Transportation Design Criteria of this DCM.

B. Lighting Evaluations and Design

For streetlighting of highways and streets, *except local residential streets with speed limits of 30 mph or less,* lighting shall be designed per ANSI RP-8. A photometric (lighting) study will be required for these new installations. ANSI RP-8 requires that a pedestrian activity classification be made to determine the required lighting levels. *See* ANSI RP-8 for further guidance on pedestrian activity classification and streetlighting design requirements. Additional information may also be found in the TxDOT Highway Illumination Manual, and AASHTO GL-7, "Roadway Lighting Design Guide". All designs adhering to ANSI RP-8 standards shall be verified and documented using appropriate lighting design software. A licensed Professional Engineer in the state of Texas shall stamp all lighting designs before each submittal.

For all local *residential* streets with speed limits of 30 mph or less, street lighting shall be installed at intersections, cul-de-sacs, and no more than 250 feet apart for the remainder of the street. Lighting may be installed along one side of the street, both sides in parallel, both sides alternating, or in the median. Separation distances should be measured along the centerline of the street. Additional lighting may need to be considered if there are obstacles or road geometries that cutoff some of the light. *See* the Sample Local Residential Streetlighting Layout shown below in Figure 7.1.

When designing or adding streetlights to existing roadways and/or neighborhoods, consideration should be given to the style and placement of any existing fixtures. New streetlighting shall be chosen from the available styles that most closely matches the style of the existing lighting in the area. Historic poles are only approved for specific applications and areas designated as historic districts or within the Downtown Implementation Plan area.

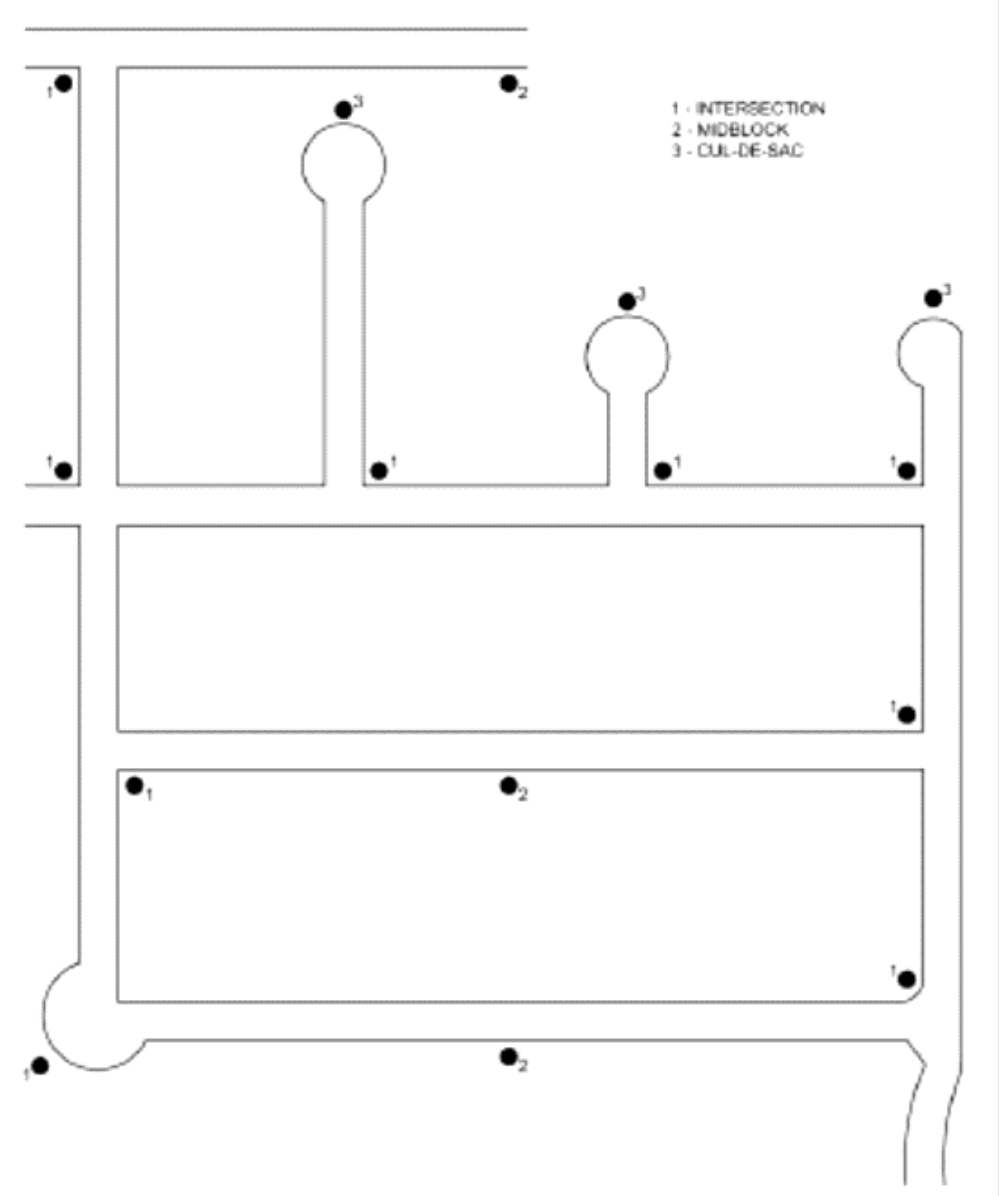


Figure 7.1 Sample Local Residential Street Lighting Layout

(Lights are shown at intersections, cul-de-sacs, and mid-block

when spacing between lights exceeds 250 feet)

C. Intersection and Crosswalks

Intersections have a much higher number of potential conflict points as vehicles and pedestrians are permitted to cross through normal lanes of traffic. Therefore, additional care is needed when planning intersection lighting. ANSI RP-8 should be used to design lighting at intersections for larger, busier streets as stated previously. *See* Figure 7.2 shown below.

Because of the additional safety concerns for vehicles, cyclists, and pedestrians at crosswalks and intersections, the following examples (taken from ANSI RP-8) are provided to assist streetlight design for local streets. While not strictly required, they should be considered as good lighting practice for these types of locations.

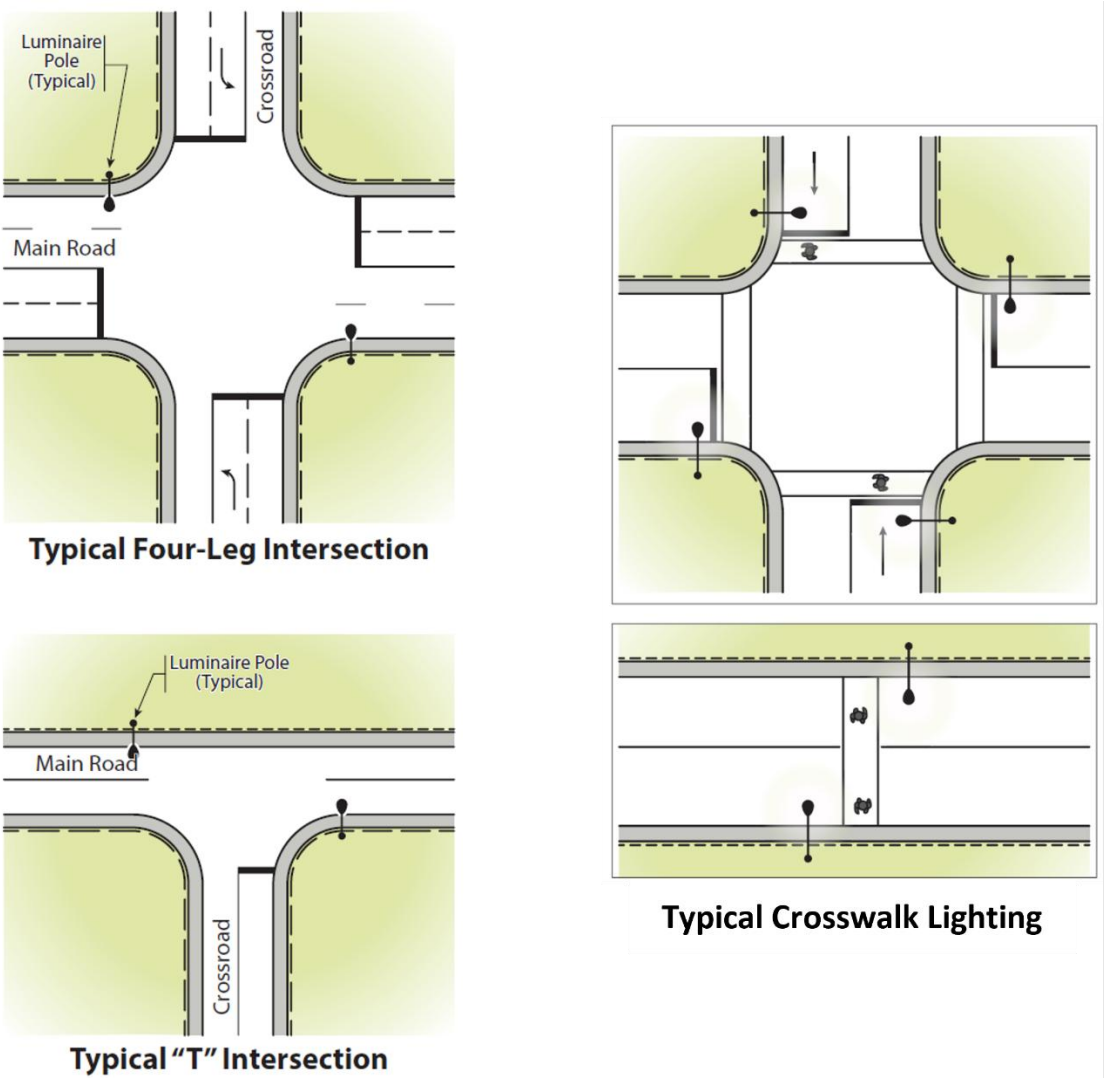


Figure 7.2 Typical Lighting Schematic for Intersections

D. Roundabouts and Traffic Circles

Like intersections, roundabouts and traffic circles have a higher number of potential conflict points than normal streets. ANSI RP-8 should be used to design lighting at traffic circles and roundabouts of larger streets. For local streets, an example of round-about lighting design considerations is shown below. Some locations may not require as much lighting as shown depending on the size of the traffic circle. *See* Figure 7.3 shown below.

