CITY OF OKLAHOMA CITY

Oklahoma City Drainage Criteria Manual

The City of Oklahoma City

Public Works Department

420 W MAIN ST, SUITE 700, OKLAHOMA CITY, OKLAHOMA

THE CITY OF OKLAHOMA CITY

Drainage Criteria Manual

Approval Sheet

Department of Public Works
420 W. Main, Suite 700
Oklahoma City, OK 73102

Approved by the City Engineer of the City of Oklahoma City this ____________ day of

______________________, 2020.

____
Eric J. Wenger, P.E., City Engineer

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1. Executive Summary

1.1 Introduction

The design of storm sewer, drainage, and flood control devices must comply with the requirements of Chapter 16 of the Oklahoma City Municipal Code. Chapter 16, entitled "Drainage and Flood Control", lists design methods, equations, mathematical variables, floodplain management, and other criteria that are used to design all facets of drainage related facilities or analyses.

This Drainage Criteria Manual (DCM), at the direction and approval of the City Engineer, provides supplemental information related to the Drainage Ordinance requirements and engineering design criteria for surface runoff, storm sewer and floodplain improvements within the City of Oklahoma City.

The City Engineer may revise the DCM to provide for needed updates and changes. Updates will be posted to the City's website at okc.gov for 60 days prior to changes becoming effective. An email with notifications of the revisions and updates will be sent to developers, engineers, and contractors with contact information on file with the Public Works Department. The consulting engineer must contact the Public Works Department to obtain the most current DCM document available prior to use.

Commented [A1]: This needs to be modified to notify City of OKC engineers of record somehow. Not just a posting on City website. Also, this doesn't provide any feedback/approval process. Should go to PC and CC so consultants have a way to provide feedback and changes are not just made no matter consultants and developers feedback.

From time to time, in response to, and because of, field observations, comments from the public, and/or development community, the City Engineer may require additional requirements that must be complied with regardless of whether the requirements are mentioned elsewhere in the Drainage Ordinance or the DCM. The following list of design items must be complied with in the design of drainage facilities:

~~1.~~

- Any desired variations from the requirements of the DCM must be approved by the City Engineer.

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All drainage designs and devices shall conform to the City of Oklahoma City Standard Specifications. All approved standard construction details are available from the Public Works Department.

1.2 Base Vertical Datum Adjustment Factors NGVD29 to NAVD88

All elevations related to any design, base flood elevations, plan elevations, or else, shall be referenced to NAVD 88 vertical datum or most recently adopted control. The FEMA

2009 (or most current) publication of the various county Flood Insurance Studies (FIS) updated and converted all previous noted elevations from NGVD 29 to NAVD 88 datum.

However, Oklahoma City uses a locally produced "URBAN FLOOD ANALYSIS IN OKLAHOMA CITY OKLAHOMA" (USGS, 1983) publication for floodplain management purposes in development applications. This document lists higher urbanized flood flow rates and elevations than the FEMA FIS (circa 1983) for the 50-year and 100-year storm events to be used for development and floodplain management purposes.

For this reason, elevations listed in the 1983 Urban Flood Analysis in Oklahoma City (USGS, 1983) report shall be adjusted upward to the current NAVD 88 vertical datum or most recently adopted control. Each county has an adjustment value unique to that county. For any floodplain activity in each county containing any Oklahoma City property limit, add the following values to NGVD 29 elevations to adjust upward to current NAVD 88 datum:

County Adjustment Factors:

Oklahoma County	+0.425 feet
Canadian County	+0.547 feet
Cleveland County	+0.369 feet
Pottawatomie County	+0.295 feet

2. Storm Water Run-Off Calculation Methods

2.1 Introduction

This chapter provides the City approved sources for rainfall data and Hydraulic and Hydrology (H&H) calculations for the design of drainage conveyance systems to meet the requirements of the Drainage Ordinance and DCM.

2.2 Rainfall

Total rainfall is provided for calculation of flows using programs such as HEC-1, HEC-HMS, or WinTR-55. Rainfall intensities are provided for calculation of flow using the rational or modified rational methods. Annual average rainfall for the City is also provided for using the current USGS regression equations as in the National Stream Stats (NSS) methods.

Total rainfall is calculated from the current NOAA Atlas 14 rainfall records and presented in rainfall total depths varying in inches over a given duration and frequency as well as in the rainfall intensity in inches per hour varying over a given duration and frequency.

2.3 Runoff Calculations Methods

There are many methods for calculating runoff for a design of components of the storm drainage system. Methods acceptable within the City depend on the type of design analysis and include the Rational Method, Modified Rational Method for stormwater detention, Soil Conservation Service (SCS) Method, and USGS Regression Equation Methods used within StreamStats. Peak flow calculations are used for sizing drainage conveyance systems. Total volume of the flow is used in sizing detention facilities for storage quantity requirements.

Table 2-2: List of Runoff Calculation Methods

	Applicable Use		Use with Minimum Basin Area (Acres)	Use with Maximum Basin Area (Acres)
	Peak Flow	Total Volume		
Rational Method	Yes	No	0	200
SCS Method	Yes	Yes	200	2000
USGS Regression Equations	Yes	No	200	None
Modified Rational	No	Yes	0	200

Any drainage basin analyzed to calculate flow rates for any frequency storm shall be considered fully urbanized to produce urbanized flow rates for design purposes. All drainage calculations or flood studies shall consider fully urbanized runoff conditions and urbanized flow rates.

2.3.1 Rational Method

Runoff from surface drainage areas may be determined by the Rational Method formula:

$$Q = CIA$$

Where,

Q = Flow in cubic feet per second

A = Surface area to be drained in acres, determined by field topographic surveys or based on Oklahoma City most current contours

C = Area runoff coefficient, fraction of runoff, and may vary between 50-percent and 95-percent expressed as a dimensionless decimal fraction, that appears as surface runoff from the contributing drainage area.

I = Rainfall intensity based on the rainfall rate in inches per hour

Table 2-3: Runoff Coefficients, "C" Factors

Development Type	Zoning	Runoff Coefficients
Undeveloped/grass		0.50
Single Family Residential Including Mobile Homes	R-1	0.70
Acreage Residential 0.5-2.0 ac	RA, RA2 or R-1	0.65
Acreage Residential 2.0-5.0 ac	RA, RA2 or R-1	0.60
Duplex	R-2	~~0.75~~0.70
Quad-Plex	R-3	0.80
Apartment Complexes	R-4	0.85
Commercial-Offices	C-1 through C-3	0.90
Shopping Centers	C-4	0.95
Industrial	I-1 through I-3	0.95

Commented [A2]: Why does duplex runoff coefficient differ from R-1 when lot size and coverage requirements are the same?

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most hydraulically remote part of the drainage area to the point under consideration. The other significant assumption is that intensity of rainfall is constant over the entire basin during this time.

Time of concentration consists of overland flow time, T_o, plus the time of travel, T_f, in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. The latter portion, T_f, of the time of concentration can be estimated from the hydraulic properties (velocity) of the storm sewer, gutter, swale, ditch, or channel. Overland flow time, on the other hand, will vary with surface slope, surface cover and distance of surface flow.

The time of concentration can be calculated using the following equation:

$$T_c = T_o + T_f$$

Where,

T_c = Time of concentration (minutes)

T_o = Initial or overland flow time (minutes)

T_f = Travel time in the ditch, channel, gutter, storm sewer, etc. (minutes)

NOTE: Minimum time of concentration, T_c, shall be 5-minutes.

The overland flow time, T_o, can be calculated using the following equation:

$$T_o = K\, L^{0.37}/S^{\,0.2}$$

Where,

K = Retardance factor

L = Length of the overland flow in feet

S = slope of the ground (ft/ft)

NOTE: The maximum overland flow length shall be 1,000 feet

Table 2-4: Retardance "K" factor for type of Cover

Dense Grass	1.13
Average Grass	1.000
Poor Grass	0.942
Bare Soil	0.604
Acreage Residential 0.5 to 2.0 acres	0.633

Acreage Residential 2.0 to 5.0 acres	0.756
Residential / Duplex / Quad-Plex	0.511
Commercial / Apartment Complex	0.445
Industrial/Pavement	0.372

The total time of concentration shall be the combination of overland flow time with the remaining flow path travel time, T_f, which is calculated using the hydraulic properties (velocity) of the swale, ditch, or channel. The calculated velocity shall be based on Manning's equation. The following equation is used for calculating the travel time forward:

$$T_f = (FPL/V)/T$$

Where,

FPL = Flow Path Length in feet

V = Velocity in feet per second

T = 60 seconds

Rainfall intensities for the Rational Method are calculated using the following method. The intensity, i, is the average rainfall rate in inches per hour for the period of maximum rainfall of a given frequency having duration equal to the time of concentration. For a given time of concentration, T_c, and a given design storm frequency, the rainfall intensity, i, can be obtained using the following equation:

$$i = B / (T_c + D)^E$$

Where,

i = Rainfall Intensity in inches per hour

T_c = Time of Concentration in minutes

B, D, E = Parameters defined in Table 2-1 for various storm frequencies.

Table 2-1: Rainfall Intensity Parameters.

Return Period	Parameters for the IDF Equations		
	B	D	E
2-Year	104.332663	17.298017	0.934857
5-Year	79.655486	14.827708	0.825124
10-Year	87.535303	15.882422	0.811341

25-Year	101.481871	16.773612	0.805881
50-Year	98.924724	15.864806	0.775353
100-Year	102.769257	15.860016	0.760373

2.3.2 SCS Unit Hydrograph Method

The Soil Conservation Service (SCS) method is considered acceptable for certain analyses and for determining variable values for input to other software such as HEC-HMS or HEC-1. The NRCS program WinTR-55 or the U.S. Army Corps of Engineers computer programs HEC-HMS or HEC-1 are acceptable ways of utilizing the SCS methodology.

2.3.3 USGS Regression Equations

The United States Geological Survey (USGS) regression equations are used in the StreamStats methods for stormwater runoff calculations. The result of utilizing StreamStats is a non-urbanized flow. The non-urbanized flow is to be urbanized by applying a Basin Factor through NSS. The method described in USGS Scientific Investigation Report 2019-5143 may be used for the calculation of urbanized flows.

Commented [A3]: USGS regression equations has an urbanization factor that is applied. Why requirement to use Basin Factor through NSS?

2.3.4 Modified Rational Method

The modified rational method (MRM) is an extension of the rational method to produce simple runoff hydrographs. The MRM is often called the rational hydrograph method. Application of the MRM produces a runoff hydrograph and runoff volume in contrast to application of the rational method, which produces only the peak design discharge (Qp).

2.4 Acceptable Methods for Hydraulic Calculations

Manning's method shall be used for the hydraulic calculation of drainage ditches and storm sewers. For drainage ditch structures draining up to 20-acres, Manning's equation for uniform flow can be used.

2.4.1 Manning's Equation

The size of closed storm sewers, open channels, culverts, and bridges shall be determined by using Manning's Equation which may be modified for use with runoff determined by the Rational Formula to:

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

Where:

Q = discharge in cubic feet per second

A = cross sectional area of water in conduit in square feet

R = hydraulic radius of water in conduit (R = water flow area/wetted perimeter)

S = mean slope of the flowline gradient in feet of vertical rise per foot of horizontal distance

n = Manning's roughness coefficient. The typical values of Manning's roughness coefficients for capacity calculations are provided in the following table:

Table 2-5: Manning's roughness coefficients

RCP & RCB	0.013
CGMP	0.024
HP	0.013
HDPE	0.013
Concrete Lined Channel	0.013
Grass Lined Channel	0.035
Concrete Curb & Gutter	0.013
Asphalt Pavement	0.016
Rip-Rap	$n = 0.0395(d_{50})^{1/6}$ d_{50}=nominal stone dia in feet

In addition to Manning's equation, use of the other design methods may be required to adequately size storm water facilities. Design of storm sewer systems shall maintain the hydraulic grade line below any gutter elevation and any manhole top lid/rim elevation to eliminate flooding inlets at the gutter line or system overflow along the design reach limit.

Commented [A4]: For public only? Should not be required for private.

2.4.2 Backwater Profile Using HEC-RAS or HEC-2

The U.S. Army Corp of Engineers Programs HEC-RAS River Analysis System or HEC-2 Water Surface Profiles Program shall be used to analyze all open channels with drainage areas larger than 20-acres. Normal depth shall be used as the boundary condition if a beginning water surface elevation is not known. If a previous study is available downstream of the existing location, the boundary conditions should be based on the known water surface elevation of the approved study.

Commented [A5]: The acreage requirement for the useage requirement of HEC-RAS or HEC-2 varies throughout this document. See 5.3, 5.5.1, 5.5.2 and 5.5.3. I would recommend it be consistent and be 40-acres. Request all DA below 40 Ac. be permitted to be calculated by a normal depth open channel flow calculation.

Normal depth calculations may be used to determine water surface elevations in open channels with drainage areas of 20 acres or less. For open channels in this category, the engineer will be responsible for determining the most applicable method to use.