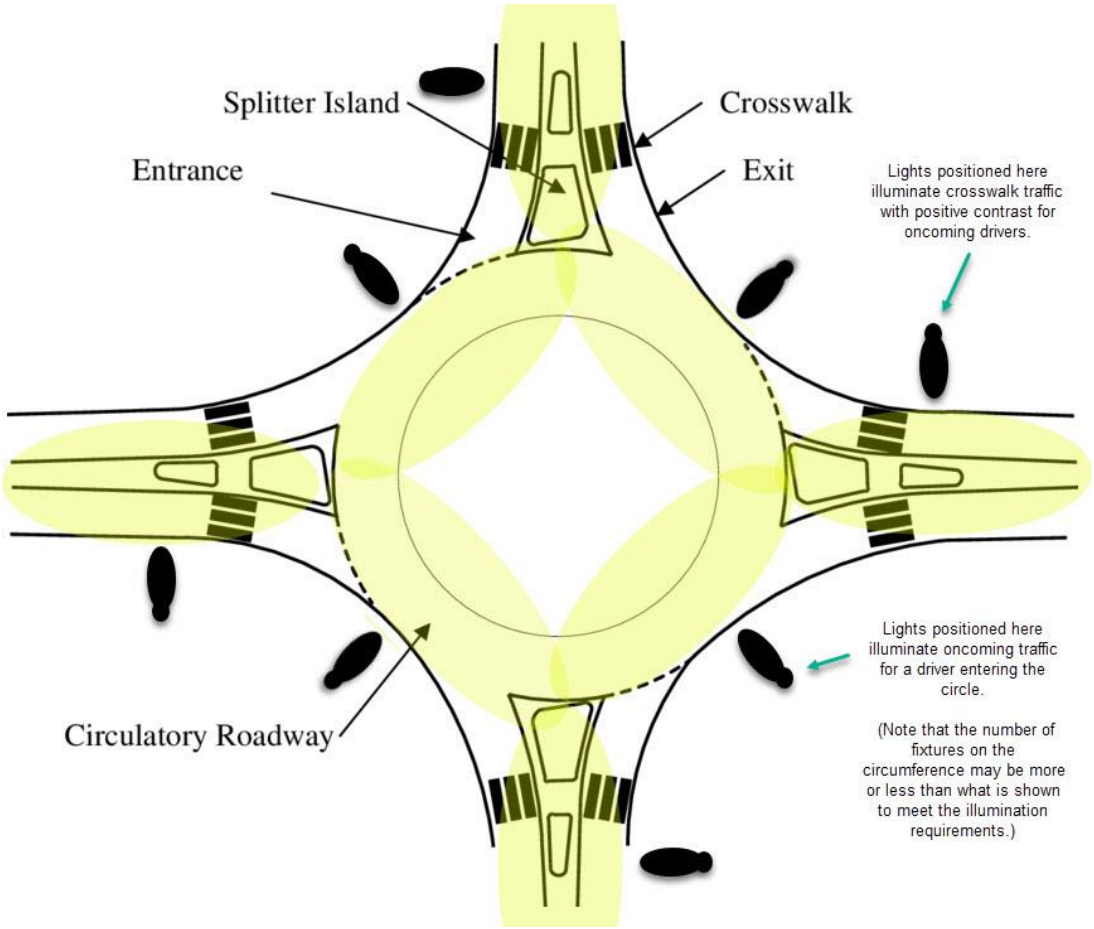


Figure 7.3 Roundabout Lighting Placement Schematic

E. Railroad Crossings

Railroad crossings are slightly different than normal intersections and require lighting adjustments accordingly. It is of course, vitally important that drivers are able to see a train that is crossing, and conversely, that the train engineer has a clear picture of any obstructions while approaching an intersection. Street lighting at railroad crossings should therefore illuminate the intersection while not causing glare for the drivers or train engineer. The following figure illustrates the recommended lighting placement for a railroad crossing. *See* Figure 7.4 shown below.

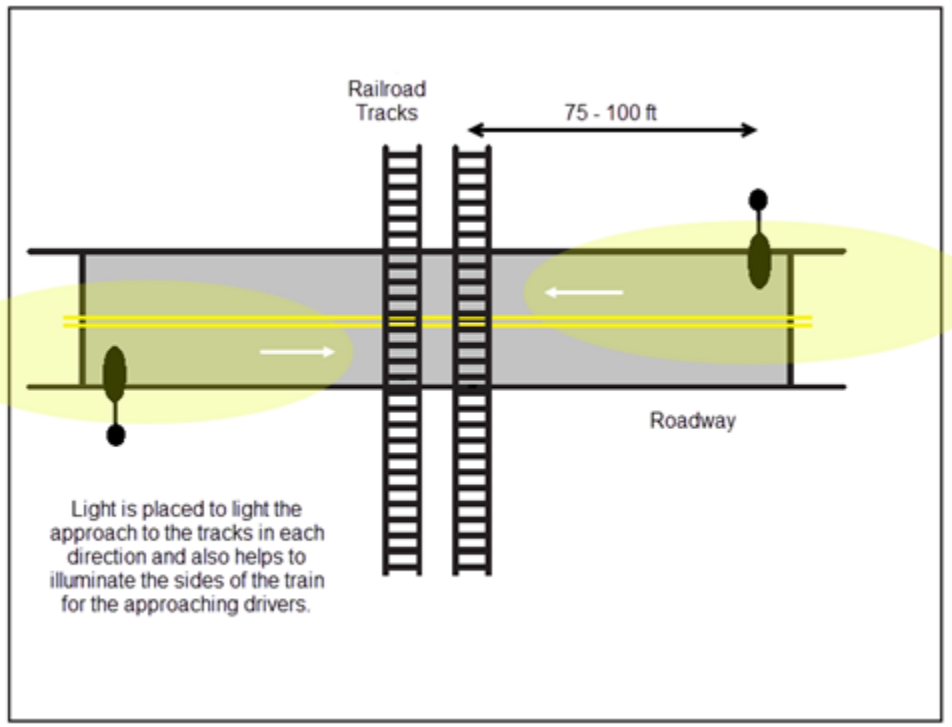


Figure 7.4 Railroad Crossing Schematic

7.2.3 Installation Requirements

A. Placement

1. Highways and Streets (except for local residential streets with speed limits of 30 mph or less)

   Installation should follow TxDOT recommendations in the TxDOT Highway Illumination Manual. Where TxDOT requirements do not apply, the streetlight system shall be installed in the ROW or within public utility easements and poles should be placed approximately 2.5 feet back from curbs and 10 feet back from edge of paving for uncurbed roads or, where there is sidewalk abutting the curb, approximately 1 foot behind the sidewalk. Deviations of more than 1 foot in either direction from these requirements must be approved by DME Engineering.

2. Local Residential Streets (speed limits of 30 mph or less)

   The streetlight system shall be installed in the ROW or within public utility easements. Poles should be placed approximately 2 feet back from the curb of 10 feet from un-curbed pavement. If a sidewalk abuts the curb, then the pole should be placed approximately 1 foot behind the sidewalk. In a residential neighborhood, streetlights should be placed within 5 feet of common property lines (e.g. between neighbors).

B. Vertical and Horizontal Clearance

New streetlights should not interfere with existing structures or rights-of-way, including sidewalks, nor should the placement preclude the ability to perform maintenance on the pole in a safe manner. *See* National Electric Safety Code (NESC) section 234 for specific clearances required for overhead

electric installations. The exception to this requirement is when streetlight arms are mounted directly to wooden distribution poles.

Proposed trees should be located at least 25 feet from any streetlight location. When installing new lights in a location with existing trees, consideration should be given to the age and maturity of the tree and whether it will interfere with the light when it is fully grown. DME will be responsible for tree trimming around streetlights to preserve the integrity of streetlighting as needed.

Median-mounted poles should be installed at least 20 feet back from an intersection to minimize the number of vehicle-streetlight collisions due to vehicles and trucks turning too sharply at the intersection.

In areas predominantly served by overhead electric powerlines, streetlights are usually installed by attaching streetlight arms to existing wood distribution poles. Care should be given when planning for lighting in these areas as overhead lines pose a conflict when placing new lighting poles. Clearances must be maintained for safety. Redesign/relocation of existing overhead power lines just to accommodate lighting is costly and time consuming. Utilizing existing wood pole locations and installations on the opposite side of the street are two ideas for additional placement options in these areas.

C. Approved Fixtures and Materials

The approved streetlight components for each class of roadway are listed below in Tables 7.2-A and 7.2-B.

Table 7.2-A: Approved Luminaires and Hardware by Location

	ROADWAY CLASSIFICATION					
	HIGHWAYS AND FREEWAYS (UNLESS OTHERWISE SPECIFIED BY TXDOT)	**ARTERIALS AND LARGE COLLECTORS**	**ALTERNATE ARTERIALS AND COLLECTORS**	**COLLECTORS AND LOCAL STREETS**	**EXISTING RESIDENTIAL LOCAL STREETS (ALSO USED IN HISTORIC DISTRICTS)**	**NEW RESIDENTIAL LOCAL STREETS (≤ 30 MPH)**
Make	Signify Lumec RFL	Signify Lumec RFM	Gardco Optiform M	Signify Lumec RFM	Hadco	Gardco
Model	RFL-241W112LED-4K-G2-R2M-UNV-DMG-ML-RCD7-API-GY3	RFM-160W48LED-4K-G2-R2M-UNV-DMG-ML-RCD7-API-GY3	OPF-M-A10-840-2TM-MAR-UNV-TR7-DGY	RFM-85W24LED-3K-G2-R2M-UNV-DMG-ML-RCD7-API-GY3	C-1891P RL34AANN2A SNR7WA3 NNNNSP1	OPF-S-P05-730-T2M-AR1-UNV-SP2-TR7
Wattage	241W LED	160W LED	112W LED	85W LED	69W LED	66W LED
Lumens	30,188	19,489	20,357	8,753	7,734	11,253
Color Temperature	4000k	4000K	4000K	3000K	3000K	3000K
Light Distribution Type	Type II	Type II	Type II	Type II	N/A	Light II
Voltage	120 – 277V or 347 – 480V	120 – 277V or 347 – 480V	120-277V	120 – 277V or 347 – 480V	120 - 277V	120 – 277V
B-U-G Rating	B4-U0-G4	B3-U0-G3	B3-U0-G3	B3-U0-G3	B2-U5-G4	B2-U0-G2
Pole Type	Steel, white concrete, or wood	Steel, white concrete, or wood	Dark Gray Steel	Steel, white concrete, or wood	Residential - Concrete aggregate Historic – Cast Aluminum	Steel, square, gray
Globe Type	N/A	N/A	N/A	N/A	Hadco, RL34 Acrylic Victorian	N/A
Arm Type	8-ft. metal (specs depend on pole type)	8-ft. metal (specs depend on pole type)	8-foot metal	8-ft. metal (specs depend on pole type)	N/A	Std-mount, no arm

Table 7.2-B: Approved Pole Types by Location

Part Information	Part Description	Highway and Freeway [1]	Arterial and Large Collector	Collector and Local Street	Existing Res. Local Street	Historic District [2]	New Res. Local Street [3]
POLE TYPE – WOOD DISTRIBUTION							
N/A	Wood pole. Various heights, but standard id 35 feet. DME warehouse item. Direct buried. Overhead electric service.	Yes	Yes	Yes	Yes	No	No
Arm - Shakespeare #OPAR-8-H	8-ft. curved aluminum arm.	-	-	-	-	-	-
POLE TYPE – WHITE CONCRETE							
Lonestar #351101	35-ft. Concrete pole, white color. Single or double arm available. DME warehouse item. Direct buried. Underground electric service.	Yes	Yes	Yes	Yes	No	No
Arm - Curlee #2009032TG-Flat Base	8-ft. flat aluminum arm.	-	-	-	-	-	-
POLE TYPE – CONCRETE AGGREGATE							
Lonestar #20004-SJB (Waterford Series)	20-ft. Concrete aggregate pole. Post-top luminaire configuration. Direct buried. Underground electric service. Legacy – replacement and maintenance only	No	No	No	Yes	No	No
POLE TYPE – ANTIQUE ALUMINUM							
Acuity #PX-CP18-12-F4-AB3/133T3-ANBK	12-ft. antique, decorative aluminum pole. Post-top luminaire configuration. Requires concrete foundation. Underground service.	No	No	Yes[2]	Yes[2]	Yes[2]	No
POLE TYPE – EMBEDDED STEEL							
(Single Arm) KW Industries RTSU35-9.0-11-RAL7043-18S-GS-E	35-foot round steel pole, gray color (RAL7043). Single arm, direct buried pole. Underground electric service. Arm included with pole. Pairs with Gardco Optiform M luminaire.	Yes	Yes	Yes	No	No	No
(Double Arm) KW Industries RTSU35-9.0-11-RAL7043-28S-GS-E	For use in medians. 35-foot round steel pole, gray color (RAL7043). Double arm, direct buried pole. Underground electric service. Arm included with pole. Pairs with Gardco Optiform M luminaire.	Yes	Yes	No	No	No	No