2.4.3 Use of Other Commercially Available Packages

Use of other software such as EPA-SWMM, XP-SWMM, AutoCAD Storm and Sanitary Analysis, or any other similar commercially available package is permitted if a justification for the value of parameters is provided by the engineering consultant.

3. Street, Inlets, and Closed Storm Sewer

3.1 Introduction

Streets, curb inlets, and closed storm sewers are used for providing drainage systems within areas of development. Streets are an integral part of an urban drainage system. Streets are used to provide drainage until its flow capacity is exceeded then curb inlets are provided to drain the street. A closed storm sewer system is provided to accept flow from inlets.

The following subsections describe design features and requirements for a drainage system for streets, curbs, and gutters.

Streets without curbs and gutters are permitted in accordance with the Drainage Ordinance. In this case, the use of borrow ditches are permitted for street drainage.

Open-top drop inlets shall not be used.

3.2 Roadway Drainage

3.2.1 Design Flow

The street shall be designed for fully urbanized conditions as determined by current zoning for the area. It is the responsibility of the Engineer to verify it uses the most updated zoning map for the area. The current zoning map can be found on the Oklahoma City website. However, the minimum composite runoff coefficient shall meet the requirements of Table 2-3.

3.2.2 Roadway Flow Capacity

Street capacities are calculated based on the area and wetted perimeter of the roadway cross-section when considering the street width and crown of the roadway. The minimum capacity for any stretch of roadway is based on the minimum slope of the roadway section. A minimum slope of 0.60% shall be maintained at every location along a proposed street. The roadway capacity may be calculated using the Manning equation. Depending on the standard paving section used, the curb height may vary from 4-inch to 8-inch; paving width may vary from 26-foot to 48-foot; the crown height will vary depending on the paving width:

Commented [A6]: Why are we switching to 0.6% here? 0.4% has been adequate. Could require 0.6% through intersection or could require a trickle channel through the intersection.

$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

Commented [A7]: This drastically reduces the calculated flow in streets as it does not consider area or anything above the crown. IF this intended for arterial it should be clarified and the old calculation shall be permitted for locals, collectors etc.

Where:

Q = discharge in cubic feet per second

S_x = paving cross slope from gutter to crown shall be 2%

S = mean longitudinal slope of paving shall be 0.60% minimum

T = width of flow in feet

n = Manning's roughness coefficient for paved sections = 0.013 minimum

A four-lane street shall be used for conveyance of flow provided the flow depth is limited to 6-inches or one lane in width each way, whichever is less.

Streets in residential developments must carry the runoff from the 25-year storm without exceeding the top of curb at any point. The street capacity can be calculated accordingly.

3.2.3 Drainage Related Street Design Features

Paving crowns must be omitted at all intersections to avoid ponding. Vertical curves are not permitted at crests and sags (vertical high and low points of a roadway profile) within Oklahoma City. To eliminate possible ponding, grade changes shall be designed by using tangents with minimum lengths of 25-feet and a minimum slope of 0.6%. The maximum profile grade break shall be 1.2%.

Commented [A8]: Why are we switching to 0.6% here? 0.4% has been adequate. Could require 0.6% through intersection or could require a trickle channel through the intersection.

3.3 Curb Inlets (Design 2 Inlets)

3.3.1 Inlet Design Flow and Location

Inlets must be designed for fully urbanized conditions as determined by current zoning for the area. However, the minimum composite runoff coefficient or shall meet the requirements of Table 2-3. Storm drain inlets shall be designed and placed at the following locations to provide quick and efficient removal of surface water from the street:

A. Curb inlet grates are required to drain the very low flow that usually cannot enter curb hoods. Grates shall be located at the lowest point of the sump or the downstream end of a curb inlet.

B. At least one curb inlet shall be located at a sump location unless the location is being served with a flume with a curb opening.

C. If a street/roadway is designed to drain towards a "T" intersection and the intersecting street is flowing at 70% or greater street capacity as described in Section 3.2.2 above, then inlets must be placed before the intersection to drain all of the upstream street discharge. If a street is designed to drain towards a "T" intersection, additional finished floor and driveway location restrictions are imposed to protect against driveways acting as a channel that may drain storm water runoff towards a garage causing flooding. A driveway edge for a lot along a T-intersection shall have a minimum offset of 20-feet from the center line of the intersecting street or the minimum finished floor elevation of the structure shall be elevated to at least 1 foot above the top of curb at the driveway location. If the minimum finished floor elevation is raised, a foundation permit will be required, along with a surveyor's certificate certifying the finished floor elevation.

D. If the 25-year urbanized flow in the roadway exceeds the street capacity a curb inlet shall be provided to capture 25-year flow. The by-passed flow must be included in the capacity calculations for the next downstream inlet, whether it is on a continuous grade or within a sump.

E. Curb inlets located at sumps shall be designed to intercept a minimum of the peak discharge from the 50-year design event with an overflow structure designed to intercept the difference between the inlet capacity and the 100-year by-pass from all other upstream inlet locations. If there is no overflow structure, the curb inlets at sumps must be designed to carry the 100-year storm and the 100-year by-pass from all other upstream inlet locations. All streets must have inlets between Design 2-0 and Design 2-4. Curb inlets lager than Design 2-4 are not allowed, unless specifically approved by the City Engineer. Inlets located in cul-de-sacs can be no larger than a Design 2-0, unless specifically approved by the City Engineer.

F. The curb cut width for a flume opening or the entrance width of an overflow flume shall not exceed 15 feet. The minimum flume width shall be 4 feet. Pipe bollards shall be placed at all flume openings. The maximum bollard spacing shall be 4 feet.

Commented [A9]: This should be revised to an either or situation as to not cause a reduction in lots for a developer. Either driveway edge shifted or Min. FF requirement 1' above TC at T intersection.

Commented [A10]: Why no longer allowing 2-5? There are instances that it does not interfere with

Commented [A11]: Why is this being applied across the board. I understand R-1 where there is not adequate room between driveways but larger lots there is plenty of room between driveways for something bigger than 2-0

3.3.2 Design and Construction Standards

The City of Oklahoma City Construction Standards contains engineering design and construction details for Design 2 Inlets. Design 2 Inlets are multiple curb openings and two grates. This type of inlet is usually the most practical type of roadway drainage because it resists clogging and offer little interference to vehicular, bicycle, or pedestrian traffic. The maximum inlet capacities are included in Table 3-1 below.

Table 3-1: Design 2 Inlet Capacities

Type	Total Capacity	Grate Capacity	Hood Capacity	Approx. Length
Design 2-0	8.2 cfs	3.2 cfs	5 cfs	5 ft
Design 2-1	13.2 cfs	3.2 cfs	10 cfs	10 ft
Design 2-2	18.2 cfs	3.2 cfs	15 cfs	15 ft
Design 2-3	23.2 cfs	3.2 cfs	20 cfs	20 ft
Design 2-4	28.2 cfs	3.2 cfs	25 cfs	25 ft

On a residential street, the first most upstream inlet is constructed when the 25-year flow in the street meets the top of curb or the drainage area exceeds 20-acres.

On streets other than a residential classification, the first most upstream inlet is constructed at a point such that no more than one driving lane will be inundated during a 25-year frequency storm.

3.4 Grated Street Inlets

3.4.1 Inlet Design Flow and Location

This type of inlet is allowed only for addressing a drainage and flooding issue in an already developed area and use of these inlets in new subdivisions will not be allowed, unless approved by the City Engineer.

Grated street inlets shall be designed for fully urbanized conditions as determined by current zoning for the area. However, the minimum composite runoff coefficient shall meet the requirements of Table 2-3.

They are typically located at a sump or close to a sump location. The lots adjacent to a grated street inlet located at a sump shall be elevated 1-foot above the top of curb of the inlet.

Commented [A12]: This seems like a requirement for new development and not addressing flooding in an already developed area.

3.4.2 Design and Construction Standards

The City of Oklahoma City Construction Standards contain engineering design and construction details for the Grated Street Inlets. This type of inlet shall be used when a Design 2 Inlet is not suitable due to a specific site condition. The maximum inlet capacities are included in Table 3-2 below.

Table 3-2: Grated Inlet Capacities

Type	26-foot on-grade	26-foot sump	32-foot on-grade	32-foot sump
Alternate "A" *	67 cfs	112 cfs	84 cfs	140 cfs
Alternate "B" **	Inlet capacities to be based on manufacturer's design capacity			

* IKG Industries Type WL Size 20A Galvanized Steel Grate

** Neenah Foundry Type R-4999-NX with Type C Frame

3.5 Design 5, 6, and 7 Inlets

3.5.1 Design Flow

Similar to other types of inlet, design flow for these inlets shall be based on fully urbanized flow and based on current zoning for the area. However, the minimum composite runoff coefficient shall meet the requirements of Table 2-3. These inlets shall be designed for the 50-year urbanized flow with a 100-year overflow. In commercial areas where an overflow flume cannot be provided due to site conditions, inlets shall be designed for the 100-year urbanized flow in conjunction with an adequately sized closed storm sewer system in accordance with Section 3-7 design requirements.

3.5.2 Inlet Location and Other Considerations

This type of inlet shall be located in a sump within a parking lot or in ~~paving within an apartment complex~~a paved area.

3.5.3 Design and Construction Standards

The City of Oklahoma City Construction Standards contains engineering design and construction details for the Grated Box Inlets. These types of inlets shall not be used in streets. They are designed to be used in paved areas such as parking lots and apartment complexes.

Table 3-3: Design 5, 6, & 7 Inlet Capacities

Inlet Name	Number of Grates	Capacity
Design 5	1	1.6 cfs
Design 6	2	3.2 cfs
Design 7-1	4	6.4 cfs
Design 7-2	6	9.6 cfs
Design 7-3	8	12.8 cfs

These types of inlets located in sump areas shall be designed for the 50-year urbanized flow with a 100-year overflow. In areas where an overflow flume cannot be provided due to site conditions, inlets shall be designed for the 100-year urbanized flow in conjunction with an adequately sized closed storm sewer system.

The capacity of the Design 5, 6, & 7 Inlets shall be as indicated in Table 3-3. A maximum allowable headwater of 9-inch shall not be exceeded. The minimum finished floor elevation of adjacent buildings must be 1-foot above the water surface elevation of the 100-year design event.

3.6 Box Inlets with Side Openings

3.6.1 Inlet Design Flow

The inlet capacity must be calculated to limit the 100-year event headwater elevation to 12-inches maximum above the weir elevation. The vertical height of the inlet openings shall not exceed 9-inches. The capacity must be calculated using the horizontal weir calculation until the weir flow depth equals or exceeds 9-inches (contact with lid). Above that point, the capacity must be calculated using the equation for a vertical orifice. The weir discharge coefficient must be 3.087 (producing critical depth) and the orifice discharge coefficient must be 0.60.

Weir equation:

$$Q = CLH^{3/2}$$

Where:

C = 3.087

L = Length in feet

H = Head in feet

Orifice Equation:

$$Q = CA(2GH)^{1/2}$$

Where:

C = 0.60

A = square feet

G = 32.2

NOTE: For a vertical orifice, H is measured from the center of the orifice opening in Feet.

All building structures adjacent to box inlets with a lid shall be elevated to 1 foot above the top of lid or the 100-year headwater elevation, whichever is greater.

3.7 Closed Storm Sewer

3.7.1 Calculations and Design

The Oklahoma City drainage ordinance requires on-grade storm sewer systems carrying urbanized runoff from streets shall be designed to capture a minimum 25-year frequency storm. The maximum area draining to the street shall not exceed 20 acres. If at any point a 25-year urbanized runoff exceeds street capacity, a set of inlets and a closed storm system to carry a minimum of the 25-year urbanized runoff shall be provided. At sump areas the storm sewer shall be designed to serve a 50-year urbanized flow with a concrete flume being constructed over the storm sewer to ensure that any overflow from a 100-year urbanized flow can reach a suitable outlet without threatening any existing and proposed structures.

The capacity calculations for a closed storm sewer shall be performed using Section 2-5. In addition to Manning's equation the use of the other design methods may be required to adequately size stormwater facilities.

Design of storm sewer systems shall maintain the hydraulic grade line (HGL) below any gutter elevation and any manhole top lid/rim elevation to eliminate flooding inlets or system overflow along the design reach limit. If the storm sewer system is discharging to a detention pond, creek or channel, the Q100 water surface elevation (WSEL) from the downstream drainage infrastructure shall be used as the tailwater elevation for the HGL analysis. ~~However, if~~If the storm sewer system is connecting to an existing storm sewer system, ~~water surface elevation at the full flow condition~~a Manning's full-flow capacity calculation and an inlet control calculation of the downstream storm sewer pipe shall be used ~~as~~ to determine the tailwater elevation for the HGL analysis.

Commented [A13]: Contradicts Sec. 16.13.2 of DO. Should be removed from DO and requirement should be put here.

3.7.2 Minimum Sizing and Other Design Standards

A closed storm sewer system shall be sized for urbanized flow conditions. A closed storm sewer shall meet the requirements of and be compliant with the drainage ordinance regardless of the capacity of the downstream storm sewer. A closed storm sewer within public right-of-way shall not be less than 18-inches in diameter. A closed storm sewer crossing a public street shall utilize Reinforced Concrete Pipe (RCP) with "O" rings or a Reinforced Concrete Box (RCB). A closed storm sewer within a public drainage easement, next to curbs, and between houses shall either be RCP with "O" rings, RCB, or High-Performance Polypropylene (HP) pipe with watertight (WT) gaskets. All joints on RCP, RCB, and HP shall be wrapped with a continuous filter fabric strip overlapping 2 feet on each side of the pipe joint to ensure proper protection. Corrugated Metal Pipe (CMP) shall not be used in publicly funded improvements or for any improvements to be dedicated to the City. CMP may be used in rural private improvements or developments. High-Density Polyethylene Pipe (HDPE) shall only be allowed in private improvements or developments.

Commented [A14]: Or High-Performance Polypropylene (HP) pipe with watertight (WT) gaskets.

Commented [A15]: A closed storm sewer crossing a public street shall utilize Reinforced Concrete Pipe (RCP) with "O" rings, a Reinforced Concrete Box (RCB) or High-Performance Polypropylene (HP) pipe with watertight (WT) gaskets.

Commented [A16]: This should be a white book requirement...Not DCM or DO requirement. Also request that HDPE be considered based on the requirement to wrap joints and back fill to 1' above pipe.

Commented [A17]: Request to be considered for public improvements and no crushed rock backfill requirement under paving for private storm.

A closed storm sewer shall be constructed with a minimum soil cover of 2 feet from the top of the finished grade to the top of the pipe. Any variation from this minimum depth must be pre-approved by the City Engineer. If 2-foot soil cover cannot be achieved, Class IV pipe shall be required. A closed storm sewer shall be constructed with crushed rock backfill under the public street and under paving within the public drainage easement. A closed storm sewer shall have a minimum flow velocity of 2.5 fps and a maximum velocity based on the type of material as shown in Table 3-4 below.

Table 3-4: Minimum Manning's "n" Value and Maximum Velocities for Sewer Materials

Material	Maximum Velocity (fps)	Minimum "n" value

Concrete	15	0.013
CGMP	12	0.024
HP	14	0.013
HDPE	14	0.013

3.7.3 Horizontal and Vertical Alignments

The diameter of the pipe shall not decrease proceeding down gradient within the closed storm sewer system. At points where pipe diameters change, the pipe soffit elevations shall match, and flow line elevations shall drop through the manhole or junction box. A diversion of flow is not allowed (i.e., the discharge point and all inlets of a closed storm sewer system shall be within the same watershed). Unless there is a difficulty providing the depth of cover, it is desirable to use closed storm sewer conduit with a circular cross-section. A closed storm sewer shall not be located under paving parallel to the centerline of the roadway unless specifically approved by the City Engineer. ~~All closed storm sewers~~For all closed storm sewer systems, the pipe or the required erosion control measures and the required drainage easement must be extended to the property limits of the improved development.

When tying two storm sewer reaches together, the crowns of the upstream pipe and the downstream pipe shall match.

3.7.4 Manhole, Inlets, and Junction Boxes

A manhole or junction box shall be required for any change in direction, pipe size or slope of any storm sewer in Oklahoma City. Separation for all manholes and junction boxes for RCP less than or equal to 60-inch diameter or RCB less than or equal to 5 feet in height, shall be a maximum of 375 feet. A structurally designed and adequately sized concrete junction box with a minimum 6-inch space between the outside of the pipes and inside wall shall be used for connecting three or more pipes of 18 inches or larger. 5-foot or 6-foot diameter manholes may be used in these locations, if approved by the City Engineer. The design engineer must provide documentation or drawings showing that sufficient manhole wall distance will remain between the pipe openings such that the structural integrity of the manhole is not diminished. A radius junction box shall be used to obtain a horizontal direction change for pipes larger than 30 inches. The minimum length of a storm sewer pipe between structures shall be 5 feet.

3.7.5 Outfall Condition and Grade to Drain Requirements

Pipe/Culvert Outfall shall be lowered to the flow line of receiving creek or shall tie into the existing low point at the property line. If these conditions cannot be met, the developer shall obtain a grade to drain easement from the adjacent property owner(s) of sufficient length and width to ensure the proper function of the storm sewer system. A 3-foot cut-off wall is required at all pipe/culvert outfalls. If the discharge velocities are higher than the existing downstream natural soil shear stresses and velocities shown in Table 4-1

Commented [A18]: What if internal creek?

This is not practical. In a lot of situations the storm sewer would stop at a creek or drainage ditch within the property. Also need to allow for room for scour protection at discharge of pipe such as rip rap.

Commented [A19]: This needs to be clarified for round pipe only. Arch or elliptical would need to match bottom in many situations.

Commented [A20]: This isn't always achievable...engineer to provide HGL to show no issue if flowlines are matched.

Commented [A21]: See above re: property limits

Commented [A22]: 3' cut off wall should not be required in low flow, low velocity outfall situations. This is an over engineered requirement for all situations. You are requiring scour protection for high discharge velocities on top of this. This should be reconsidered as it is redundant.

and Table 4-2, permanent structural and/or non-structural erosion controls shall be required in accordance with Table 4-2. A temporary easement from the adjoining property owners shall be obtained by the developer if necessary. The 100-year water surface elevation at the storm sewer outfall must be shown on plans. The 100-year water surface in the receiving stream shall be used as the beginning elevation of any storm system hydraulic grade line (HGL) calculation.

Commented [A23]: Getting easement from adjacent property owner should not be required as it is not possible in all situations

Commented [A24]: When sizing for 100-year?

Does not make sense to use 100-yr HGL on a 50-yr design. Corresponding HGL should be used for corresponding frequency design.

4. Bridges, Culverts, and Other Special Structures

4.1 Introduction

Streamflow or continuous flow of water across continuous roadways must be through culverts or bridges. Design of bridges and culverts shall conform to city construction standard details and standard specifications.

4.2 Bridge and Culvert Design and Location

Bridges and culverts must be designed to pass the 50-year urbanized flow per zoning and shall also be designed such that the 100-year urbanized flow does not overtop the roadway. In addition, the 50-year water surface elevation shall be below the low chord of a bridge and no more than 1-foot above the top of the culvert at the upstream end of the culvert. Driveway pipes shall be designed to convey the 25-year design flow based on urbanized flow and zoning requirements.

The minimum size of a pipe culvert shall be an 18-inch diameter round concrete pipe or equivalent size and material. Multiple barrel culverts shall be acceptable, so long as each barrel meets minimum spacing, grade, and capacity criteria as required by the pipe product manufacturer's recommended individual design standard.

The minimum size of Reinforced Concrete Box culvert shall be a 4-foot span x 3-foot rise.

Analysis of bridges or culverts shall be prepared by using FHWA HY-8 Culvert Analysis, U.S. Army Corps HEC-RAS River Analysis System, or HEC-2 Water Surface Profiles Program (other acceptable programs may be used with the approval of the City Engineer).

4.3 Design Standards

Reinforced Concrete Pipe (RCP) or Reinforced Concrete Box (RCB) shall be required for all culverts crossing publicly funded streets or other improvements to be dedicated to the city. Corrugated Metal Pipe (CMP) shall not be used in publicly funded improvements or for any improvements to be dedicated to the City. CMP and High-Density Polyethylene Pipe (HDPE) may be used only in rural private improvements or developments. All joints on RCP, RCB, and CMP shall be wrapped with a continuous filter fabric strip overlapping 2 feet on each side of the pipe joint to ensure proper protection. Facilities shall be constructed with a minimum cover of 2 feet from the top of the finished grade to the top of the pipe. If the minimum cover cannot be achieved a Class IV pipe shall be used.

Bridges and culverts shall follow the alignment and grade of the natural channel whenever possible. Minimum slope of culverts shall equal 0.5% unless the site condition or slope of natural channel requires use of a flatter slope, with the approval of City Engineer. In cases where the barrel cannot be aligned with the channel flow line, additional alignment

Commented [A25]: Reinforced Concrete Pipe (RCP), Reinforced Concrete Box (RCB) or High-Performance Polypropylene (HP) pipe shall be required for all culverts crossing publicly funded streets or other improvements to be dedicated to the city.

Commented [A26]: Request HDPE to be considered.

Commented [A27]: Min design slope should not be set at 0.5%. Should be based on velocity min. of 2 ft/sec. A lot of storm sewer is designed at less than 0.5% because unable to achieve 0.5% in a lot of instances.

The other design requirements are (correctly) based on velocity. Why even look at slopes? This should be a velocity based analysis every time.

or transition protection against erosion shall be provided as approved by the City Engineer.

4.4 Erosion Control and Scour

4.4.1 Maximum Shear Stress

Storm water conveyance systems require a variety of structures and appurtenances to control, divert, redirect flows, and control velocities to minimize erosion and scour. Erosion and local scour can result in channel degradation, undermining and structural failures. Excessive suspended sediments result in undesirable environmental impacts, aesthetic problems, and burdensome maintenance.

Most unlined natural or man-made channels are affected by either tractive forces, shear forces or drag forces. These forces are applied on the submerged portions of the channel bed and side slopes acting in the direction of flow. The maximum unit tractive force or shear stress shall be calculated with 100-year urbanized flow depth as:

$$\tau_0 = \omega\, y\, s$$

Where,

τ_0 = maximum shear stress (lb/ft^2)

ω = unit weight of water (62.4 lb/ft^3)

y = 100-year flood depth in feet

S = average bottom slope (ft/ft)

The maximum shear stress shall not exceed the values and velocities show in Tables 4-1 and 4-2. The maximum shear stress and maximum velocities are related to soil types. A more detailed design of channel protection based on "Design of Roadside Channels with Flexible Linings" (FHWA) or "Hydraulic Design of Energy Dissipators for Culverts and Channels" (USDOT) shall be used in accordance with the City Engineer's approval.

Table 4-1: Typical Permissible Shear Stresses for Bare Soil and Stone Linings

Lining Category	Lining Type	Permissible Shear Stress (lb/ft^2)
Base Soil Cohesive (PI=10)	Clayey Sands	0.037 -0.095
	Inorganic Silts	0.027-0.11
	Silty Sands	0.024-0.072
Bare Soil Cohesive (PI≥ 20)	Clayey Sands	0.094
	Inorganic Silts	0.083
	Silty Sands	0.072
	Inorganic Clays	0.14
Base Soil Non-cohesive (PI<10)	Finer than coarse sand D_{75} < 0.05-inch	0.02
	Fine gravel D_{75} = 0.3-inch	0.12
	Gravel D_{75} = 0.6-inch	0.24
Gravel Mulch	Coarse gravel D_{50} = 1-inch	0.4
	Very coarse gravel D_{50} = 2-inch	0.8
Rock Riprap	D_{50} = 6-inch	2.4
	D_{50} = 12-inch	4.8

Table 4-2: Maximum Permissible Velocities for Open Channels

Type of Grass or Cover	Slope Range (%)	Maximum Permissible Velocity – Feet Per Second
Bermuda Grass	0-5	5
	5-10	4
	>10 Not Permitted use drop structures	
Buffalo Grass, Kentucky Grass, Smooth Brome, Blue Grama	0-5	5
	5-10	4
	>10 Not Permitted use drop structures	
Grass Mixture	0-5	4
	5-10	3
	>10 Not Permitted use drop structures	
Lespedeza sericea, weeping love grass, ischaemum (yellow bluestem), alfalfa, crabgrass	0-5	3.5
	>5 Not Permitted use drop structures	

4.4.2 Protected Outlets and Outfall

If exit shear stresses exceed the bare soils permissible maximum stress or maximum velocity permitted, the outlet area downstream of the location shall be protected.

4.4.2.1 Riprap

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{gD^{25}}}\right)^{\frac{4}{3}}\left(\frac{D}{TW}\right)$$

Where:

D_{50} = riprap size in feet

Q = design discharge in ft^3/s

D = culvert diameter (circular) in feet

TW = tailwater depth in feet

g = acceleration due to gravity (32.2 ft/s^2)

NOTE: Tailwater depth should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D.

5. Open Channels

5.1 Introduction

The Drainage Ordinance requires conveyance of the stream flow by natural channel or through the utilization of engineered open channels. Open channel design flow calculations are very similar to the calculation of flows for other storm sewer structures. Hydraulic design calculations and construction standards are described in the following sections.

5.2 Design Flows

Fully urbanized conditions shall be used for calculation of flows. However, the minimum composite runoff coefficient shall meet the requirements of Table 2-3. The appropriate method as discussed in prior chapters of this document shall be used for calculation of design flows.

The City allows the use of the SCS method for calculation of flows or runoff with HEC-HMS and HEC-1. Calculation of time of concentration may be done using the TR-55 method.