Part Information	Part Description	Highway and Freeway [1]	Arterial and Large Collector	Collector and Local Street	Existing Res. Local Street	Historic District [2]	New Res. Local Street [3]
POLE TYPE – BREAK-AWAY STEEL[4]							
(Single Arm) KW Industries RTSU35-9.0-11-RAL7043-18S-GS-BSC-1.00-SKT Foundation 30" x 96" Concrete	35-foot round steel pole, gray color (RAL7043). Single arm, breakaway base mounted on a poured concrete foundation. Underground electric service. Arm included with pole. Pairs with Gardco Optiform M luminaire. Contact DME for poured concrete foundation standards.	Yes[4]	Yes[4]	No	No	No	No
Double Arm (Single Arm) KW Industries RTSU35-9.0-11-RAL7043-28S-GS-BSC-1.00-SKT Foundation 30" x 96" Concrete	For use in medians. 35-foot round steel pole, gray color (RAL7043). Double arm, breakaway base mounted on a poured concrete foundation. Underground electric service. Arm included with pole. Pairs with Gardco Optiform M luminaire. Contact DME for poured concrete foundation standards.	Yes[4]	Yes[4]	No	No	No	No
POLE TYPE – BRIDGE-MOUNT STEEL STEEL[5]							
(Single Arm) KW Industries RTSU35-9.0-11-RAL7043-28S-GS-ATB1-17 Foundation TXDOT Bridge	For use in medians. 35-foot round steel pole, gray color (RAL7043). Double arm, breakaway base mounted on a concrete bridge foundation. Underground electric service. Arm included with pole. Pairs with Gardco Optiform M luminaire.	Yes	Yes	No	No	No	No
POLE TYPE – STEEL RESIDENTIAL							
KW Ind., Part# SSP20-4-11-DGY GARDCO-DM10-BC Foundation 24" x 72" Concrete	20-ft., dark gray (RAL7043), 4-in. square steel pole. Drilled for single-luminaire with standard mounting pattern. Underground service. Pairs with Gardco Optiform S luminaire. Contact DME for poured concrete foundation standards.	No	No	No	No	No	Yes

Notes:
[1] Unless, otherwise specified by TxDOT.
[2] Historic streetlighting is only available for use in designated historic districts.
[3] Speed limits of 30 mph or less.
[4] Steel streetlight poles are only used for highways and roadways where TxDOT or City-approved plans require placement of break-away bases or non-standard mounting heights.

D. Historic Lighting

Historic lighting is a modern light fixture with a decorative pole and fixture that give the lighting the look of early 20th century lighting. Historic lighting has been approved for use only in the *designated historic* districts of Denton. All requests for historic lighting within these districts must be submitted to DME Engineering for design and approval. Historic lighting is not approved for installations outside of the historic districts. The requesting organization, developer, or agency shall be responsible for all costs related to the design and installation of historic streetlights.

E. Control System

All new streetlighting in the DME service area shall have a control node installed which, at a minimum, will turn the light on and off according to ambient light conditions (photocell control) and shall be compatible with the CityTouch lighting control system. *See* Table 7.2-C shown below. Where street lighting is installed by the developer, DME shall provide and install control nodes at the developer's expense. DME will commission the control nodes into the CityTouch program.

Where streetlighting is served by other electric utilities than DME, DME does not require or install control nodes.

Table 7.2-C: CityTouch-compatible control node models

Model Number	Voltage (V)	Use	Function
LLC7290	120 – 277	Cobra head lights	Photocell controller
LLC7294	347 – 480	High-voltage cobra head lights	Photocell controller
LLC7291	120 - 277	Post-top lights	Astro-clock (GPS location-based timers)

F. Dimming and Light Trespass

The City adheres to ANSI RP-8 lighting levels for all streets *except* local residential streets with speed limits of 30 mph or less. Lighting that has been designed to ANSI RP-8 cannot be dimmed without diminishing the lighting level which, by definition, no longer meets the RP-8 standard. Thus, all streetlighting that is not in residential neighborhoods with speed limits of 30 mph or less will be maintained at full brightness.

On local residential streets with speed limits of 30 mph or less, the streetlights may be dimmed by resident request at specific locations due to light pollution concerns by residents. DME will dim residential streetlights down as low as 60%.

The City also reserves the right to install house side shields (available only on cobrahead lights) and make other reasonable modifications to the luminaires to minimize impacts to the residents at the DME's discretion.

G. Migratory Birds and Other Flying Species

DME will dim residential streetlights down as low as 50% during select animal migration or activity periods as specified by the City Environmental Services & Sustainability Department.

H. International Dark Sky Association

DME installs and maintains two types of streetlight luminaires (light fixtures), post-top and cobrahead. The cobrahead light fixtures are endorsed by the International Dark Sky Associate (IDA) which makes recommendations on lighting with minimal up-light. The existing post-top lighting fixtures are not IDA endorsed, however an acceptable IDA approved alternate is being considered for all residential streets with speeds less than 30 mph.

7.2.4 Construction Requirements

Streetlight construction (e.g. conduit, wiring, etc.) shall follow the DME Standard Construction Drawings, stated below:

A. DSL-ARM
B. DSL-STD
C. DSL-12A
D. DSL-20C (Legacy)
E. DSL-35C
F. DSL-20S
G. DSL-35SE
H. DSL-35SE2
I. DSL-35SBK
J. DSL-35SBK2
K. DSL-35SBD

Conduit runs should not exceed 700 feet between pulling locations. When bends total 180 degrees conduit runs should be limited to 500 feet or less. No run of conduit should have more than 360 degrees of total bend between pulling points.

The total length of a single lighting circuit at 120V should be less than 1,000 feet, the total length of a single lighting circuit at 240V should be less than 2,000 feet, and the total length of a circuit at 480V should be less than 4,000 feet unless circuit design and loading has been validated by engineering.

Additional design information may be found in the *TxDOT Highway Illumination Manual*.

7.3 Developer and DME Responsibilities

7.3.1 Highways and Streets (except local residential streets with speed ≤ 30 mph)

Developer is responsible for streetlighting design that meets the requirements of ANSI RP-8 for the appropriate roadway characteristics. A photometric (lighting) study shall be required. The final design must be approved and stamped by a Texas licensed professional engineer. Final design must also be approved by DME Engineering.

Lighting levels, placement, and compliance with ANSI RP-8 must be verified and documented with lighting design software. At a minimum, documentation shall be provided to DME Engineering showing:

A. Street geometry (width, number of lanes, median size)

B. Street classifications (arterial, collector, etc.)

C. Pedestrian activity classification

D. Criteria levels applied (illuminance vs. luminance method, and levels)

E. Lighting placements (median, side, parallel, staggered)

F. Maximum separation distance*

As an alternative to displaying the maximum separation distance as stated in 7.3.1.F above, a layout drawing of the project may be provided with calculation grid values and/or light level isolines indicating that the installation meets the applicable requirements.

For TxDOT projects, the design contractor will provide specific lighting requirements, if any. The design package should dictate where lighting should be placed and what types of poles and fixtures should be used.

For City initiated projects, the City's Engineer or their contractor will design the street lighting and submit to DME Engineering for approval. Once approved, the city's contractor will perform all civil work, and pull wiring and install streetlights and poles. DME will provide service points as needed. DME will also install and commission control nodes for interconnection with CityTouch.

A monthly maintenance, repair, and usage fee will be charged to the City thereafter for all streetlights on public streets per current DME rates.

7.3.2 Local Residential Streets (with speed limits ≤ 30mph)

The Developer (or DME if DME is responsible for the given project) is responsible for the design and layout of streetlights at all intersections, cul-de-sacs, and no more than 250 feet between. DME Engineering shall approve the final design. Once the project is approved and permitted, the Developer is responsible for providing all civil work including grading, trenching, installation of conduit and pull-boxes, etc.

DME is responsible for installation of wire, streetlights and poles, and service points. DME will charge an initial installation cost to the developer based on the number of lights.

A monthly maintenance, repair, and usage fee will be charged to The City thereafter for all streetlights on public streets per current DME rates.

For City initiated projects, the City's Engineer or their contractor will design the street lighting and submit to DME for approval. Once approved, the city's contractor will perform all civil work, and pull wiring and install streetlights and poles. DME will provide service points as needed. DME will also install and commission control nodes for interconnection with CityTouch.

For private streets and drives (where the City of Denton does not take ownership of the roadway or streetlights), one of the following will occur:

A. If non-standard lights are installed, DME will provide a metered service point. Developer is responsible for installation of entire streetlighting system. Designated customer (individual, HOA, etc.) will be responsible for monthly power costs and all maintenance. **OR**

B. If standard DME lighting is installed, Developer is responsible for all civil work (grading, trenching, installation of conduit, etc.) and installation of poles and streetlights. DME will pull wires and connect the lights at the Developer's expense. Designated customer (individual, HOA, etc.) will be responsible the monthly streetlight power and maintenance rates. **OR**

C. Exceptions to this rule must be agreed upon by all parties in a formal agreement.

7.3.3 Streetlighting in Non-DME-Served Areas

Standard streetlights have been approved by the City as listed in the General Requirements section of this manual. Electric utilities other than DME may or may not be able to provide the same luminaires. Non-standard lights will not be maintained by DME or the City. DME will provide, install, maintain, and repair standard the City streetlights at the Developer's expense. The electric service provider will charge the City according to the rates agreed upon between the City and the electric service provider.

For streets in non-DME service territories, Developer should coordinate with the electric utility, DME, and the City at the earliest stage of development to determine and agree upon the following:

A. Developer, City/DME, and Customer responsibilities

B. Service points and project design

C. Mode of disconnect for safe maintenance (e.g. in-line fuses, etc.)

D. Mode of billing (metered usage, monthly rate, etc.)

E. Designated customer/developer responsible for fees

F. Other concerns as applicable

7.3.4 Customer/Citizen Requests for addition/removal of Streetlighting

Streetlights managed by DME are funded through the City's Capital Improvement Projects (CIP) process. As concerns are identified and provided to DME via citizen comments, staff input, and/or City Council direction the requests are directed to DME Engineering for technical evaluation. The technical evaluation is to determine if the modifications would provide added safety and visibility according to national and local standards and ordinances. Light pollution/intrusion, cost, feasibility, and aesthetic value are also considered. At the conclusion of the technical evaluation, DME Engineering submits a recommendation for or against inclusion of the project in the CIP.

DME will maintain the list of all requested modifications and prioritize those that have been recommended for inclusion within the upcoming CIP. Some or all of the highest priority projects will be programmed into the upcoming budget based on availability of funds.

Requests for dimming will be considered in residential areas, and in coordination with the City's Environmental Services & Sustainability Department, DME may dim streetlights in residential developments to no lower than 50% brightness. Cobrahead streetlights along other local, collector, and arterial streets may not be dimmed due to safety and regulatory requirements.

Section 8: Environmentally Sensitive Areas Design Criteria

8.1 Overview

The purpose of Section 8 - Environmentally Sensitive Areas (ESAs) Design Criteria is to provide the technical design criteria needed to achieve compliance with DDC Subchapter 7, Section 7.4. The goal is to provide basic guidance for implementing certain components of ESA plans, such as ESA Field Assessments. While the intent of this section is to assist applicants and developers with ESA requirements, full responsibility and liability for proper design and compliance with DDC § 7.4 remains with the developer or applicant. Users of this Manual should be knowledgeable and experienced in environmental surveys, inventorying and restoration (see the basic requirements for a qualified person in this section).

This section does not provide complete guidance for Alternative ESA Plans, as those plans are developed through a variance procedure, due to special circumstances or conditions that apply to the parcel for which the variance is sought. The Alternative ESA Plan procedure is described in DDC § 2.8.4.