5.3 Hydraulics of Open Channels

Presented in this section are the basic equations and computational procedures for uniform, gradually varied and rapidly varied flow. These flow conditions may be encountered in any open channel hydraulic analysis. HEC-RAS or HEC-2 computer programs shall be used to perform hydraulic analysis on open channels with drainage areas greater than 10 acres. Other methods of channel calculations may be used. However, any calculation method must account for the effects of any downstream culverts, permanent obstructions, or backwater effects. HEC-RAS is a hydraulic simulation model developed by the US Army Corps of Engineers and is the successor to HEC-2. Hydraulic behavior of open channels is dependent on the type of flow in the channel. Four different types of flow or flow regimes affect design, construction, and open channel performance. The flow types or regimes are described in the following sections.

Commented [A28]: Contradicts 2.4.2 of DCM. Request that this requirement be set at 40 acres. Request all DA below 40 Ac. be permitted to be calculated by a normal depth open channel flow calculation.

5.4 Natural Channels

Natural channels are channels closely following historic alignments and without changes to the historic condition. A natural channel definition is voided if any realignment of this channel is proposed. Construction of a new earthen channel does not comply with the definition of a natural nhannel.

Commented [A29]: channel

A natural channel shall be included in the platted "Common Area" and the maintenance of the common area shall be the responsibility of the Homeowner Association as per the requirements of the current drainage ordinance. The 100-year floodplain based on fully urbanized conditions shall be included in the private drainage easement or platted "Common Area".

5.5 Design and Construction Standards

For all design and construction details for channel designs shall include 1 foot of free board from 100-year water surface elevations as calculated.

5.5.1 Grass Channel

All improved grass channels shall be privately maintained regardless of size or contributing drainage basin. The side slopes of improved grass channels shall not exceed 3:1 (H:V). The analyses of all open channels shall use approved methods of flow calculations such as HEC-RAS or HEC-2. Additional erosion protection measures may be required as described in previous sections.

5.5.2 Concrete Channels

Concrete channels may be used to provide conveyance for publicly maintained secondary channels with over 40 acres of drainage area. The analyses of all open channels shall use approved methods of flow calculations such as HEC-RAS or HEC-2. The maximum velocities shall be limited to 15 fps. If the maximum limits are exceeded, drop structures or energy dissipators shall be considered to reduce the impacts of the excessive velocities. Concrete channels must be designed in accordance with the approved Oklahoma City Construction Standards.

5.5.3 Rip-Rap Channels

Rip-rap channels may be used to alleviate the possibility of erosion for channels not required to be concrete lined. All open channels shall use approved methods of flow calculations capacity analysis shall be performed using HEC-RAS or HEC-2. The side slope of the rip-rap channel shall not exceed a slope of 2:1 (H:V).

The Manning "n" value shall be computed by the following equation:

$$n = 0.0395(d_{50})^{1/6}$$

Where:

d_{50} = nominal rip-rap stone diameter in feet
Example: n = 0.042 for 18-inch rip-rap.

The minimum stone diameter shall be 12 inch.

Commented [A30]: 100-year + 1' within the channel? I was under the impression 50 year fits and 100 year within easement?

1' of freeboard on channel should not be required. Barry Lodge said this was not the intent. Request to be removed.

Commented [A31]: Contradicts 2.4.2 and 5.3 of DCM. Request that this requirement be set at 40 acres. Request all DA below 40 Ac. be permitted to be calculated by a normal depth open channel flow calculation.

Commented [A32]: The argument is being made (again) that the acreage thresholds should be the same across the DCM/DO:
2.4.2 HEC should be used for analysis on open channels with DA larger than 20 acres.
5.3 HEC should be used for analysis on open channels with DA larger than 10 acres.
5.5.2 HEC should be used for the analysis of open concrete channels with DA larger than 40 acres.

We need to define a standard threshold where above that HEC is required and below that a depth analysis can be performed.

Commented [A33]: Contradicts 2.4.2 and 5.3 of DCM. Request that this requirement be set at 40 acres. Request all DA below 40 Ac. be permitted to be calculated by a normal depth open channel flow calculation.

Commented [A34]: Minimum size?

Commented [A35]: Contradicts 2.4.2 and 5.3 of DCM. Request that this requirement be set at 40 acres. Request all DA below 40 Ac. be permitted to be calculated by a normal depth open channel flow calculation.

5.6 Wire-Wrapped Rip-Rap or Gabions

Gabion channels may be used in lieu of loose rip-rap if approved by the City Engineer. The minimum design criteria shall be the same as Rip-Rap Channels. Engineer shall provide design calculations supporting all use of wire-wrapped rip-rap or gabions.

6. Design and Construction of Detention Ponds

Development typically includes the addition of impervious surfaces resulting in increased runoff flow rates and increases in runoff volume of storm water that the basin released before the development. These increases are caused by the reduction of a catchments ability to infiltrate rainfall due to the construction of buildings, parking areas, and other developments. The Drainage Ordinance requires detention in order to reduce the detrimental impacts of additional impervious surfaces. Storm water detention is defined as the temporary storage of storm water runoff in a basin in which the outflow is controlled in order to reduce or eliminate flooding or other adverse effects downstream.

Stormwater detention is required for all development, unless the development meets one of the exemptions identified in the Drainage Ordinance. All designs must meet Drainage Ordinance requirements. The proposed site development will not cause any negative impact on the downstream flow rate or flood elevation.

On-site stormwater detention will not be required for individual residential lots, regardless of whether such lots are part of a platted subdivision or are an unplatted tract.

6.1 Site Assessment for Detention Requirement

On-site stormwater detention, in the form of a detention pond, is required for all development in Oklahoma City, unless the development meets one of the exemptions identified in the Drainage Ordinance. Any exemptions or waivers of the detention requirement that have been approved will be applicable only to the specific final plat for which the exemption was granted. Engineering plans for every development within the City will be reviewed to determine if the detention meets requirements established within the Drainage Ordinance. ~~Detention requirements may be expanded to include areas with reported or projected flooding of downstream properties. Therefore, preliminary determinations can change prior to the approval of plans. If at any time during the review process, and before approval, it is determined that the subject development will cause or increase flooding downstream, improvement and enhancement to planned detention ponds will be required.~~ The consulting engineer will be solely responsible for ensuring that all submitted design documentation meets specifications outlined in the DCM.

Commented [A36]: This is unfair to the Engineer and developer and should not be the case. Detention will now be required in all situations unless a waiver is approved. If waiver approved then the decision should not change at any time during the review and approval process.

6.2 Design Flow or Runoff Calculations

6.2.1 Historic Condition

The determination of the historic (i.e. pre-developed) runoff rate determines the maximum rate of all combined developed pond outflow and un-detained site release. Unless granted a waiver by the City Engineer, the developer shall install detention facilities maintaining a discharge rate not to exceed the historical runoff rate prior to development. The historic runoff rate is determined by evaluating the contributing drainage area(s) as undeveloped in accordance with current City standards. Listed below are a few notable exceptions that will be considered:

- If an offsite upstream drainage area discharges onto the property considered for development, then the entire offsite area shall be evaluated in the current existing conditions at the time of the proposed development.

- If a previous developed hard surface exists on the development site, and was properly permitted, then the existing hard surface area shall be evaluated as fully developed.

- If a developed site with a permitted detention pond discharges onto a property being considered for development, the off-site conditions existing prior to that development will be used for the existing and proposed detention models.

Commented [A37]: This should be modified to state that any upstream DA may be considered as historic if such property has provided detention.

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6.2.2 "To Pond" Drainage Areas

The drainage areas draining into the storage facility are considered "to pond" areas. The "proposed conditions" will be the condition of a subject development after construction is completed based on the approved site plan. The hydrologic calculations must consider all the proposed buildings, parking areas, roads, and other hard surfaces.

6.2.3 "Bypass" Drainage Areas

Catchment areas that discharge from the property without flowing through the proposed detention pond outlet are considered bypass areas. The hydrologic calculations from bypass areas must consider and model all additional hard surfaces like the proposed conditions stated in the previous section. The total discharge from the proposed development must consider the combined effect of the pond discharge together with the un-detained "bypass" flow.

6.3 Design Details or Pond Configuration

6.3.1 General Details

Storm water detention is defined as the temporary storage of storm water runoff in a basin in which the outflow is controlled in order to reduce or eliminate flooding or other adverse effects downstream. The detention pond is analyzed as the area and volume of the development set apart for the temporary storage of storm water. All proposed detention ponds shall be located outside of existing public easements, rights-of-way, and neighboring properties. When a detention pond is designed for a platted area or multi-owner property, the limits of the entire detention pond facility will be contained in a private drainage easement. The detention pond will include all outlet structures, emergency spillways, and riprap (or other erosion protection). Proposed detention pond areas shall not be used to store, hold, or contain building structures or materials either permanently or temporarily. An exception to this would be recreational amenities such as playground equipment or benches that can be demonstrated not to interfere with the functionality of the pond. Parking areas may be used as detention storage if the water surface elevation generated from a 100-year event is less than or equal to 1 foot at the outlet. Calculations shall be provided for the storm durations that produce the highest water surface elevation in the pond and the maximum site/pond discharge for the designed pond and outlet configuration.

All pond areas shall have maximum side slopes of 3 vertical to 1 horizontal (3:1) unless paved with concrete. If unpaved embankments or cuts exceed the maximum slope, then a retaining structure shall be provided. A paved trickle channel shall be provided for unpaved ponding areas. The trickle channel must be designed to extend along the longest portion of the pond area. A concrete trickle channel is required for all dry ponds. The trickle channel shall be constructed of concrete~~, a minimum of 2 feet wide and 6 inches deep,~~ 6 inches thick, a minimum of 4 feet wide, 2 inches deep at the center, with a minimum slope of 0.4%. On each side of the trickle channel shall be a minimum of 1-inch height of established grass in accordance with City details.

All detention pond facilities, except parking lot storage ponds, must be designed to allow for 1 foot of freeboard. Freeboard is described as the vertical distance between the top of the pond enclosure and the maximum water surface.

Commented [A38]: Was 10% additional storage considered in lieu of 1' freeboard. 1' freeboard is excessive in small ponds. Maybe the lesser of 10% additional storage and 1' of freeboard? Is top of pond enclosure at the overflow weir elevation or top of berm? Big difference here.

All pond surface cover must be composed of one or all of the following:

1. Solid slab grass sod
2. Concrete
3. Asphalt

Any other materials will require approval from the City Engineer prior to application.

The designed detention pond size will be demonstrated by stage versus storage data. This data shall be graphical or tabulated data showing the storage area at a given stage elevation in the pond.

6.4 Outlet Configuration

The outlet control structure allows detained storm water to discharge from a detention pond at a controlled rate. Outlet control structures shall be designed as simply as possible as to require little or no attention and/or maintenance for proper operation. No mechanical means such as pumping will be allowed as an outlet control structure.

All outlet control structures shall be configured and designed to maintain a discharge rate not to exceed the maximum allowable outflow, Q_o, described in the previous sections for all the following storm events:

- 50% event (2-year storm, Q_2)
- 20% event (5-year storm, Q_5)
- 10% event (10-year storm, Q_{10})
- 4% event (25-year storm, Q_{25})
- 2% event (50-year storm, Q_{50})
- 1% event (100-year storm, Q_{100})

Outlet control structures shall consist of hydraulic components such as weirs, culverts, standpipes, or any combination thereof, used in either a series or parallel configuration.

An overflow spillway will be included and provided as part of any proposed detention facility. ~~This overflow spillway shall be constructed of concrete.~~ The ~~concrete~~ overflow spillway may be an extension of the outlet control structure or a separate structure altogether. The ~~concrete~~ overflow structure shall be designed to pass the fully-developed 100-year runoff into the pond ~~function~~ with all other discharge elements fully blocked without ~~exceeding the allowable historic discharge rate from the pond/site~~overtopping the pond dam. The minimum finished floor elevations for structures adjacent to the pond shall be set a minimum of 1.0 foot above the calculated 100-year water surface elevation in the pond with all primary outlet elements blocked. The overflow spillway shall be constructed of concrete unless an alternate material is approved by the City Engineer. If a material other than concrete is used for the overflow spillway, a detailed as-built drawing of the spillway, signed and sealed by the design engineer, demonstrating that the spillway was constructed in accordance with the approved plans shall be submitted.

Commented [A39]: My comment is 2-fold here. Why a concrete overflow weir mandatory? This is overkill for some of these smaller detention ponds. Why not require it when design velocities over a certain threshold. Why not allow for flexamat? Concrete overflow weir can be an eyesore. Secondly you are requiring detention on top of detention if you require the overflow weir to regulate the 100-year historic as well! Then you are requiring 1' of freeboard above that (when the primary outlet is blocked). This is extremely excessive. Overflow weir should be required to handle developed flow in an overflow situation. It should not be required to regulate the 100-year historic flow. Furthermore min FF should be set 1' above the 100-yr utilizing primary outlet.

FFE should be set 1' above 100-year WSEL of functioning pond. Emergency weir will handle Q100 without overtopping pond. Unnecessary to set FFE above Emergency scenario.

Rating curve data for the designed outlet control structure will be provided. This shall be graphical or tabulated data showing the outflow discharge at a given stage elevation in the pond. This data will be used and compared to the hydraulics of the outlet control structure shown in the plan sheets to verify the accuracy.

6.5 Underground Detention

~~Unless written permission is granted from the City Engineer, all detention facilities shall be surface ponds. Underground detention will only be considered if the designer can adequately demonstrate that the proposed development introduces site restraints such that a surface pond is impractical. If approved,~~Underground detention systems may be used at the discretion of the engineer. For all underground detention systems, the ~~designer~~ design engineer must show construction details for underground storage facilities that meet the following criteria:

Commented [A40]: Why is written permission being required? We are utilizing these more and more due to rising land prices. Should be at the discretion of the engineer/developer.

1. Composed of reinforced concrete pipe (RCP), polyvinyl chloride pipe (PVC), or high-performance polypropylene pipe (HP), or injection-molded thermoplastic chambers.
~~1.~~2. If injection-molded thermoplastic chambers are used, the aggregate void volume of the rock backfill is not allowed to be included as part of the storage volume of the detention system.

~~2.~~3. All connection from underground detention facilities to public storm sewer system must be RCP or HP,

~~3.~~4. Outflow must be able to drain directly into an existing storm facility without mechanical assistance,

~~4.~~5. Storage area must have an access point for maintenance,

~~5.~~6. Must show no permanent habitable areas to be proposed on the overhead surface.

Commented [A41]: Pre-fab underground detention systems such as Stormtech, Contech, Stormtrap, etc. should be permitted. Also why limiting the connection to the public storm to two materials?

Chapter 16 – Drainage Ordinance Revision & Drainage Criteria Manual
Summary of Revisions

- Chapter 16 – Drainage & Flood Control has not had a major revision since the early 1980s
- Two Local Consulting Engineers retained for collaboration with City staff on revisions to Chapter 16 and the Drainage Criteria Manual (SRB and J&A)
- Minor revisions include updating definitions and cleaning up general inconsistencies identified in the current ordinance
- Major revisions from the current ordinance to the revised ordinance include:

DETENTION

- Current Ordinance only requires on-site detention for new development if there have been reports of downstream flooding.
- Revised Ordinance would require on-site stormwater detention for all new developments. A waiver of this requirement may be considered if one of the following are met:
    - If the site drains directly to a public street or public storm sewer system. Developer/engineer must demonstrate with calculations that the public street or storm sewer system has adequate capacity to convey the additional storm runoff in accordance with the Drainage Ordinance and the Drainage Criteria Manual. If the site runoff flows onto adjacent property, the waiver will not be approved.
    - If the site drainage discharges directly to a creek or river channel, and the developer/engineer provides calculations showing that the downstream discharge in the creek or river will increase as a result of the on-site detention
- Removed requirement for Fee-in-Lieu of Detention (FILO)
- Current ordinance requires detention for 100-year event only.
- Revised Ordinance will require multi-frequency outlet structure design for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events. Research of other cities shows that the multi-frequency outlet design is standard practice.
- Individual lots such as residential houses will not be required to provide detention.

DRAINAGE CHANNELS

- Current ordinance requires a channel to convey the runoff from a 50-year storm event.
- Revised ordinance will require all open drainage channels in a development to be designed to convey the runoff from the 100-year storm event, or have the land that would be inundated by such an event be contained within an easement or common area.

DRAINAGE CRITERIA MANUAL (DCM)

- All storm sewer design criteria has been removed from the Drainage Ordinance and will be published in the City of Oklahoma City Drainage Criteria Manual (DCM).
- The DCM will be presented as a reference document to the Drainage Ordinance.
- Subsequent revisions to the DCM may be approved administratively by the Public Works Director/City Engineer without additional approval by the City Council. Revisions will be posted on the City website for a minimum of 60 days before becoming effective.

Commented [A1]: This summary does not tell the whole story. DCM as written is requiring detention on top of detention and 1' of freeboard above the 100-year with primary outflow blocked. This is a substantial requirement that should have been mentioned. Please see comments in DCM.

Commented [A2]: I don't disagree with this statement but the other requirements for the overflow design and 1' freeboard with primary outlet blocked are substantial and not standard practice. See comments in DCM.

Commented [A3]: This is not how it is currently written. It does not exclude individual lots such as residential houses. See comments in DCM.

Commented [A4]: This does not mention the 1' of freeboard requirement. See comments in DCM.

Commented [A5]: There are still design requirements written into the DO. See comments in DO.

STORM SEWER SYSTEMS

- Current ordinance requires a 10-year storm event design for on-grade storm sewer systems.
- Revised ordinance requires on-Grade Storm Sewer Systems to be designed for the 25-year storm event.

PUBLIC STORM SEWER SYSTEMS vs PRIVATE STORM SEWER SYSTEMS

- If all the drainage or storm water runoff to be intercepted and carried by the storm sewer system is generated on the development site, that storm sewer system shall be a PRIVATE storm sewer maintained by the property owner.
- Private storm sewer systems will not be submitted to Public Works Engineering for review and approval. Private Storm Sewer Systems will not be inspected by Public Works Engineering inspections personnel. All plan reviews and inspections of the Private Storm Sewer Systems will be provided the Development Services plumbing inspectors in accordance with the applicable Plumbing Code.
- Public Storm Sewer Systems shall be provided when an off-site drainage area of greater than 6 acres enters the development site
- Public Storm Sewer Systems shall be provided when an existing storm sewer system, either public or private discharges onto a new development site.
- Plans for public storm sewer systems will be reviewed by Public Works Engineering for approval. Following construction of public storm sewer systems, the new infrastructure must be dedicated to the City, and the City will assume future maintenance of the system.

FLOODPLAIN ACTIVITY PERMIT

- FEMA Elevation Certificates will no longer be required for buildings/structures that lie within 200 feet of a FEMA mapped floodplain.
- Revised ordinance will clarify that FEMA Elevation Certificates are required when a building or structure is within the limits of the FEMA mapped floodplain.

Commented [A6]: This is not how the DO is currently written. It states it may be permitted if approved by City Engineer. Does not state that it is required unless I am missing it somewhere. See comments in DO.

Commented [A7]: I don't see where this is stated? I see where it only requires Surveyor Cert when within 200' but must have missed this requirement?

Chapter 16 - DRAINAGE AND FLOOD CONTROL[1]

§ 16-1. - Purpose and scope.

It is the intent of this chapter to establish community floodplain management ordinances to protect the general health, safety and welfare of the public from the hazards and damages of flooding; to provide clean and sanitary channels for stormwater runoff; to prevent pollution of watersheds, streams and channels; to prevent the encroachment of structures and improvements on channels to protect natural scenic areas; and to provide for the conservation of the natural resources of the area. All subdivisions of land and all developments or improvements of any character which affect runoff, stormwater flow or drainage in any portion of the City of Oklahoma City (City) shall be subject to the provisions of this chapter and the technical details within the Oklahoma City Drainage Criteria Manual (DCM). This chapter is not intended to repeal, abrogate, or impair any existing requirements, obligations, easements, covenants, or deed restrictions. However, where another ordinance conflicts or overlaps this chapter or the DCM, whichever imposes the more stringent restrictions shall prevail.

§ 16-2. – Administration

1. Local Floodplain Administrator

   The City Engineer is designated as the Local Floodplain Administrator (Administrator) to administer and implement the provisions of this chapter, the DCM, and appropriate sections of 44 CFR, National Flood Insurance Program (NFIP) pertaining to floodplain management. Prior to authorization of any building permit by the City, the City Engineer shall review all such stream flow and runoff calculations as required under the terms of this chapter and the DCM. The City Engineer has final authority over engineering interpretations.

2. Applicability of provisions.

   a. The Consultant Engineer (Engineer) registered in the State of Oklahoma must sign and seal all final plans submitted to the City for review and approval. Review and approval of the plans by the City shall not relieve the Engineer of responsibility for all aspects of the design included as part of the plans.

   b. The flood prone area provisions of this chapter shall apply to all lands, tracts, parcels or lots which are in part or in whole traversed by, or encompassed by or lying within 200 feet of the external boundaries of the delineated Federal Emergency Management Agency (FEMA) floodplain for that watercourse as shown on the effective floodplain maps, or an area deemed flood prone by the City Engineer.

   c. The location and boundaries of the floodplain are shown on the FEMA Flood Insurance Rate Maps (FIRM) Flood Hazard Boundary Map of the City, which are hereby incorporated into this chapter and placed on file in the office of the City Clerk. The maps, together with everything shown thereon and all amendments thereto, shall be as much a part of this chapter as if fully set forth and described herein. Application of this chapter to floodplain boundaries may be modified on portions of major river channels, primary channels, and secondary channels only by specific application of Flood Insurance Studies and Flood Insurance Rate Maps as completed and received from the Administrator.

d. The boundaries of the floodplain are as they appear on the effective Flood Hazard Boundary Maps. The boundary lines on the map shall be determined using the scale appearing on the map. Where there is conflict between the boundary lines on the map and actual field conditions, the dispute shall be settled by the City Engineer. In all cases the person contesting the location of the boundary shall be given a reasonable opportunity to present a case to the City Engineer and to submit technical evidence if so desired. The City Engineer shall not allow deviations from the boundary line as mapped unless the evidence clearly and conclusively establishes that the mapped location of the line is incorrect.

e. The areas of special flood hazard are identified by the FEMA in a scientific and engineering report entitled, "The Flood Insurance Study for Canadian County, Oklahoma and Incorporated Areas" dated June 7, 2019, with accompanying Flood Insurance Rate Map, are hereby adopted by reference and declared to be a part of this chapter.

f. The areas of special flood hazard identified by the FEMA in a scientific and engineering report entitled, "The Flood Insurance Study for Cleveland County, Oklahoma and Incorporated Areas" dated January 15, 2021, with accompanying Flood Insurance Rate Map, are hereby adopted by reference and declared to be a part of this chapter.

g. The areas of special flood hazard identified by the FEMA in a scientific and engineering report entitled, "The Flood Insurance Study for Oklahoma County, Oklahoma and Incorporated Areas" dated December 18, 2018, with accompanying Flood Insurance Rate Map, are hereby adopted by reference and declared to be a part of this chapter.

h. The areas of special flood hazard identified by the FEMA in a scientific and engineering report entitled, "The Flood Insurance Study for Pottawatomie County, Oklahoma and Incorporated Areas" dated May 16, 2019, with accompanying Flood Insurance Rate Map, are hereby adopted by reference and declared to be a part of this chapter.

3. Disclaimer of liability.

The degree of flood protection required by this chapter is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. On occasion, greater floods can and will occur, and flood heights may be increased by manmade or natural causes. This chapter does not imply that land outside the floodplain areas or uses permitted within floodplain areas will be free from flooding or flood damages. This chapter shall not create liability on the part of the City or any officer or employee thereof for any flood damages that result from reliance on this chapter or any decision made hereunder.

Plans prepared by Engineers are the representations and responsibilities of those professionals. Approval of plans and other documents by the City, the City Engineer, or the Administrator are for administrative purposes only and are not and shall not be deemed a representation, guaranty, or warranty. Neither the City nor City Engineer nor the Administrator has the responsibility to verify or validate the information, assumptions, conclusions, or recommendations provided in a plan, document, and any approval thereof shall relieve not any landowner, developer, professional engineer or architect or other person or entity so providing.

4. Penalty.

Any person who shall violate any of the provisions of this chapter shall be deemed guilty of a Class "A" offense. For any second or subsequent offense and upon proof of prior conviction, said person shall be guilty of a Class "B" offense.

5. Enforcement.

The City Engineer, or their designated representatives, has full authority to enforce the provisions of this chapter and the DCM and permits issued under Federal and State authorities.

§ 16-3. - Inclusion by reference the Oklahoma City Drainage Criteria Manual

The means and methods of calculations, design parameters, requirements and limitations referenced within and supporting the intent and purpose of this chapter shall be outlined and defined by the most recent version of the Oklahoma City Drainage Criteria Manual (DCM). The DCM provides the means and methods of calculations necessary for the application of and compliance with the minimum standards of this chapter and other governing ordinances, rules, and regulations. Calculations made utilizing DCM, as a technical standards and requirements, must be confirmed by the signature and seal of an Engineer registered and licensed in the State of Oklahoma.

§ 16-4. - Definitions.

The following words, terms, and phrases, when used in this chapter, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

44 CFR means applicable subsections of Chapter 44 of the Code of Federal Regulations also referred as the national Flood Insurance Program (NFIP).