The following documents govern the design criteria in this section:

A. The Denton Development Code
B. Floodplain Development Checklist
C. ESA Field Assessment Checklist
D. Alternative Environmentally Sensitive Area Checklist
E. The iSWM Landscape Technical Manual
F. The National Wetland Plant List

8.2 ESA Identification

8.2.1 The Official ESA Map

A. To locate potential ESAs, the applicant shall use the City of Denton's Official ESA Map.
B. The legend in the Official ESA Map displays the types of ESAs and their designations.
    1. The City recognizes four types of ESAs
        a. Cross Timbers Upland Habitat
        b. Water Related Habitat
        c. Riparian Buffer ESA
        d. Floodplain ESA
    2. ESAs can have one of two designations
        a. Designation Confirmed
            i. ESA assessments expire after 24 months; the applicant shall check the date that the assessment was approved to ensure that the current designation is correct
        b. Not Assessed or Assessment Expired

C. Areas determined to be ESAs during field assessments are added to the Official ESA Map.

D. Areas determined not to be ESAs during field assessments may potentially be removed from the Official ESA Map.

E. Because ESA criteria applies to all land and development, it may be necessary to perform ESA Field Assessments in areas not identified on the Official ESA Map. This could be due to site conditions or current aerial photography (among other reasons).

8.3 ESA Field Assessments

8.3.1 ESA Field Assessor

ESA features shall be identified during the ESA Field Assessment by a qualified person. Minimum requirements to be considered a qualified person are:

A. Have a bachelor's degree in ecology or similar field of study; or

B. Be a certified/trained wetland scientist; or

C. Have similar qualifications in plant identification, soil classification, and hydrology.

1. The City accepts professional licenses and certifications such as Professional Wetland Scientist (PWS), Wetland Professional in Training (WPIT), and continuing professional education courses from applicable programs.

8.3.2 ESA Forms

All ESA submittals shall utilize the City's Assessment Forms:

A. Cross Timbers Upland Habitat Assessment Form

B. Floodplain ESA Assessment Form

C. Riparian Buffer ESA Assessment Form

D. Water-Related Habitat Assessment Form

8.3.3 ESA Field

ESA Field Assessments shall contain, at a minimum:

A. Assessor qualifications

B. Comprehensive reports appropriate for each ESA type and feature assessed

C. A project narrative with details of the assessment, including, but not limited to:

1. A brief description of the project's nature
2. Descriptions and locations for ESAs identified on the Official ESA Map
3. Descriptions and locations of any ESAs determined to be present
    a. Include detailed reasoning as to why ESA features were identified
    b. Include colored photographs as supporting evidence
4. Description and location of any ESAs determined to be absent

a. Include detailed reasoning as to why ESA features were not identified

b. Include colored photographs as supporting evidence

D. Shapefiles identifying both confirmed ESAs, and ESA locations that should be removed. The following geographic information shall be used:

1. Geographic Coordinate System: GCS North American 1983

2. Datum: D North American 1983

3. Prime Meridian: Greenwich

4. Projected Coordinate System: NAD 1983 State Plane Texas North Central FIPS 4202 Feet

5. Projection: Lambert Conformal Conic

E. A site map or series of maps, that delineate the boundaries and types of ESAs as indicated on the Official City of Denton ESA Map

F. A site map that delineates the boundaries and types of ESAs that were assessed; this may differ from the Official ESA Map

1. Indicate the reach of each assessment and locations of photographs taken on a map; this may be its own map

8.4 ESA Preservation Requirements

Where ESAs are identified, whether through field assessments or an existing, confirmed designation, ESA protection must be installed.

A. ESA protection shall consist of protective fencing established at the perimeter of any ESAs. Where a protected tree is located near the ESA perimeter, protective fencing shall be installed at the dripline of the tree.

B. Land-clearing to allow for the installation of ESA protection fencing shall occur upslope of the ESA perimeter (that is, on the outside perimeter), and shall not exceed a width of four feet. It shall not encroach into the dripline or critical root zone of any tree to be protected.

C. Protective fencing should be a minimum of four (4) feet in height and consist of plastic safety fencing or other approved fencing material. Protective fencing shall be supported by posts not exceeding 20 feet spacing.

D. Protective fencing shall be placed downslope of any perimeter controls for erosion and sedimentation.

8.4.1 ESA Inspections

A. Initial Inspections

1. An initial inspection must be conducted prior to commencing land-disturbing activities for the approval of permits or issuance of a Notice-to-Proceed.

2. ESA protective fencing shall be inspected against corresponding site plans for proper placement and installation.

B. Routine Inspections

1. ESA inspections shall be conducted after land-disturbing activities have commenced to

ensure compliance with ESA criteria, and may be conducted during all phases of development, including:

a. cut and fill
b. demolition
c. clearing and grading
d. grubbing
e. stockpiling
f. installation of utility infrastructure
g. construction
h. vertical building

2. Routine inspection items shall include:
   a. Maintenance, repair and replacement of ESA protective fencing; damaged ESA fencing shall be repaired or removed and replaced during all phases of development until final inspection.
3. During development, access to the ESA shall be prohibited; the ESA shall be preserved in its original state.
4. The disposal of any waste material into the ESA is prohibited.
5. Siltation/sedimentation to the ESA is prohibited; any that occurs shall be addressed in a timely manner.
   a. Siltation/sedimentation impacting up to 0.10 acres of any ESA must be removed by hand or equivalent method, as approved by the City.
   b. Siltation/sedimentation impacting 0.10 acres or more of any ESA must be addressed through an Alternative ESA Plan.
6. The permanent loss of any native vegetation is prohibited.
   a. Native vegetation loss impacting up to 0.10 acres of any ESA or the loss of up to two (2) trees, shall be replaced in-kind.
   b. Native vegetation loss impacting 0.10 acres or more of any ESA, or the loss of three (3) trees or more, must be addressed through an Alternative ESA Plan.

8.5 Restoration Plans for Permitted Uses and Activities

8.5.1 Restoration Plan Requirements

Permitted uses and activities for each ESA are described in DDC §§ 7.4.6-7.4.8. For permitted uses and activities, the applicant shall provide a restoration plan which, at a minimum, includes:

A. Locations and descriptions of any areas within the ESA that will require restoration.
B. Locations and descriptions of temporary stabilization measures.
C. Descriptions of restoration activities, including but not limited to:
   1. Erosion minimization

2. Native plant restoration
3. Invasive vegetation removal

D. Schedule/timeline for restoration activities

E. Descriptions and locations of permanent seed mixes and/or plantings.

8.5.2 Restoration Activities

A. This subsection applies to approved Restoration Plans and, and mitigation for Alternative ESA Plans.

B. Restoration and/or mitigation shall be initiated immediately whenever development activities have permanently or temporarily ceased within the ESA.

1. Development activities have permanently ceased when land-disturbing activities within the ESA have been completed.
2. In the context of this provision, "immediately" means as soon as practicable, but no later than the end of the next workday, following the day when development activities have temporarily or permanently ceased.

C. Restoration and/or mitigation shall be completed prior to close-out or issuance of final Certificate of Occupancy.

8.5.3 Alternative ESAs

For Alternative ESA plans, mitigation must be initiated as ESAs are disturbed and to the same extent, unless alternatively specified in the approved Plan.

Section 9: Design Deviations

9.1 Overview

9.1.1 General

All developments within the City and its extraterrestrial jurisdictions shall conform to the design criteria established in this DCM. In the event that a development cannot comply with the design criteria established, a design deviation process is used to evaluate, document, and approve proposed alternative methods.

Any deviation from the required design criteria for design of facilities outlined in this DCM must be submitted as a design deviation request to the City's Engineer and Department Reviewer, prior to incorporating it into the final design of a project.

9.2 Design Deviation Procedure

9.2.1 Request for Design Deviation Submittal and Processing

A. All design deviation requests must be submitted as a formal request to Development Project Facilitation using the 'Request for Design Deviation Form' included in Appendix B, along with supporting documentation.

1. The 'Request for Design Deviation Form' shall be filled out completely with exception of the portions noted as "For Use by City".
2. Supporting documentation shall include:
    a. All pertinent information on the facilities involved or to be involved. The specific portion of this DCM, policies, or design standard(s) for which a design deviation is sought;
    b. Description(s) of all other design alternatives which the applicant has evaluated in attempts to comply with the design criteria prior to the request for design deviation; and
    c. A statement that provides justification for the requested design deviation and how it is the necessary and optimal solution when compared with reasonable alternatives for the scenario presented.
3. Design deviation requests that do not contain the required Request for Design Deviation Form and supporting documentation are incomplete and will not be reviewed.

B. The request and supporting documentation shall be submitted concurrently with Civil Engineering Plans, Zoning Compliance Plans, Planned Development, or Specific Use Permit submittal.

9.2.2 Criteria for Granting of Design Deviation

A. The review of a design deviation request by the City's Engineer and Department Reviewer shall assess whether the request:

1. Clearly demonstrates an exceptional hardship which prevents the design criteria from being met. This hardship cannot be solely self-imposed and should be based upon physical characteristics of the property, environmental conditions, or existing conditions created by surrounding development;

2. Is not detrimental to the public welfare;
3. Does not adversely impact the operations of the system or the public facility in question;
4. Is supported by a signed and sealed engineering analysis performed by a Licensed Professional Engineer in the State of Texas, if requested by the Engineering Department; and
5. Shall not be solely to mitigate a financial hardship.

B. The decision of the City's Engineer and Department Reviewer is guided by the criteria for approval, but is ultimately discretionary based on their engineering judgment and professional experience.

C. All approved design deviation requests shall be signed by the City's Engineer and Department Reviewer, before implementation.

D. The decision of the City's Engineer and Department Reviewer to grant a design deviation shall not relieve the applicant's Engineer of the professional obligation and responsibility to ensure any approved alternatives to the use of the material, design, or method of construction are fit for the intended purposes of the facilities at issue.

E. If a design deviation request is denied by the City's Engineer and Department Reviewer, the applicant may consider reviewing alternatives and resubmitting the application with more information as is deemed necessary, for re-evaluation by the City's Engineer and Department Reviewer.

9.3 Revocation of an Approved Design Deviation

9.3.1 Applicability and Procedure

A. An approved design deviation request may be revoked by the City's Engineer and Department Reviewer, if:
1. The supporting documentation that the City's Engineer and Department Reviewer used to review and approve the design deviation request is materially altered or updated. Any individual or entity that receives an approved design deviation request must provide the City's Engineer and Department Reviewer with any change in plans or conditions to the project that affect the requested deviation as soon as practicable after any such change occurs. Failure to provide these updates may result in design deviation revocation by the City.
2. The applicant is shown to have provided inaccurate or incomplete information during review of the design deviation request.
3. The City determines there is a failure to comply with any term, condition, or requirement applicable to a design deviation;

B. A decision to revoke a design deviation is effective immediately. Notice of the decision shall be communicated to the applicant.