Administrator/Floodplain Administrator means the person responsible for implementing the community's local floodplain ordinance and ensuring that the community is complying with minimum NFIP standards and enforcing any locally imposed higher standards. The Administrator shall review, and evaluate floodplain development permit applications, review elevation certificates for completeness and accuracy, review development plans and specifications for compliance with this chapter, inspect floodplain construction to verify location relative to the floodplain/floodway and ensure compliance with this chapter, educate community members and local officials about floodplain management, maintain documentation and records of floodplain activities, and investigate violations of this chapter and initiate corrective action.

Base Flood means the flood having a one percent chance of being equaled or exceeded in any given year commonly referred to as the 100-year frequency flood.

Base Flood Elevation (BFE) means the computed elevation to which the flood is anticipated to rise during the base flood.

Board means the Oklahoma Water Resources Board.

Bridge means a hydraulic structure that is constructed with abutments and a superstructure which are typically made of concrete, steel, or other materials. Since superstructures are not an integral part of the abutments and could therefore potentially move, the hydraulic criteria for bridges are different than for culverts.

Building (see Structure).

Channel means defined landforms, either natural or manmade or man improved, whereby stormwater is carried between points of origin and destination.

City means the City of Oklahoma City.

City Engineer means the professional engineer designated in Section 2-111 of this Code.

Clearing means the process of manually or mechanically removing the vegetative and/or nonvegetative cover of any land.

Corps of Engineers (COE) 404 Permit means a permit issued by the United States Army Corps of Engineers pursuant to Section 404 of the Clean Water Act.

Construction includes, but is not limited to, land preparation such as clearing, grading, and filling; the installation of streets and/or walkways; excavation for a basement, footings, piers, or foundations or for the erection of temporary forms; and the installation on the property of building, accessory buildings, structures or improvements, such as garages or sheds not occupied as dwelling units or not part of the main structure.

Culvert means a closed conduit for the passage of stormwater under an embankment, such as a road, railroad, or trail. Flow generally enters a closed conduit (culvert) by an open channel, generally at a similar elevation. The geometry of the culvert inlet is utilized in the determination of the required size and capacity of the culvert. (See DCM for calculating culvert capacity)

Detention means storage that reduces the rate of stormwater runoff, for a short period of time, to lower peak flows whereby controlling the discharge rate of release to the receiving stream, river, pipe, channel, or culvert.

Detention facility or *detention pond* means a constructed facility, improvement, or pond functioning to retain or attenuate stormwater flow or runoff.

Developer means a person or entity that owns the land upon which a development is made or is to be made, occupies or uses has the right to occupy or use the land where a development is made or is to be made or contracts for a development to be made.

Development or *development in floodprone areas* means any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavations, or drilling operations, and/or storage of equipment or materials.

Drainage Criteria Manual (DCM) means the manual providing design guidance for use by landowners, developers, architects and/or engineers, and/or their agents, in preparation of drainage plans for development within the City. It establishes rules and design standards and requirements and methods that must be consistently followed and will be enforced throughout the City's jurisdiction. The design methods presented in this manual are intended to provide minimum standards for determination of runoff rates, methods of storm water collection, conveyance, and detention. The DCM sets forth the technical details, provisions, standards, and requirements established by the City Engineer, as may be amended from time to time.

Driveway pipe means a culvert located under a driveway.

EPA means the United States Environmental Protection Agency.

Elevated building means, for insurance purposes, a non-basement building which has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns:

1. built, in the case of a building in zones A1—30, AE, A, A99, AO, AH, B, C, X, and D, to have the top of the elevated floor, or in the case of a building in zones V1—30, VE, or V, to have the bottom of the lowest horizontal structure member of the elevated floor elevated above the ground level by means of pilings, columns (posts and piers), or shear walls parallel to the floor of the water; and

2. adequately anchored so as not to impair the structural integrity of the building during a flood of up to the magnitude of the base flood.

In the case of zones A1—30, AE, A, A99, AO, AH, B, C, X, and D, "elevated building" also includes a building elevated by means of fill or solid foundation perimeter walls with openings sufficient to facilitate the unimpeded movement of floodwaters.

In the case of zones VI—30, VE, or V, "elevated building" also includes a building otherwise meeting the definition of "elevated building" even though the lower area is enclosed by means of breakaway walls if the breakaway walls meet the standards of Section 60.3(e)(5) of the National Flood Insurance Program regulations.

*Engineer means a r*egistered professional engineer licensed in the State of Oklahoma. The City Engineer and other City employees who are *r*egistered professional engineers licensed in the State of Oklahoma are not included in this definition.

Erosion means the process of gradual wearing away of land areas or masses or portions thereof.

Erosion and sediment control measures are methods used to reduce the amount of soil particles that are carried by stormwater, from a land area or mass and deposited in a receiving water, or stormwater conveyance facility or improvement.

Excavation means the process of removing earth, stone, land, soil, topsoil, or other materials.

FEMA Elevation Certificate (EC) means a document for the purpose of estimating the risk premium rates necessary to provide flood insurance for new or substantially improved structures in designated Special Flood Hazard Areas. It is to be used to provide elevation information necessary to ensure compliance with community floodplain management ordinances and this chapter, to determine the proper insurance premium rate and to support a request for a Letter of Map Amendment (LOMA) or Letter of Map Revision based on fill (LOMR-F). It is a technical document which must be prepared by a registered Land Surveyor, or Engineer, licensed in the State of Oklahoma.

Flood or *flooding* means a general and temporary condition of partial or complete inundation of normally dry land areas from:

1. the overflow of inland waters; or

2. the unusual and rapid accumulation, flow, or runoff of surface waters from any source.

Flood Elevation Study means an examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations, or an examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards.

Flood Insurance Rate Map (FIRM) means an official map of a community, on which the Administrator has delineated both the special hazard areas and the risk premium zones applicable to the community.

Flood insurance study (FIS) Flood Elevation Study

Floodplain or *Floodprone Area* means any land area susceptible to being inundated by water from any source (see definition of flood or flooding).

Floodplain activity permit means the permit required for development from which runoff or drainage flows through or into the boundaries of the delineated floodplain for a watercourse as shown on the official floodplain maps or an area deemed floodprone, through independent flood study, reviewed and approved by the City Engineer.

Floodplain management means the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, drainage improvements, stormwater detention, and land use and control measures.

Floodproofing means protective measures added to or incorporated in a building or structure that is not elevated above the base flood elevation to prevent or minimize flood damage. "Dry floodproofing" measures are designed to keep water from entering a building. "Wet floodproofing" measures minimize damage to a building or structure and its contents from water that is allowed into a building or structure.

Flood protection system means those physical structural works for which funds have been authorized, appropriated, and expended and which have been constructed specifically to modify flooding in order to reduce the extent of the areas within a community subject to a "special flood hazard" and the extent of the depths of associated flooding. Such a system typically includes hurricane tidal barriers, dams, reservoirs, detention ponds, levees, or dikes. These specialized flood modifying works are those constructed in conformance with sound engineering standards.

Floodway means the channel of a river or other watercourse and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without cumulatively increasing the water surface elevation more than one foot.

Flows or *discharges* means City calculated urbanized stormwater discharges or FEMA calculated stormwater discharges, whichever is higher.

Freeboard means a factor of safety expressed in feet above a flood level for purposes of flood plain management. "Freeboard"' tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed.

Frequency flood means all frequency flood(s) mentioned in this chapter shall refer to either FEMA calculated stormwater discharges or City calculated urbanized discharges, whichever is higher.

Grading means the cutting and/or filling of the land surface to a desired slope or elevation.

Grubbing means the process of removing vegetation, roots, stumps, brush, or any excess deleterious materials that cannot be used for sub-grade or structural soil.

Highest adjacent grade means the highest natural elevation of the ground surface prior to grading or construction next to the proposed walls of a building or structure.

Commented [A1]: This should not be natural grade. It should be the highest adjacent grade after earthwork/construction has been completed.

Historical runoff means, when utilized in the calculations of detention requirements, the runoff conditions existing prior to any new development, construction, or grading.

Impervious surface means any hard-surfaced areas which prevent or retard the entry of water into the soil in the manner or to the extent that such water entered the soil under natural conditions, or where water is caused to run off the surface in greater quantities or at an increased rate of flow than was present under natural conditions. Impervious surfaces shall include, but are not limited to, rooftops; sidewalks; paving; driveways; parking lots; walkways; patio areas; storage areas; and asphalt, concrete, gravel, oiled macadam or other surfaces which similarly affect the natural infiltration or runoff patterns of real property in its natural state.

Levee means a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water to provide protection from temporary flooding.

Levee system means a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices.

Lowest floor means the lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor; provided, that such enclosure is not built so as to render the building or structure in violation of the applicable non-elevation design requirements.

Basements or underground storm shelters, shall be permitted to be constructed if an engineered plan illustrating that the lowest opening to any part of the basement or shelter is not less than 1 foot above the 100-year frequency, as determined by the FEMA maps or a flood study, which plan was prepared by an Engineer and submitted to and accepted approved by the City Engineer prior to construction.

Specifically, for all new construction and substantial improvements to buildings or structures, in fully enclosed areas below the lowest floor that are subject to flooding must be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters.

Major river channels mean the cross-sectional area of the North Canadian and Canadian Rivers at and below the elevation of the 100-year frequency flood limits as established by the City, the Federal Emergency Management Agency, and the U.S. Army Corps of Engineers.

Manufactured home means a building or structure, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home"' does not include a "recreational vehicle".

Manufactured home park or subdivision means a parcel (or continuous parcels) of land divided into two or more manufactured home, or lots for sale or rent.

Mean sea level means, for purposes of the National Flood Insurance Program, the North American Vertical Datum (NAVD 88) or, other City accepted datum, as the datum can be updated from time to time, to which base flood elevations shown on a community's flood insurance rate map are referenced.

Mechanical equipment or *utility equipment* means any electrical, heating, ventilation, plumbing, and air conditioning equipment or other service facilities associated with a building or structure.

New construction for floodplain management purposes means buildings or structure for which the "start of construction" commenced on or after the effective date of an initial Flood Insurance Rate Map (FIRM) or after December 31, 1974, whichever is later, including any subsequent improvements. For Floodplain Management Purposes: Building or structures for which the start of construction commenced on or after the effective date of a floodplain management regulation adopted by a community and includes any subsequent improvements to such buildings or structures.

NPDES means National Pollutant Discharge Elimination System, EPA's program to control the discharge of pollutants to waters of the United States.

NPDES permit means an authorization, license, or equivalent control document issued by the EPA.

100-year floodplain area means river or stream flood hazard areas, and areas with a 1% or greater chance of flooding each year.

Commented [A2]: This should be struck. Should just be 1% chance not or greater chance.

Primary drainage channels are all drainage channels, streams or creeks which drain an area of 500 acres or more, excluding those areas defined as major river channels.

Private stormwater facility means a stormwater facility other than a public stormwater facility.

Public stormwater facility means a stormwater facility in a drainage or utility easement, dedicated to and formally accepted by the City for public use and benefit if constructed as approved by the City Engineer and in accordance with this chapter and if accepted by specific formal action of the City by the City Council.

Public Works Director or *Director* means the person designated in Section 2-542 of this Code.

Receiving water means a runoff process connected to a network of waterways that increase in size as the watershed area increases.

Riverine means of or produced by a river.

Riverine floodplains are a floodplain of or produced by a river having readily identifiable channels.

Secondary drainage channels are all drainage channels, streams, and creeks which drain an area of less than 500 acres, excluding those areas defined as major river channels or Primary Drainage Channels.

Sediment means soil, sand, and minerals transported by wind offsite or washed from land into water, usually after rain.

Soil means the unconsolidated mineral and organic material on the surface of the earth that serves as a natural medium for growth of plants.

Soil disturbance/soil disturbing activities mean any moving or removing by manual or mechanical means of the vegetative and/or nonvegetative cover or soil mantle, including but not limited to grading, excavations, and mining.

Special flood hazard map means an official map provided through FEMA administration, having special flood, mudslide, or flood-related erosion hazards, and shown on an Flood Hazard Boundary Map (FHBM) or FIRM as Zone A, AO, A1-30, AE, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, A99, AH, VO, V1-30, VE, V, M, or E.

Stockpiling means storing of soil or other fill or excavated material.

Stormwater system means any improved open channel, closed conduit, natural stream, creek or swale, that acts to collect, deliver, discharge and release any stormwater, improved or unimproved, across a specific development site or tract of land.

Structure means a walled and roofed building, other than a gas or liquid storage tank, principally above ground and permanently affixed to a site as well as a manufactured home on a permanent foundation.

Substantial improvement means any repair, reconstruction, or improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the building or structure either (1) before the improvement or repair is started, or (2) if the building or structure has been damaged and is being restored, before the damage occurred. For the purpose of this definition "substantial improvement" is considered to commence when the first alteration of any wall, ceiling, floor, or other structural part of the structure commences, whether or not that alteration affects the external dimensions of the building or structure. The term does not, however, include either (1) any project for improvement of a building or structure to comply with such existing State or local health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions, or (2) any alteration of a building or structure listed on the National Register of Historic Places or an official State of Oklahoma inventory of historic places.