Appendix A: Example Stormwater Facility Checklists

INSPECTION CHECKLIST FOR SIMPLE DETENTION BASIN

Facility Name: _____ **Facility Agreement Number:** _____

Basin/Pond Number: _____ **Inspected By:** _____ **Date:** _____

Type of Inspection: Annual _____, Quarterly _____, Monthly _____, Routine _____, or Storm Event _____, (# days since event _____)

Basin Conditions:

1. Is there standing water or wet spots? Yes____No _____Comments _____
2. Does sides or bottom show signs of erosion, settling, cracking, etc? Yes____No _____Comments _____
3. Does dam or emergency spillway show signs of erosion, settling, cracking, or other problems Yes____No _____Comments _____
4. Is there evidence of animal burrowing in dam? Yes____No _____Comments _____
5. Is there evidence of changes in shape or volume of basin? Yes____No _____Comments _____
6. Do vegetated areas need mowing? Yes____No _____Comments _____
7. Are there trees or woody growth in dam? Yes____No _____Comments _____
8. Are there areas that need to be re-vegetated? Yes____No _____Comments _____
9. Is there any accumulation of silt, trash, debris or litter in the basin? Yes____No _____Comments _____
10. Are there any other basin maintenance activities needed? Yes____No _____Comments _____

Structural Components:

1. Are pipes, channels, trash racks, etc. free of obstructions? Yes____No _____Comments _____
2. Are pipes, spillway or trash racks in need of repair? Yes____No _____Comments _____
3. Is the low flow or trickle channel in need of repair? Yes____No _____Comments _____
4. Is the outfall channel in need of repair? Yes____No _____Comments _____
5. Are there any other structural maintenance activities needed? Yes____No _____Comments _____

Plan for correcting deficiencies:

_____

_____

_____

_____

Signature:

_____

Owner's Representative

Date:

_____

ENGINEER'S CHECKLIST FOR STORMWATER
FACILITY MAINTENANCE AGREEMENT

Please attach additional sheets as necessary for comments and descriptions. Fit all sheets to 8½" x 11".

ORGANIZATION INFORMATION	
1. Company (Applicant)	**Address:**
2. Contact's Information: Contact Name Mailing Address Telephone Number(s) Email	**3. Execution Information:** Signatory's Name Mailing Address Telephone Number(s) Email

4. Property Location:
(Note: If the property has not been addressed, please enter the legal description)

5. Associated Plat Numbers:
(Note: if request is related to multiple plat applications, please list each individually)

6. Associated Building Permit Numbers:
(Note: if request is related to multiple permits, please list each individually)

AGREEMENT & ATTACHMENT INSTRUCTIONS

If the property owner is a **corporation**, the agreement must be signed by a person who is duly authorized to bind the corporation including, but not limited to, a President or Vice President. . If a **partnership**, the agreement must be signed by the managing partner. If the applicant is a **sole proprietor**, he/she signs the agreement on behalf of him or herself. Additionally, for corporations and partnerships, a copy of the *Articles of Incorporation*, showing signature authority for whoever signs the agreement must also be submitted (Note: Applicants may also submit a board resolution or power of attorney authorizing an agent or assign to sign on behalf of the property owner. The agreement must be completely filled out and three copies submitted to the Planning and Development Department. Signatures on all three agreement drafts must be original and notarized. Lastly, please submit a copy of the deed for the noted property.

NOTE: Agreement and all attachments should be submitted on 8 ½" x 11".

	Yes	No	N/A	Comments/Descriptions
1. Legal Agreement – Standard agreement form provided by the City.	___	___	___	_____
2. Exhibit "A" - Legal Description (Attached)				
A. Metes and Bounds.	___	___	___	_____
B. Surveyor's Drawing, with seal affixed and marked as "Drainage Easement".	___	___	___	_____
C. Preliminary Plat.	___	___	___	_____
3. Exhibit "B" - Design Plan and Specifications (Attached)				
A. Design Calculations – in accordance with iSWM.	___	___	___	_____
B. Schematic Plan (See Example Detention Plan Schematic)- prepared in accordance with approved construction plans:	___	___	___	_____
• Plan View showing critical structural elements .	___	___	___	_____
• Critical structural elements are clearly labeled in layman terms.	___	___	___	_____
• Profile including a longitudinal section showing all critical structural elements with elevations.	___	___	___	_____
• Cross-sections as needed to show size and general grading. **NOTE: All Schematics should be submitted on 8 ½" x 11".**	___	___	___	_____
C. Landscaping shown per approved Landscape Plans.	___	___	___	_____
4. Exhibit "C" - Operations and Maintenance Plan (Attached)				
A. Routine Maintenance Specifications:				
1. Mowing as needed to control weeds and woody plants.	___	___	___	_____
2. Trash removal from critical structural elements.	___	___	___	_____
3. Additional maintenance.	___	___	___	_____
B. Non-routine Maintenance Activities:				
1. Bank repair and stabilization.	___	___	___	_____
2. Re-vegetation - required when 30% or more of area is unprotected.	___	___	___	_____

	Yes	No	N/A	Comments/Descriptions
3. Sediment removal from the detention/retention facility when:	___	___	___	_____
• Detention basin – when water depth is reduced 25% or more, or basin does not drain within 72 hours.	___	___	___	_____
• Retention pond – when water depth is 4' or less.	___	___	___	_____
• Sediment traps/forebay – when depth is reduced by 50% or more.	___	___	___	_____
4. Structural repair/replacement for all damaged or deteriorated structures, trickle channel, trash rack, etc.	___	___	___	_____
5. Mechanical equipment repairs.	___	___	___	_____
6. Other maintenance Activities.	___	___	___	_____

5. Exhibit "D" - Maintenance Checklist *

A. Covers ordinary needs, in layman terms.	___	___	___	_____
B. Structural components labeled consistent with Schematic Plan.	___	___	___	_____

*See attached Inspection Checklist for Detention Basin

NOTE: All Exhibits should be submitted on 8 ½" x 11".

(seal)	I certify that this Stormwater Facility Maintenance Agreement, checklist, required attachments, and additional comments, was prepared under my responsible supervision and that the information presented on this checklist and attachments is correct to the best of my knowledge. I also understand that an acceptance of this plan by the City does not waive any City standards or requirements unless a specific waiver request has been submitted and approved. Signed_____ Date_____ Print Name:_____

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Appendix B: Design Deviation Request Form

Development Services
401 N. Elm Street, Denton, TX 76201 (940) 349-8541

City of Denton Design Deviation Request Form

Submitted by:_____Phone:_____Email:_____
Company:_____Date:_____

Project Information
City of Denton Project Number:_____Project:_____
Type of Development:_____
Location:_____ (include map)

Design Deviation Request (Each deviation from criteria requires a separate submittal and will be evaluated independently.)
Specify section of the DCM/DDC/design standard(s) for which a deviation is sought:

Please explain how the project is unable to meet the design criteria.
(This hardship cannot be solely self-imposed and should be based upon physical characteristics of the property, environmental condition, or existing conditions created by surrounding development.)

What other design alternatives have been evaluated to comply with the design criteria, prior to the request for design deviation:

Detailed explanation of requested design deviation:

The deviation request will be evaluated based on the criteria set forth in DCM 8.2.2.

☐ By submitting the design deviation request, the applicant hereby acknowledges and understands the design deviation procedure. (Please check.)

CITY OF DENTON
Development Services
401 N. Elm Street, Denton, TX 76201 (940) 349-8541

Supporting Documentation

List and provide attachments supporting the design deviation as stated in the DCM Section 8.2.1.
(drawings, calculations, topographic information, photographs, maps, or other pertinent information)

FOR USE BY THE CITY OF DENTON

Justification of Decision:

Deviation Decision: ☐ Accepted ☐ Denied

Reviewing Department: ☐ Solid Waste ☐ Stormwater ☐ Transportation ☐ Water/Wastewater ☐ Street Light

Department Reviewer:_____ City's Engineer:_____

Date:_____ Date:_____

Signature:_____ Signature:_____

(The deviation request decision must be signed by both the Department Reviewer and the City's Engineer.)

2 of 2

Note: Request the fillable Deviation Request form from your Facilitator.

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Appendix C: Poles and Luminaires - Standard Lighting Fixtures

Figure C.1: Residential Lighting – 20-ft. concrete aggregate pole woth post-top luminaire

Figure C.2: General Street Lighting – Wood (distribution) pole with single-mast arm and cobra head luminaire

Figure C.3: General Street Lighting – 35-ft. white concrete pole with single or double-mast arms and cobra head luminaire

Figure C.4: Historic District Lighting – 12-ft. concrete aggregate pole woth post-top luminaire

Figure C.5: Alternate General Streetlighting – 35-ft. dark gray steel pole with single or double mast arms and new cobra head luminaire.

Appendix D: Types of Environmentally Sensitive Areas

The City of Denton has identified four distinct ESAs - Floodplains, Riparian Buffers, Water-Related Habitat, and Cross Timbers Upland Habitat. Native plants associated with each ESA are listed below. A complete list of Native Plants is included in Appendix E.

A. Floodplain ESAs exist on the terraced banks surrounding waterways where the land is subject to flooding. The City of Denton uses the most current FEMA Flood Insurance Rate Map (FIRM) to define boundaries of protected Floodplain ESAs. Areas designated as 1% Annual Chance Floodplain, labeled on the FIRM as Zone A or Zone AE, would be classified according to existing conditions as developed or undeveloped floodplains. Areas identified as undeveloped floodplains become protected Floodplain ESAs. Floodplain ESA habitat is often an extension of the more sensitive Riparian Buffer. Typical Floodplain ESA habitat is dominated by tree species that can tolerate intermittent flood events.

B. Riparian Buffer ESAs are adjacent to bodies of water such as wetlands, streams, rivers, ponds and lakes. A healthy functioning Riparian Buffer will have a mix of woody and herbaceous plants. Streams, creeks, and rivers are classified by their duration of flow; there are three types:

   1. Perennials flow continuously except during severe drought.
   2. Intermittent flow only for a portion of the year seasonally or after rainfall.
   3. Ephemerals only flow in direct response to rainfall and will often be dry.

C. Water-Related Habitat ESAs are split into four categories: wetlands, bottomland hardwood forests, springs, and deepwater habitats. These areas are typically found in low-lying areas near bodies of water but can also be isolated low-lying areas that meet characteristics of water-related habitats. These characteristics will likely include hydric soils, signs of hydrology, and hydrophytic vegetation.

   1. Wetlands can be isolated or adjacent and will have all three wetland indicators present: hydric soils, hydrology, and hydrophytic vegetation. Adjacent wetlands are connected to a jurisdictional water body, such as a lake or river, and are subject to federal regulation under the Clean Water Act; isolated wetlands are not connected to surface water bodies and are regulated at the state or city level.

      a. An area shall be classified as a wetland if it meets the Army Corps of Engineers three parameter technical criteria as outlined in the Corps of Engineers 1987 Wetlands Delineation Manual (Section D. Routine Determinations).

      b. The recommended routine method assumes sufficient hydrology and hydric soils if the area in question has over 50% vegetative cover of hydrophytic (facultative-wet and/or obligate as listed in the National Wetland Plant List (NWPL), Great Plains Region, and a clearly defined boundary between the hydrophytic and upland plant communities.

      c. Permitted water quality ponds, roadside ditches, and ponds fed by wells or other sources of artificial hydrology are not considered wetlands.

      d. The Wetlands Classification System (WCS) includes five major Systems: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. The first four include both wetlands and deepwater habitats, but the Palustrine only includes wetland habitats. In North Central

Texas, the predominant wetland types are Riverine, Lacustrine and Palustrine, and are detailed in Table 9-A below.

Table D-1: Predominant Wetland Types of North Central Texas	
Wetland Type	**Major Characteristics**
Riverine	Wetlands and deepwater habitats within a stream or river channel; includes oxbow lakes and sloughs; periodically influenced by flooding
Lacustrine	Wetlands and deepwater habitats associated with large lakes and reservoirs; situated in basins that lack significant tree or shrub cover
Palustrine	All non-tidal wetlands dominated by trees, shrubs, or persistent plants; includes Bottomland hardwood forests, which is the most widespread type of wetland in Texas and includes trees like pecan, sugarberry, and black willow.

2. Bottomland Hardwood Forest ESAs consist of deciduous forested wetlands and river bottoms. Denton defines this habitat as areas containing at least 50 percent of native trees and understory vegetation typically found in a bottomland hardwood forest.