Sump areas means low elevations which collect water.

Surface means the upper most boundary of either standing or flowing water and that elevation of said surface boundary equals the Water Surface Elevation.

Surveyor's Certificate means a document prepared by a qualified engineer/surveyor, licensed in the State of Oklahoma, which provides information on: elevation of a building or structure relative to flood elevations, building or structure type, and as-built finished floor elevation established by independent flood study approved by the City.

Urbanized discharge means FEMA/USGS (USGS Open File Report 83-26) historical "urbanized" information for the City studies for streams and rivers, or new hydrology for unstudied FEMA drainage basins for portions of the City; prepared, signed, sealed, and submitted to the City Engineer by an Engineer.

Vegetative cover means vegetative growth shielding the soil surface from erosion.

Violation means act or omission in violation of this chapter, the DCM or any other referenced applicable requirement or the failure of a structure, building, improvement, or other development to be fully compliant with this chapter, the DCM or any other referenced applicable requirement. A structure, building, improvement or other development without the elevation certificate, other required certifications, or other evidence of compliance required in CFR 60.3(b)(5), (c)(4), (c)(10), (d)(3), (e)(2), (e)(4) or (e)(5) is presumed to be in violation until such time as that documentation is provided.

Water surface elevation means the heights in relation to mean sea level expected to be reached by floods of various magnitudes and frequencies at pertinent points in the floodplains or riverine areas.

§ 16-5. - Responsibility for improvements.

1. It is intended by this chapter that the improvements of primary drainage and major river channels shall be the responsibility of the developer, since the developer is directly and materially benefitted and for the long-term benefit of the community as a whole. The developer of land or improvements within an area containing a primary drainage channel must design, plan and carry out their developments in a manner that will not interfere with, increase, change or restrict the natural flow of water or materially change the condition of runoff or discharge within the calculated area below the 100-year maximum flood elevation. Increased runoff or discharge and changes in primary drainage channels which are created by such developments within primary drainage areas are the planning responsibility of the developer and will be constructed and maintained in accordance with the provisions of this chapter. The improvement of secondary drainage channels is the responsibility of the developer, since the primary benefit is to the area served by the secondary channel and not to the community. Community as used in this chapter shall not mean the City but rather members of the general public individually and collectively. Provided, this chapter does not create any responsibility or liability upon the City to make improvements or to prevent flooding.

2. Stormwater facilities

a. When specifically requested by a Developer or Engineer, the City Engineer may approve, on a case-by-case basis, the construction of a private stormwater facilities and systems within a private drainage easement. Private stormwater facilities and systems may be utilized when the entire development generates all the stormwater drainage on the site, and there is not any offsite or pass-through stormwater runoff or discharge. Private stormwater facilities and systems shall not be dedicated to the City and all construction, operation and maintenance responsibilities shall remain with the developer and property owner(s). Post-construction operation and maintenance responsibilities of private stormwater facilities and systems placed in a private drainage easement or suitable common area as a part of a plat may be assigned to a Property Owners Association or Homeowners Association.

The design, construction, operation and maintenance of private stormwater facilities and systems will not be reviewed or inspected by Public Works Engineering or City Engineer personnel. Private stormwater facilities and systems will be inspected by Development Services Plumbing Inspectors in accordance with the applicable Plumbing Code.

b. Public stormwater facilities and systems are required to be used when there is offsite stormwater flow from a drainage area of greater than six (6) acres that enters the subject development site and must be carried through the development site to the point of discharge. The public stormwater system must be designed in accordance with this chapter and the DCM and constructed in accordance with plans designed by an Engineer and

Commented [A3]: This does not mandate private storm sewer for all drainage created on-site. It says may be used and at the discretion of the City Engineer. Summary of Changes issued by the City states that Private Storm Sewer will be required. Which is it?

Commented [A4]: This needs to make reference to the Detention section 16-10 because otherwise detention is a private stormwater facility located within a Private D/E and/or CA and therefore would not be reviewed and/or inspected by Public Works Engineering.

reviewed for compliance by the City Engineer. Public stormwater facilities and systems must be placed in an appropriately sized easement approved by the City Engineer and dedicated to the City for public benefit, and upon formal acceptance by the City Council of the public stormwater facilities and systems and the easement, the City will assume maintenance. Public Storm Sewer Systems shall be provided when an existing storm sewer system, either Public or Private discharges onto the Development site.

c. If the offsite drainage area entering the development is between 0 and 6 acres, the flow may be intercepted and directed to a defined point of discharge such as a to a paved flume and/or an underground pipe, either of which will be privately constructed, operated and maintained and be a private stormwater facility and ownership.

Commented [A5]: If it is private why is paved flume or underground pipe mentioned in this statement. Also why is the statement either of which made when stating it will be private. Either of should be deletated.

3. Where construction of a stormwater drainage facility or system is required along a property line common to two or more property owners, the property owner proposing development or use of their property shall be responsible for meeting the stormwater drainage requirements at the time of development.

4. Drainage easements of adequate width to provide working room for construction and maintenance must be provided for all storm sewers with the minimum width being 15 feet. Drainage easements should include additional width for structures, buildings, and improvements adjacent to drainage easements are not affected by excavation or other work within and to the edges of the drainage easement.

§ 16-6. - Primary drainage channel requirements.

All primary drainage channels, which are located within or immediately adjacent to an improvement, construction area, development or subdivision, must be protected and/or improved in accordance with this chapter, the DCM and as follows:

1. All land within a development having an elevation below the 100-year frequency flood elevation of the primary drainage channel must be left unimproved as a common area with a private stormwater dedication or as a private drainage easement. If that land is not within a FEMA designated floodway, the area can be filled and improved. The developer must obtain and comply with all applicable permits and requirements prior to commencing any grading, excavation, or fill.

Commented [A6]: This says you can't fill in the floodplain on your property. This would do away with FEMA revisions and no-rise studies. This should be modified to require no rise study or FEMA revision if fill in floodplain.

2. The existing channel lying within or immediately adjacent to a subdivision or a parcel of land proposed for development or redevelopment must be cleaned by the property owner, only if it is not Waters of the United States or, considered non-jurisdictional by the COE, to provide for the free flow of water runoff, and the channel alignment and geometry shall be improved to contain and convey stormwater runoff generated by a 100-year rainfall event, within the limits of the dedicated drainage easement or common area, provided for in Subparagraph 1 above.

Commented [A7]: This can't be required if the property owner doesn't own the land.

Commented [A8]: "Must" be cleaned. Why is the City requiring the developer to clean the channel. This should be left to the discretion of the developer.

3. Site drainage improvements must provide for the grading of all building pads to an elevation where all building pads will not be subject to overflow from a 100-year frequency flood and in a manner that will provide for a rapid runoff of stormwater. Construction of new and substantially improvements to existing buildings and structures are subject to all regulations and requirements of this chapter, the DCM, and the following:

a. New construction or substantial modification of residential buildings and structures (including manufactured homes) and accessory buildings must have the lowest floor (including basements) elevated to 1 foot above the level of the 100-year frequency flood.

b. New construction or substantial modification of nonresidential buildings and structures and accessory buildings within the 100-year frequency floodplain must have the lowest floor (including basement) elevated to 1 foot above the 100-year frequency flood level or floodproofed, including utility and sanitary facilities, up to 1 foot above the level of the 100-year frequency flood.

Commented [A9]: This should be clarified to above ground structures. Not feasible if they are underground.

c. Mechanical and utility equipment for residential or nonresidential buildings and structures must be designed and/or located to prevent water from entering or accumulating within the components during conditions of a 100-year event flood.

d. If a nonresidential building or structure is intended to be floodproofed, an Engineer must develop and/or review its structural design, specifications and plans for the construction, and must certify that the design and methods of construction are in accordance with the accepted standards of practice for meeting the elevation requirements of this chapter. A record of such certificates which includes the specific elevation (in relation to mean sea level) to which such buildings or structures are floodproofed must be submitted by the Engineer to City Engineer for review as to compliance with this chapter and the DCM before any construction may commence.

e. A fully urbanized condition must be used to calculate flow for the design of stormwater facilities and systems.

Commented [A10]: This needs to be better clarified to primary drainage channels. Detention should not be required to follow this requirement if downstream of historic condition or developed condition with existing detention pond.

4. Whenever drainage channel improvements are constructed or improved, sodding, back sloping, cribbing, and other bank protection must be designed and constructed to control erosion for the anticipated conditions and flows resulting from a 100-year frequency rainfall event.

5. An open primary drainage channel may not be located in a street easement.

All pipe or box culverts, bridges, and other drainage improvements must be designed and constructed in accordance with this chapter and the DCM. Whenever the City is to assume future ownership and maintenance responsibility, the property owner must dedicate drainage easements accepted by formal action of the City Council., Provided, however, the acceptance only of an easement is not an acceptance of the drainage improvement, which requires separate formal action of the City Council.

Commented [A11]: The acceptance of the easement is not acceptance of the drainage improvement? Requires going to CC twice? You either bond improvements or they are installed and inspected and accepted. In either instance you should not have to go to CC twice.

§ 16-7. - Secondary drainage channels.

All secondary drainage channels which are within, or immediately adjacent to, an improvement, construction area, development, or subdivision, must be protected and/or improved by the developer in accordance with this chapter, the DCM and as follows:

1. All land within a development having an elevation below the 100-year frequency flood elevation of the secondary drainage channel must be dedicated for the purpose of providing: containment of runoff and drainage flow in a drainage facility within a private drainage easement, or in a common area. Private drainage facilities and systems must be constructed, operated, and maintained by the developer, property owner, or Homeowners Association or Property Owners Association.

2. Secondary drainage channels which have a function of transporting water through the development or collecting water from cross channels but are not deemed jurisdictional Waters of the United States, by the Army Corps of Engineers regulations. The secondary drainage channel with a drainage area of 40 to 500 acres must be improved with a concrete lined channel or enclosed storm sewer system. Drainage areas less than 40 acres shall have an improved closed storm sewer system unless written approval has been given by the City Engineer for construction of a concrete lined channel. When the development area to be drained is less than 6 acres, a paved open channel, designed by an Engineer for use as a sidewalk, having a minimum width of 4 feet and provided with 6-inch curbs, when also designed to drain stormwater runoff from the street to a natural stream or an improved open channel. In all cases above, the developer may develop the land without making channel improvements for areas non-jurisdictional, only if the landowner or developer has dedicated 100% of the land inundated by the 100-year frequency storm as a common area or private drainage easement dedicated to stormwater drainage.

Commented [A12]: Needs to be some provision in here for intercepting off-site sheet flow.

Commented [A13]: Conditions? Can I fill in any of this area without requiring improvements so long as we dedicate as private D/E or CA?

3. Site drainage improvements must provide for the grading of all building pads to an elevation where all building pads will not be subject to overflow from a 100-year frequency flood. Manufactured home placement pads must be elevated to 1 foot above the FEMA 100-year frequency flood elevation. Construction of new and substantial improvements to existing buildings and structures are subject to all regulations and requirements of this chapter, the DCM, and the following:

a. New construction or substantial improvements of residential or nonresidential buildings and structures (including manufactured homes) must have the lowest floor (including basements) elevated to 1 foot above the level of the 100-year frequency flood.

b. Nonresidential building and structures and accessory buildings may meet this requirement by floodproofing the buildings and structures, including utility and sanitary facilities, up to 1 foot above the level of the 100-year frequency flood.

c. Mechanical and utility equipment for residential or nonresidential buildings and structures must be designed and/or located to prevent water from entering or accumulating within the components during conditions of flooding of 100-year frequency flood.

d. If a nonresidential building or structure is intended to be floodproofed, an Engineer must develop and/or review its structural design, specifications and plans for the construction, and must certify that the design and methods of construction are in accordance with the accepted standards of practice and meeting the elevation requirements of this chapter. A record of such certificates which includes the specific elevation (in relation to mean sea level) to which such buildings or structures are floodproofed must be submitted by an Engineer to the City Engineer for review as to compliance with this chapter and the DCM before any construction may commence.

4. An open drainage channel may not be located in a street easement or utility easement unless it is placed in an enclosed storm sewer culvert or pipe or except under the following conditions:

a. Where a paved street surface of at least two lanes is provided on both sides of a paved channel to provide access to abutting properties.

b. Where lots are platted to back up to the street right-of-way where the open drainage channel is located between the rear lot line and the paved street, and further provided that at no time in the future may access be allowed or constructed over the open drainage channel to the rear of a lot so platted. For the purpose of this chapter, a lot which sides to a public street is not considered to back up to the street right-of-way.

c. When a condition outlined in either Subsection 4.a. or 4.b. above is present, adequate space adjacent to the channel must be dedicated as right-of-way to provide for maintenance of the paved drainage channel and its bank, paved or unpaved.