3. Springs are points of natural groundwater discharge that produce flow, a pool of water, or maintain hydrophytic plant communities (refer to Facultative-wet or Obligate plant species as listed in the in the National Wetland Plant List (NWPL), Great Plains Region. Physical indicators include pooling of water, hydrophytic plants, or the presence of a water temperate gradient in a creek or pool.

4. Deepwater habitats are permanently flooded lands lying below the deepwater boundaries of wetlands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium within which the dominant organisms live, whether or not they are rooted in, or attached to, the substrate. As in wetlands, the dominant plants are hydrophytic.

Wetlands and deepwater habitats are defined separately because traditionally the term wetlands has not included deep, permanent water; however, both must be considered an ecological approach to classification. The boundary between wetland and deepwater habitats in the riverine and lacustrine systems lies at a depth of 2 meters (6.6 feet) below water; however, if emergent, shrubs or trees grow beyond this depth, their deep-water edge is the boundary.

D. Cross Timber Upland Habitat ESA are deciduous forest interspersed with prairie grasses. It can be split into four vegetative sub-regions. The predominate sub-region found in Denton, TX is the Eastern Cross Timbers. The Eastern Cross Timbers is dominated by Post Oaks and Blackjack Oaks.

Appendix E: Native Plants for ESAs

Table E-1: Native Plants List – Canopy Trees	
Common Name	**Botanical Name**
Red maple	*Acer rubrum*
Texas buckeye	*Aesculus arguta*
Pecan	*Carya illinoiensis*
Texas hickory (Black hickory)	*Carya texana*
Net-leaf hackberry	*Celtis reticulata*
Desert willow	*Chilopsis linearis*
White ash	*Fraxinus americana*
Green ash	*Fraxinus pennsylvanica*
Texas ash	*Fraxinus texensis*
Black walnut	*Juglans nigra*
Ashe juniper (Mountain cedar)	*Juniperus ashei*
Eastern red cedar	*Juniperus virginiana*
Sweetgum	*Liquidambar styraciflua*
Texas red oak	*Quercus buckleyi*
Escarpment live oak	*Quercus fusiformis*
Bur oak	*Quercus macrocarpa*
Blackjack oak	*Quercus marilandica*
Chinquapin oak	*Quercus muehlenbergii*
Shumard oak (Red oak)	*Quercus shumardii*
Bigelow oak	*Quercus sinuata var. breviloba*
Post oak	*Quercus stellata*
Live oak	*Quercus virginiana*
Black willow	*Salix nigra*
Western soapberry	*Sapindus saponaria var.drummondii*
Chittamwood (Gum bumelia)	*Sideroxylon lanuginosum*
Winged elm	*Ulmus alata*
American elm	*Ulmus americana*
Cedar elm	*Ulmus crassifolia*
Slippery elm	*Ulmus rubra*
Prickly ash (Texas hercules club)	*Zanthoxylum hirsutum*

Table E-2: Native Plants List – Small Trees and Shrubs	
Common Name	**Botanical Name**
White buckeye (Texas buckeye)	*Aesculus arguta*
Common beebush (Whitebrush)	*Aloysia gratissima*
Indigobush (False Indigo)	*Amorpha fruticosa*
Roosevelt-weed	*Baccharis neglecta*
Argarita (Mahonia)	*Berberis trifoliolata*
American beautyberry	*Callicarpa americana*
Buttonbush	*Cephalanthus occidentalis*
Eastern redbud	*Cercis canadensis*
Texas redbud	*Cercis canadensis var. texensis*
Roughleaf dogwood	*Cornus drummondii*
Downy hawthorn	*Crataegus mollis*
Greenhawthorn	*Crataegus reverchoni*
Common persimmon	*Diospyros virginiana*
46 Elbowbush	*Forestiera pubescens*
Carolina buckthorn	*Frangula caroliniana (Rhamnus caroliniana)*
Possum-haw	*Ilex decidua*
Yaupon Holly	*Ilex vomitoria*
Texas Walnut (Nogalito, Little walnut)	*Juglans microcarpa*
Mock orange	*Philadepphus pubescens*
Chickasaw plum	*Prunus angustifolia*
Oklahoma plum (Sand plum)	*Prunus gracilis*
Mexican plum	*Prunus mexicana*
Hog plum	*Prunus rivularis*
Hoptree	*Ptelea trifoliata var. mollis*
Flameleaf sumac	*Rhus copallinum*
Smooth sumac	*Rhus glabra*
Buffalo currant	*Ribes aureum*
White prairie rose	*Rosa foliolosa*
Elderberry	*Sambucus nigra var. canadensis*
Eve`s necklace	*Sophora affinis*
Coralberry	*Symphoricarpos orbiculatus*
Mexican buckeye (Texas buckeye)	*Ungnadia speciosa*
Farkleberry	*Vaccinium arboreum*
Rusty blackhaw	*Viburnum rufidulum*
Arkansas yucca	*Yucca arkansana*
Lotebush	*Ziziphus obtusifolia*
Peppervine	*Ampelopsis arborea*
Heartleaf ampelopsis	*Ampelopsis cordata*
Pipevine	*Aristolochia tomentosa*

Table E-2: Native Plants List – Small Trees and Shrubs	
Common Name	**Botanical Name**
Rattan vine	*Berchemia scandens*
Trumpet vine	*Campsis radicans*
Ballonvine	*Cardiospermum halicacabum*
Cowitch (Ivy-treevine, sorrelvine)	*Cissus incisa*
Old-man's-beard	*Clematis drummondii*
Bluebill (Leather-flower)	*Clematis pitcheri*
Carolina snailseed	*Cocculus carolinus*
Sharp-pod morning glory	*Ipomoea cordatotriloba var. cardatrtriloba*
Cotton morning glory	*Ipomoea cordatotriloba var. torreyana*
Coral honeysuckle	*Lonicera sempervirens*
Virginia creeper	*Parthenocissus quinquefolia*
Blackberry	*Rubus oklahomus*
47 Dewberry	*Rubus trivialis*
Greenbriar	*Smilax bona-nox*
Bristly greenbriar	*Smilax tamnoides*
Summer grape	*Vitis aestivalis*
Mustang grape	*Vitis mustangensis*
Riverbank grape	*Vitis riparia*

Table E-3: Native Plants List – Grasses	
Common Name	**Botanical Name**
Elliott's bentgrass (Annual tickle grass)	*Agrostis elliottiana*
winter bentgrass (Tickle grass)	*Agrostis hyemalis*
Big bluestem	*Andropogon gerardii*
Bushy bluestem	*Andropogon glomeratus*
Splitbeard bluestem	*Andropogon ternarius*
Broomsedge bluestem	*Andropogon virginicus*
Oilfield threeawn (Prairie threeawn)	*Aristida oligantha*
Purple threeawn	*Aristida purpurea*
Silver bluestem	*Bothriochloa laguroides*
Sideoats grama	*Bouteloua curtipendula*
Blue grama	*Bouteloua gracilis*
Hairy grama	*Bouteloua hirsuta*
Texas grama	*Bouteloua rigidiseta*
Red grama	*Bouteloua trifida*
Erect brachyelytrum	*Brachyelytrum erectum*
Downy brome	*Bromus pubescens*
Buffalograss	*Buchloe dactyloides*
Broadleaf woodoats (Inland sea-oats)	*Chasmanthium latifolium*
Hooded windmillgrass (Crowfoot grass)	*Chloris cucullata*
Short-spike windmillgrass	*Chloris subdolichostachya*
Tumble windmillgrass	*Chloris verticillata*
Feather finger grass (Showy chloris)	*Chloris virgata*
Carolina jointtail	*Coelorachis cylindrica*
Fall witchgrass	*Digitaria cognata*
American barnyard grass	*Echinochloa muricata*
Canada wildrye	*Elymus canadensis*
Virginia wildrye	*Elymus virginicus*
Gummy lovegrass	*Eragrostis curtipedicellata*
Big-top lovegrass	*Eragrostis hirsuta*
Plains lovegrass	*Eragrostis intermidia*
Spreading lovegrass	*Eragrostis pectinata*
Creeping lovegrass	*Eragrostis reptans*
Poverty droopseed	*Sporobolus vaginiflorus*
White tridens	*Tridens albescens*
Purpletop (redtop, purpletop tridens)	*Tridens flavus*
Longspike tridens	*Tridens strictus*
Eastern gammagrass	*Tripsacum dactyloides*
Prairie trisetum	*Trisetum interruptum*
Browntop signalgrass (Hurrah grass)	*Urochloa fasciculata*

Table E-3: Native Plants List – Grasses	
Common Name	**Botanical Name**
Broadleaf signalgrass	*Urochloa platyphylla*
Texas panicum (Texas signalgrass)	*Urochloa texana*
Common sixweeksgrass	*Vulpia octoflora*

Table E-4: Native Plants List – Herbaceous Wetland	
Common Name	**Botanical Name**
Ear-leaf ammannia	*Ammannia auriculata*
Purple ammannia (Toothcup)	*Ammannia coccinea*
Water-hyssop	*Bacopa monnieri*
Disk water-hyssop	*Bacopa rotundifolia*
Texas bergia (waterwort)	*Bergia texana*
Caric sedge (Benjamin's sedge)	*Carex bushii*
Davis' Caric sedge	*Carex davisii*
Heavy-fruit caric sedge	*Carex gravida*
Few-flower caric sedge	*Carex hyalina*
Foxtail caric sedge	*Carex vulpinoidea*
Taper-leaf flat sedge	*Cyperus acuminatus*
Yellow flat sedge	*Cyperus flavescnes*
Slender flat sedge	*Cyperus lupulinus*
Fragrant flat sedge	*Cyperus odoratus*
Bent-awn flat sedge	*Cyperus reflexus*
One-flower flat sedge	*Cyperus retroflexus*
Sedge	*Cyperus setigerus*
Burhead (Erect burhead)	*Echinodorus berteroi*
Creeping burhead	*Echinodorus cordifolius*
Needle spikerush	*Eleocharis acicularis*
Spikerush	*Eleocharis geniculata*
Spikerush	*Eleocharis monteicensis*
Large-spike spikerush	*Eleocharis palustris*
Dwarf spikerush	*Eleocharis parvula*
Square-stem spikerush	*Eleocharis quadrangulata*
Horsetail (Scouring-rush)	*Equisetum hyemale*
Fimbristylis	*Fimbristylis puberula*
Umbrella sedge	*Fuirena simplex*
Bladderpod (Bagpod)	*Glottidium vesicarium*
Blue mud plantain	*Heteranthera limosa*
Water-pennywort	*Hydrocotyle umbellata*
Dudley's rush	*Juncus dudleyi*
Common rush (Soft rush)	*Juncus effusus*
Ring-seed rush	*Juncus filipendulus*
Inland rush	*Juncus interior*
Grassleaf rush	*Juncus marginatus*
Torrey's rush	*Juncus torreyi*
Water willow	*Justicia americana*
Slender-leaf flat sedge	*Kyllinga pumila*

Table E-4: Native Plants List – Herbaceous Wetland	
Common Name	**Botanical Name**
Frogfruit (Lance-leaf frogfruit)	*Lippia lanceolata*
Frogfruit (Turkey tangle)	*Lippia nodiflora*
Seedbox (Rattlebox)	*Ludwigia alternifolia*
Primrose-willow	*Ludwigia decurrens*
Creeping seedbox (Torrey's seedbox)	*Ludwigia glandulosa*
Water primrose	*Ludwigia prploides*
Floating water primrose (Creeping primrose)	*Ludwigia repens*
Water horehound (American bugleweed)	*Lycopus americanus*
Lance-leaf loosestrife	*Lythrum alatum*
California loosestrife	*Lythrum californicum*
Prostrate water-hyssop	*Mecardonia procumbens*
Lax hornpod	*Mitreola petiolata*
Water pepper (Swamp smartweed)	*Polygonum hydropiperoides*
Pink smartweed	*Polygonum pensylvanicum*
Water smartweed	*Polygonum punctatum*
Pleat-leaf knotweed	*Polygonum tenue*
Pickerelweed	*Pontederia cordata*
Star-rush white-top sedge (Umbrella grass)	*Rhynchospora colorata*
Toothcup	*Rotala remosior*
Common arrowhead (Duck potato, Wapato)	*Sagittaria latifolia*
Delta arrowhead	*Sagittaria platyphylla*
Lizard's tail	*Saururus cernuus*
Giant bulrush	*Schoenoplectus californicus*
Three-square bulrush (American bulrush)	*Schoenoplectus pungens*
Soft-stem bulrush (Great bulrush)	*Schoenoplectus tabernaemontani*
Rattlebush	*Sesbania drummondii*
Southern cattail	*Typha domingensis*
Common cattail	*Typha latifolia*

Table E-5: Native Plants List – Aquatic Plants	
Common Name	**Botanical Name**
Larger waterwort	*Callitriche heterophylla*
Coontail	*Ceratophyllum demersum*
Water stargrass	*Heteranthera dubia*
Umbrella water-pennywort	*Hydrocotyle umbellata*
Lesser duckweed	*Lemna aequinoctialis*
Southern naiad	*Najas guadalupensis*
Lotus	*Nelumbo lutea*
Spatterdock (Cow lily, Yellow pond lily)	*Nuphar advena*
White water-lily	*Nymphaea odorata*
Water-thread pondweed	*Potamogeton diversifolia*
Long-leaf pondweed	*Potamogeton nodosus*
Baby pondweed	*Potamogeton pusillus*
Sago pondweed	*Stuckenia pectinatus*
Cone-spur bladderwort	*Utricularia gibba*
Wild celery (Eel grass)	*Vallisneria americana*
Common poolmat (horned pondweed)	*Zannichelia palustrus*

Table E-6: Native Plants List – Ferns	
Common Name	**Botanical Name**
Engelmann's Adder's tongue	*Ophioglossum engelmannii*
Adder's tongue	*Ophioglossum vulgatum*
Purple cliff-brake	*Pellaea atropurpurea*
Common woodsia	*Woodsia obtusa*

Table E-7: Native Plants List – Cacti	
Common Name	**Botanical Name**
Pinapple cactus	*Coryphantha sulcata*
Pincushion cactus	*Coryphantha vivipara*
Plains nipple cactus	*Escobaria missouriensis*
Eastern prickly-pear	*Opuntia humifusa*
Plains prickly-pear	*Opuntia macrorhiza*
Brown-spine prickly-pear	*Opuntia phaeacantha var. major*
Green-flower cholla (Jumping cactus)	*Opuntia tunicata*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Prairie acacia	*Acacia angustissima*
Hop hornbeam	*Acalypha ostryifolia*
Virginia copperleaf	*Acalypha virginica*
Western yarrow	*Achillea millefolium*
Wild onion (Meadow garlic)	*Allium canadense*
Prairie onion	*Allium drummondii*
Blue star (Texas slimpod)	*Amsonia ciliata*
Ble star (Willow slimpod)	*Amsonia tabernaemontana*
Blue funnel lily	*Androstephium coeruleum*
Tenpetal anemone	*Anemone berlandieri*
Carolina anemone	*Anemone caroliniana*
Western rock-jasmine	*Anrdosac occidentalis*
Pussytoes anemone	*Antennaria parlinii*
Arkansas lazy daisy	*Aphanostpehus skirrhobasis*
Prairie dogbane (Indian-hemp)	*Apocynum cannabinum*
Green-dragon (Jack-in-the-pulpit)	*Arisaema dracontium*
Indian plantain	*Arnoglossum plantagineum (Cacalia plantaginea)*
Antelope-horns (trailing milkweed)	*Asclepias asperula*
Butterfly milkweed	*Asclepias tuberosa*
Green-flower milkweed	*Asclepias viridiflora*
Green milkweed	*Asclepias viridis*
Drummond's aster	*Aster drummondii*
Heath aster	*Aster ericoides*
Aromatic aster	*Aster oblongifolius*
Late purple aster	*Aster patens var. gracilis*
Silky aster	*Aster pratensis*
Saltmarsh aster	*Aster subulatus*
Bent-pod milk-vetch	*Astragalus distortus*
Slim-pod milk-vetch	*Astragalus leptocarpus*
Lotus milk-vetch	*Astragalus lotiflorus*
Western daisy	*Astranthium intefrifolium*
Plains wild indigo	*Baptisia bracteata*
Green wild indigo	*Baptisia sphaerocarpa*
Texas green-eyes	*Berlandiera betonicifolia (B. texana)*
Prairie Bishop's weed	*Biflora americana*
Scarlet spiderling	*Boerhavia diffusa*
Erect spiderling	*Boerhavia erecta*
Plains kuhnia (False boneset)	*Brickellia eupatorioides var. corymbulosa*
Plains winecup (Plains poppy-mallow)	*Callirhoe alcaeoides*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Winecup (Purple poppy-mallow)	*Callirhoe involucrata*
Palmleaf poppy-mallow (Finger poppy-mallow)	*Callirhoe pedata (C. digitata)*
Sundrops (Squarebud day primrose)	*Calylophus berlandieri*
Yellow sundrops (yellow eveving-primrose)	*Calylophus serrulatus*
Horseherb (Prostrate lawnflower)	*Calyptocarpus vialis*
Wild hyacinth	*Camassia scilloides*
Indian paintbrush	*Castilleja indivisa*
Redroot (Jersey tea)	*Ceanothus herbaceus*
Basketflower	*Centaurea americana*
Mountain pink	*Centaurium beyrichii*
Lady Bird's centaury	*Centaurium texense*
Short-stalked chickweed	*Cerastium brachypodum*
Nodding chickweed	*Cerastium nutans*
Wild cherry	*Chaerophyllum tainturieri*
Common least daily	*Chaetopappa asteroides*
Partridge pea	*Chameachrista fasciculata (Cassia fasciculata)*
Sensitive pea	*Chameachrista nicitans (Cassia nictitans)*
Pit-seed goosefoot	*Chenopodium berlandieri*
Thick-leaf goosefoot	*Chenopodium pratericola*
Soft golden aster (Camphorweed)	*Chrysopsis pilosa*
Tall thistle	*Cirsium altissimum*
Bull thistle	*Cirsium horridulum*
Texas thistle	*Cirsium texanum*
Violet collinsia	*Collinsia voilacea*
Erect dayflower	*Commelina erecta*
Texas bindweed	*Convolvulus equitans*
Horseweed	*Conyza canadensis*
Rain-lily	*Cooperia drummondii*
Lance Coreopsis	*Coreopsis lanceolata*
Plains coreopsis	*Coreopsis tinctoria*
Rock coreopsis	*Coreopsis wrightii*
Mealy fumewort	*Corydalis crystallina*
Scratch daisy	*Croptilon hookerianum*
Woolly croton	*Croton capitatus*
Tropic croton	*Croton glandulosus*
One-seeded croton	*Croton monanthogynous*
Texas croton	*Croton texensis*
Buffalo gourd	*Cucubita foetidissima*
Texas Gourd	*Cucurbita texana*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Winged pigweed	*Cycloloma atriplicifolium*
Showy prairie clover	*Dalae compacta*
Golden dalea	*Dalea aurea*
White prairie clover	*Dalea candida var candida*
Bigtop dalea	*Dalea enneandra*
Round-head dalea (White prairie clover)	*Dalea multiflora*
Angels Trumpet (Indian apple)	*Datura wrightii*
Rattlesnake-weed	*Daucus pusillus*
Prairie larkspur	*Delphinium carolinianum var. virescens*
Tansy mustard	*Descurainia pinnata*
Illinois bundleflower	*Desmanthus illinoensis*
Prairie bundleflower	*Desmanthus leptolobus*
Panicled tick-clover	*Desmodium paniculatum*
Sessile tick-clover	*Desmodium sessilifolium*
Tweedy's tick-clover	*Desmodium tweedyi*
Pony foot	*Dichondra carolinensis*
Woolly cotton-flower	*Dimorphocarpa wislizenii*
Rough buttonweed	*Diodia teres*
Low silverbush (Low wild mercury)	*Ditaxis humilis*
Shooting star	*Dodecatheon meadia*
Wedge-leaf draba (Whitlow-wort)	*Draba cuneifolia*
Broad-pod draba	*Draba platycarpa*
Carolina draba	*Draba reptans*
Clasping coneflower	*Dracopis amplexicaulis*
Snake Herb	*Dyschoriste linearis*
Blacksamson	*Echinacea angustifolia*
Purple coneflower	*Echinacea atrorubens*
Yarva de tajo (Pieplant)	*Eclipta prostrata*
Englemann daisy	*Englemannia peristenia (E. pinnatifida)*
Basin fleabane	*Erigeron geiseri*
Philadelphia fleabane	*Erigeron philadelphicus*
Annual wild buckwheat	*Eriogonum annuum*
Longleaf wild buckwheat	*Eriogonum longifolium*
Heart-sepal wild buckwheat	*Eriogonum multiflorum*
Prairie fleabane	*Eriogonum strigosus*
Texas stork's bill	*Erodium texanum*
Brushy eryngo	*Eryngium diffusum*
Hooker's enyngo	*Eryngium hookeri*
Leavenworth eryngo	*Eryngium leavenworthii*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Rattlesnake master (Button snakeroot)	*Eryngium yuccifolium*
Western wallflower	*Erysimum capitatum*
Tall thoroughwort	*Eupatorium altissimum*
Blue mist flower	*Eupatorium coelestinum*
Late-flowering boneset	*Eupatorium serotinum*
Snow-on-the-prairie	*Euphorbia bicolor*
Fire-on-the-mountain	*Euphorbia cyanthophora*
Toothherd spurge	*Euphorbia dentata*
Snow-on-the-mountain	*Euphorbia marginata*
Weak spurge	*Euphorbia tetrapoda*
Texas spreadwing	*Eurytaenia texana*
Bluebells	*Eustoma russellianum (E. grandiflorum)*
Big-head pygmycudweed	*Evax prolifera*
Spring pygmycudweed	*Evax verna*
Shaggy dwarf morning-glory	*Evolvulus nuttallianus*
Silver dwarf morning-glory	*Evolvulus sericeus*
Florida snake cotton	*Froelichia floridana*
Prairie gaillardia (Lanceleaf gaillardia)	*Gaillardia aestivalis*
Indian blanket	*Gaillardia pulchella*
Fragrant gaillardia	*Gaillardia sauvis*
Woods bedstraw (Wild licorice)	*Galium circaezans*
Hairy bedstraw	*Galium pilosum*
Plains gaura	*Gaura brachycarpa*
Sweet gaura (Beeblossom)	*Gaura drummondii*
Velvetweed (Lizard-tail gaura)	*Gaura parviflora*
Wavy-leaf gaura (Wavyleaf beeblossom)	*Gaura sinuata*
Wild honeysuckle	*Gaura suffulta*
Crane's bill (Carolina geranium)	*Geranium carolinianum*
White avens	*Geum canadense*
Dakota vervain	*Glandularia bipinnatifida (Verbena bipinnatifida)*
Rose vervain	*Glandularia canadensis (Verbena canadensis)*
Bladderpod (Bagpod)	*Glottidium vesicarium*
Lonestar gumweed (Little-head gumweed)	*Grindelia adenodonta*
Narrow-leaf gumweed	*Grindelia lanceolata*
Prairie bluets	*Hedyotis nigricans*
Common sunflower	*Helianthus annuus*
Texas blueweed (Blue-weed sunflower)	*Helianthus cilaris*
Maximilian Sunflower	*Helianthus maximiliani*
India heliotrope (turnsole)	*Heliotropium indicum*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Pasture heliotrope	*Heliotropium tenellum*
Bladdermallow (Net-Vein herissantia)	*Herissantia crispa*
Gray golden-aster	*Heterotheca canescens*
Camphorweed	*Heterotheca subaxillaris*
Hawkweed	*Hieracium gronovii*
Nodding green violet	*Hybanthus verticillatus*
Carolina wooly-white (Old-plainsman)	*Hymenopappus acabiosaeus*
Old-plainsman (Woolly-white)	*Hymenopappus artemisifolius*
Spotted St. John's wort	*Hypericum punctatum*
Scarlet pea	*Indigofera miniata*
Standing cypress	*Ipomopsis rubra*
Sumpweed (Marsh-elder)	*Iva annua*
Warty calrop	*Kallstroemia parviflora*
Trailing ratany	*Krameria lanceolata*
Virginia dwarfdandelion	*Krigia virginica*
Wright's dwarfdandelion	*Krigia wrightii*
Wild lettuce	*Lactuca canadensis*
Western wild lettuce	*Lactuca ludoviciana*
Narrow-leaf pinweed	*Lechea tenuifolia*
Virginia pepperweed	*Lepidium virginicum*
Hairy bush-clover	*Lespedeza hirta*
Trailing bush-clover	*Lespedeza procumbens*
Tall bush-clover	*Lespedeza stuevei*
Slender lepedeza	*Lespedeza virginicum*
White bladderpod	*Lesquerella gracilis*
Narrow-leaf conobea	*Leucospora multifida*
Tall gayfeather (Tall blazing star)	*Liatris aspera*
Pink-scale gayfeather (Handsome blazing star)	*Liatris elegans*
Narrow-leaf gayfeather	*Liatris mucronata*
Prairie blazing star (Kansas gayfeather)	*Liatris pynchostachya*
Smooth gayfeather (Scaly blazing star)	*Liatris squarrosa var. glabrata*
Arkansas dogshade	*Limnosciadium pinnatum*
False pimpernel	*Lindernia dubia*
Texas yellow star	*Lindheimera taxana*
Small meadow flax	*Linum pratense*
Stiffstem flax	*Linum rigidum*
Puccoon (Carolina gromwell)	*Lithospermum caroliniense*
Narrowleaf gromwell (Narrowleaf puccoon)	*Lithospermum incisum*
Cardinal flower	*Lobelia cardinalis*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Carrot-leaf lomatium	*Lomatium foeniculaceum*
Deervetch (Prairie trefoil)	*Lotus purshianus (L. unifoliolatus)*
Texas bluebonnet	*Lupinus texensis*
Texas skeleton plant	*Lygodesmia texana*
Turks Cap (Wax mallow)	*Malvaviscus arboreus v. drummondii*
Barbara's buttons (Puffballs)	*Marshallia caespitosa*
Creeping cucumber	*Melothria pendula*
Stickleaf (Chickenthief)	*Mentzelia oilgosperma*
White four-o'clock	*Mirabilis albida*
Giant four-o'clock	*Mirabilis gigantea*
Narrow-leaf four-o'clock	*Mirabilis linearis*
Wild four-o'clock	*Mirabilis nyctaginea*
Carolina bristlemallow	*Modiola caroliniana*
Lemon mint (Lemon beebalm)	*Monarda citriodora*
Basil beebalm	*Monarda clinopodioides*
Wild bergamont	*Monarda fistulosa*
Spotted beebalm	*Monarda punctata*
Poverty-weed	*Monolepis nuttalliana*
Spring forget-me-not	*Myosotis macrosperma*
Southern forget-me-not	*Myosotis verna*
tiny mousetail	*Myosurus minimus*
Prairie celestial	*Nemastylis geminiflora*
Yellow puff	*Neptunia lutea*
Crow poison (False garlic)	*Nothoscordum bivalve*
Texas toad-flax	*Nuttallanthus texanus*
Scarlet muskflower	*Nyctaginia capitata*
Cutleaf evening primrose	*Oenothera laciniata*
Four-point evening primrose	*Oenothera rhombipetala*
Spack evening primrose	*Oenothera spachiana*
Showy evening primrose	*Oenothera speciosa*
Stemless evening primrose	*Oenothera triloba*
Soft-hair marbleseed	*Onosmodium bejariense*
Aniseroot	*Osmorhiza longistylis*
Common yellow oxalis	*Oxalis stricta*
Violet woodsorrel	*Oxalis vioacea*
Prairie groundsel	*Packera plattensis (Senecio plattensis)*
Small palafoxia	*Palafoxia callosa*
Rose palafoxia	*Palafoxia rosea*
Passionflower	*Passiflora incarnata*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Tall-bread scurf-pea	*Pediomelum cuspidata (Psoralea cuspidata)*
Rock scurf-pea	*Pediomelum reverchonii (Psoralea reverchonii)*
Round-leaf scurf-pea	*Pediomelum rhombifolium*
Foxglove	*Penstemon cobaea*
Beardtongue	*Penstemon laxiflorus*
Blue curls	*Phacelia congesta*
Annual phlox (Pride-of-Texas)	*Phlox drummondii var. mcallisterii*
Prairie Phlox	*Phlox pilosa*
Drummond's leaf-flower	*Phyllanthus abnormis*
Knotweed leaf-slower	*Phyllanthus polygonoides*
Cut-leaf ground-cherry	*Physalis angulata*
Beach ground-cherry	*Physalis cinerascens*
Downy groundcherry (Husk tomato)	*Physalis pubescens*
Finger flase dragonhead	*Physostegia digitalis*
Beautiful false dragonhead	*Physostegia pulchella*
Obedient Plant	*Physostegia virginiana var. praemorse*
Pokeweed	*Phytolacca americana*
Bracted plantain (Bottlebrush plantain)	*Plantago aristata*
Prairie plantain (Slender plantain)	*Plantago elongata*
Slender plantago (Slim-spike plantago)	*Plantago heterophylla*
Bristle-bracted plantain	*Plantago patagonica*
Red-seed plantain (Tallow-weed)	*Plantago rhodosperma*
Pale-seed plantain	*Plantago virginica*
Purple pluchea (Marsh fleabane)	*Pluchea odorata*
Clammyweed	*Polansia dodecandra*
White milkwort	*Polygala alba*
Pink milkwort (Procession flower)	*Polygala incarnata*
Pleat-leaf knotweed	*Polygonum tenue*
Juniper-leaf	*Polypremum procumbens*
Prairie parsley	*Polytaenia nuttallii*
Common selfheaf (Heal-all)	*Prunella vulgaris var. lanceolata*
Edible scurf-pea	*Psoralea hypogaeum var. subulatum*
Wild alfalfa (Slim-leaf scurf-pea)	*Psoralea tenuiflora*
Mock bishop's weed	*Ptilimnium nuttallii*
False dandelion (Carolina desert-chickory)	*Pyrrhopappus carolinianus*
Texas dandelion (Smallflower desert-chickory)	*Pyrrhopappus pauciflorus*
Mexican hat (Upright prairie coneflower)	*Ratibida columnifera*
Pigeonberry (Rougeplant)	*Rivina humilis*
Blackeyed Susan	*Rudbeckia hirta*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
Low ruellia	*Ruellia humilis*
Pale dock	*Rumex altissimus*
Heart-wing sorrel	*Rumex hastatulus*
Meadow pink	*Sabatia campestris*
Buckley's sabatia	*Sabatia formosa*
Trailing pearlwort	*Sagina decumbens*
Blue sage	*Salvia azurea*
Tropical sage	*Salvia coccinea*
Engelmann's sage	*Salvia engelmannii*
Mealycup sage	*Salvia farinacea*
Texas sage	*Salvia texana*
Thin-leaf brookweed	*Samolus valerandi*
Black snakeroot	*Sanicula canadensis*
Catclaw sensitive briar	*Schrankia nuttallii (Mimosa nutallii)*
Roemer sensitive briar	*Schrankia roemeriana (Mimosa roemeriana)*
Small scullcap	*Scutellaria parvula*
Wright's skullcap	*Scutellaria wrightii*
Yellow stonecrop	*Sedum nuttallianum*
Texas groundsel	*Senecio ampullaceus*
Cofee-bean	*Sesbania herbacea (S. macrocarpa)*
Rock cress	*Sibara virginica*
Bur cucumber	*Sicyos angulatus*
Spreading fanpetal	*Sida abutifolia*
Prickly fanpetals	*Sida spinosa*
Sleepy catchfly	*Silene antirrhina*
Widow's frill	*Silene stellata*
Compassplant	*Silphium laciniatum*
Sword-leaf blue-eyed grass	*Sisyrinchium chilense*
Dotted blue-eyed grass	*Sisyrinchium pruinosum (S. langloisii)*
American nightshade	*Solanum ptychenthum (Solanum americanum)*
Common goldenrod	*Solidago canadensis*
Tall goldenrod	*Solidago gigantea*
Stiff goldenrod	*Solidago rigida*
Elm-leaf goldenrod	*Solidago ulmifolia*
Forked scaleseed	*Spermolepis divaricata*
beggar's-lice (Bristly scaleseed)	*Spermolepis echinata*
Spreading scaleseed	*Spermolepis inermis*
Slender ladies' tresses	*Spiranthes lacera*
Mousesear	*Stachys crenata*

Table E-8: Native Plants List – Forbs (Wildflowers)	
Common Name	**Botanical Name**
False gaura	*Stenosiphon linifolius*
Smooth jewelflower (Smooth twistflower)	*Streptanthus hyacinthoides*
Trailing wild bean	*Strophostyles helvola*
Smooth-seed wild bean	*Strophostyles leiosperma*
Sunbright (Prairie flameflower)	*Talinum parviflorum*
Goat's rue (Virginia tephrosia)	*Tephrosia virginiana*
Sawtooth nerveray	*Tetragonotheca ludoviciana*
Fineleaf four-nerve daisy	*Tetraneuris linearifolia (Hymenoxys linearifolia)*
Wood sage	*Teucrium canadense*
Greenthread	*Thelesperma filifolium*
Small Bristle-leaf (Tiny Tim)	*Thymophylla tenuiloba*
Ohis spiderwort	*Tradescantia ohioensis*
Tharp's spiderwort	*Tradescantia tharpii*
Peanut clover	*Trifolium polymorphum*
Venus' looking glass	*Triodanis holzingeri*
Slender-leaved Venus looking-glass	*Triodanis leptocarpa*
Hen and Chickens	*Triodanis perfoliata*
Beaked cornsalad	*Valerianella radiata*
Wood's cornsalad	*Valerianella woodsiana*
Bracted vervain	*Verbana bractaeta*
Texas vervain	*Verbena halei*
Hoary vervain	*Verbena stricta*
White vervain	*Verbena urticifolia*
Gulf vervain (Course vervain)	*Verbena xutha*
Cowpen daisy (Golden crownbeard)	*Verbesina encelioides*
White Crownbeard (Frostweed, Iceplant)	*Verbesina virginica*
Western ironweed	*Vernonia baldwinii*
Purslane speedwell (Neckweed)	*Veronica peregrina*
Blue violet	*Viola palmata*
Common blue violet	*Viola sororia*
Carolina violet	*Viola villosa*
Prairie brazoria	*Warnockia scutellarioides*
Orange zexmenia	*Wedelia texana (Zexmenia hispida)*
Texas sleepy daisy	*Xanthisma texanum*