5. Open drainage channels must be improved by providing a paved section that will carry the runoff from a rain event, either the FEMA 100-year discharges or the urbanized 100-year discharges, whichever is higher. Whenever an open improved channel is required or authorized for a secondary drainage channel under the provisions of this chapter and that channel crosses residential lots, , or where the channel improvement is designed as a drainage area and will be privately maintained by a Property Owners Association or Home Owners Association, the City Engineer may modify the requirements of the first part of this provision to permit an alternate channel design, provided all hydraulic requirements to support the overflow resulting from a 100-year frequency rainfall are met to prevent flooding of all building pads, buildings, structures and accessory buildings.

§ 16-8. - Surface drainage.

1. In single-family residential, duplex or manufactured home developments, site grading must be carried out in such a manner that surface water and runoff from each dwelling lot will flow directly to a stormwater facility or system, improved channel, sodded swale, or paved street without crossing more than four adjacent lots.

2. Surface water and runoff collected in streets must be directed to street drains at satisfactory intervals to prevent overflow of 6-inch curbs during a 25-year frequency flood event, and all street and street drainage design must be in accordance with the DCM and this chapter. The maximum allowable water spread allowed for the 25-year storm event is one lane width for arterial streets. Surface flow on streets at point of interception shall not exceed 20 acres of drainage area.

§ 16-9. - Rural subdivisions.

1. The development of rural acreage subdivisions with 1-acre or larger lots, must be carried out in such a manner that surface water and runoff from each lot will flow to a roadway side ditch, swale, channel, or natural creek. Prior to final plat or building permit approval the developer must provide the City Engineer detailed construction plans showing channel and roadway side ditch sizes, grades, elevation, and driveway pipe sizes as well as erosion control measures necessary to prevent erosion of the proposed channel or ditch construction designed by an Engineer. These drainage improvements must include but not be limited to sodding, channel lining or ditch checks as required to prevent erosion of the proposed or existing channel or ditch. These drainage improvements are the responsibility of the developer to construct and if public, must be installed and inspected by the City prior to the acceptance of the streets and dedications on the final plat. Should the rural subdivision be constructed with private streets, then the developer and property owners will be responsible for construction and maintenance of the roadway side ditch.

Commented [A14]: More and more developments have been using a rural section on 0.5 acre developments as permitted by PUD. I would recommend making this 0.5 acre minimum and shouldn't be "must" flow into roadway side ditch. Should be "permitted to". Developer should be able to use a curb and gutter section when desired.

2. The sizing of roadway side ditches and driveway pipes will be designed to provide for the runoff from fully developed land of a 25-year frequency storm. Surface water collected in roadway side ditches must be directed to a secondary drainage channel not located within the street right-of-way as often as the terrain will allow. Driveway pipe culvert schedule, elevation, size, and grade must be provided for all rural subdivisions and submitted for approval on the paving plans.

3. The sizing of channels, creeks, and any drainage improvements that are needed for street crossings will be designed to provide for the runoff from a 50-year frequency.

4. Site drainage improvements must provide for the grading of all building pads to an elevation that will not be subject to overflow from a 100-year frequency flood plus 1 foot of freeboard and in a manner that will provide for the rapid runoff of stormwater. Substantial improvements to existing buildings and structures within the 100-year frequency floodplain are subject to all regulations and the requirements of this chapter. The areas projected for inundation by the 100-year frequency flood must remain free of all buildings and structures and must be preserved in as natural a condition as possible. The maintenance of channels serving drainage areas of less than 500 acres are the responsibility of the property owner, the adjoining or abutting property owner or owners, or a duly constituted Property Owners Association or Home Owners Association unless such improvements are in a dedicated drainage easement and the drainage easement and channels formally accepted for ownership and maintenance by the City Council. Drainage areas containing more than 500 acres must be improved as outlined in Section 16-7, Secondary Drainage Channels and constructed in accordance with this chapter and the DCM.

§ 16-10. - Detention.

1. For all new development, detention facilities shall be installed providing a developed discharge rate not to exceed the historical runoff rate prior to development for the 2-, 5-, 10-, 25-, 50- and 100-year frequency storms. All private on-site detention facilities shall be constructed in a private drainage easement or common area, and should include at a minimum the Q100 floodplain, outlet structures, and riprap.

2. On-site detention facilities require signed and sealed plans and drainage calculations by an Engineer, and must be provided to the City Engineer for review and must comply with this chapter and the DCM before the filing of a final plat or applying for a building permit on un-platted property. Approval of plans neither relieves the developer or property owner or the Engineer of responsibility or liability for the plan nor creates responsibility or liability for the City or the City Engineer.

3. The required maximum volume for stormwater detention must be calculated by the Engineer in accordance with the DCM.

4. The developer may submit to the City Engineer alternative methods of protecting downstream properties that can be accomplished without causing substantial detriment to the public good, safety or welfare of surrounding or downstream properties, the City Engineer may accept a waiver of on-site detention facilities requirements. The developer's petition must include all the plans and calculations, as produced by an Engineer, that the City Engineer may need or request to demonstrate compliance with this chapter and the DCM and to support the developer's request for a waiver of on-site detention.

a. All applications for a waiver of on-site detention facilities requirements must show no adverse impact to downstream structures or streets, and must be submitted to the City Engineer with the following information for review:

i. Site plan drawn to scale showing surveyed location, property dimensions, grade and elevations, and proposed construction or development including all impervious surfaces.

ii. A summary showing total impervious surfaces in square feet, historic site runoff calculations, and proposed site runoff calculations.

iii. Runoff from the proposed developed site must discharge directly to a public or private street or stormwater system as required in and in accordance with this chapter. Discharge onto an adjacent property will not be allowed.

The City Engineer may approve or conditionally approve a waiver of on-site detention facilities or may deny the application and require on-site detention facilities or other improvements or modifications of the stormwater control system. Any significant change to the proposed construction or development or any failure to meet the requirements or standards in this chapter or the DCM shall void the waiver and will require either compliance with this chapter and the DCM or a new application for a waiver.

b. Impervious surfaces installed or constructed as a part or portion of a public street or public sidewalk in the public street right-of-way shall not be included as a part of the on-site impervious area.

c. Whenever a property upon which an impervious surface is installed or constructed lies within two different watersheds, detention shall be provided based upon the amount of increased impervious surface within each watershed.

d. It is unlawful for any person to erect, construct, install, enlarge, alter, repair, move, improve, make, put together, or convert any building, structure, improvement, facility, or impervious surface within the City, or cause the same to be done, without providing on-site detention facilities, or request for waiver, as required by this section.

Commented [A15]: This should exclude single lot residential.

e. If the City Engineer has record of any flooding within one-half (1/2) mile of the proposed development, a waiver of the on-site detention requirement will not be considered.

Commented [A16]: Flooding needs to be defined and also does this mean upstream also? Needs clarification.

§ 16-11. - Major river channels.

All major river channels which are located within or immediately adjacent to an improvement, development or subdivision must be protected and improved by the developer as follows:

1. All land having an elevation below the 100-year City Urbanized WSEL or FEMA WSEL, whichever is higher for the final improved channel, must be dedicated in a private drainage easement or platted common area dedicated for drainage purposes.

2. The existing major river channel may be cleaned to provide free flow of water, straightened, widened, leveed, or diked, or otherwise improved to the extent required to prevent overflow from a 100-year frequency flood. The major river channel is part of Waters of the United

States, and under the jurisdiction of the Army Corps of Engineers. All necessary Federal, State and local permits will be required before working in the major river channel.

3. Site improvement must provide for the grading of all building pads to an elevation where all building pads will not be subject to overflow from a 100-year frequency flood plus 1 foot of freeboard. Manufactured home placement pads must be elevated to 1 foot above the 100-year frequency flood elevation. All manufactured homes must be anchored in accordance with requirements outlined in the Federal Emergency Management Agency Flood Plain Management Regulations, Subpart A, Section 60.3(b)(8). Substantial improvements to existing buildings and structures within the 100-year frequency floodplain are subject to all regulations and requirements of this chapter and the DCM.

4. New construction or substantial improvements of nonresidential buildings and structures and accessory buildings within the 100-year frequency floodplain must have the lowest floor (including basement) elevated to 1 foot above the 100-year frequency flood level or floodproofed including utility and sanitary facilities up to 1 foot above the level of the 100-year frequency flood. Mechanical and utility equipment for residential or nonresidential buildings and structures and accessory buildings must be designed and/or located to prevent water from entering or accumulating within the components during conditions of flooding. If a nonresidential building or structure is intended to be floodproofed, an Engineer or Architect must develop and/or review structural design, specifications and plans for the construction, and must certify that the design and methods of construction are in accordance with the accepted standards of practice for meeting the elevation requirements of this chapter. A record of such certificates, which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed, must be submitted by the Engineer or Architect to the office of the City of Engineer for review as to compliance with this chapter and DCM before any construction may commence.

5. Fill, grading measures, and building floodproofing measures must be compliant with this chapter and the DCM and the minimum standards as set forth in the "Floodproofing Regulations" prepared by the Office of the Chief of Engineers, U.S. Army, Washington, D.C., June 1972.

§ 16-12. - Bridges and culverts.

Commented [A17]: I thought we were going to revised and break into two sections.

1. All flow of water across continuous streets or alleys must be through culverts or bridges. Bridges shall be designed such that the 100-year frequency flood flow will not overtop the roadway. In addition, the low chord of the bridge shall be set to provide a minimum of 1 foot of freeboard above the 50-year frequency flood flow.

2. Culverts shall be designed to carry the 50-year frequency flood flow with no more than 1 foot of headwater at the upstream end of the culvert and such that the 100-year frequency flood flow will not overtop the roadway.

3. No rise in the 100-year frequency flood flow water surface elevation will be allowed upstream of the bridge or culvert as a result of the construction or installation of any building or structure, unless such increase is confined to the limits of the developer's property.

Commented [A18]: Not for a drive pipe????

§ 16-13. - Closed storm sewers.

1. Closed stormwater facilities and systems must be constructed of precast or prefabricated pipe or cast-in-place or precast, closed box culvert design in conformance with DCM, and

construction specifications and requirements. Stormwater facilities and systems carrying runoff from streets must be designed to accept the run-off from a 25-year frequency rain event for the drainage area involved. Provided that in sump areas the stormwater facilities and systems must be designed to serve the 50-year frequency storm event with a 4-foot minimum width of concrete flume with a 6-inch curb, being constructed over the stormwater facilities and systems to ensure that the difference between the 50- and the 100-year frequency storm overflow can reach a suitable outlet without inundating any building pad.

Commented [A19]: This should not even be in the DO. This should be a white book requirement. If the City is going to require wrapping of joints and gravel backfill to 1' over pipe then HDPE should be permitted.

2. If closed stormwater facility or system discharges to creek, channel, swale, or detention pond, Q100 WSEL shall be used to establish the tailwater elevation for Q100 HGL analysis. If closed stormwater facility or system discharges to an existing storm sewer system Q50 WSEL of the existing stormwater facility or system shall be used to establish the tailwater elevation for Q50 HGL analysis. If the stormwater facility or system is private, it is up to the engineer to design the site and evaluate the HGL analysis.

Commented [A20]: This differs from 3.7.1 of the DCM. Should be removed from DO and only specified in DCM.

3. The maximum curb opening to flume is 15 feet. Whenever curb openings are greater than 6 feet, bollards spaced 3 feet apart will be required to eliminate the potential inadvertent motor vehicles getting on the sidewalks.

§ 16-14. - Open paved storm drainage.

Open paved storm drainage channels must be constructed in accordance with City specifications, this chapter, and the DCM requirements. Fences may neither be erected closer than one foot (measured horizontally) from the edge of the paved section nor over the open paved storm drainage channel except as approved by the City Engineer.

§ 16-15. - Areas outside subdivisions.

The City reserves the right to require drainage improvements to be designed and built to preclude any backup of stormwater inundating any areas outside of the dedicated drainage easements in the development or subdivision or onto adjacent land as a result of a 100-year frequency flood.

§ 16-16. - Floodplain Activity Permit Requirements

A floodplain activity permit is required for all man-made activities occurring within the FEMA floodplain, and all man-made activities within 200 feet of the external boundary of a FEMA floodplain. All activities within the FEMA Floodplain, including Zone A or Zone AE, may require a flood study to show such activities do not cause any rise in Q100 WSEL.

Commented [A21]: FEMA has already considered the 1 foot increase. This is contrary to that.

The following provisions apply to lands designated as floodprone areas. Additional review and measures are required to assure protection from flooding as set forth below:

1. *Special review of building permits or development in floodprone areas.* A floodplain activity permit is required for development within 200 feet of the external boundaries of the delineated floodplain for that watercourse as shown on the official floodplain maps or an area

deemed floodprone by the City Engineer. No floodplain activity permit, if any, will be issued for new development or for the start of new construction or for expansion or additional construction to existing buildings or structures or for any residential or nonresidential structure or any bridges or any accessory building including manufactured homes unless the application for floodplain activity permit is submitted and accompanied by the following information for review:

a. Plans submitted pursuant to the DCM drawn to scale showing the nature, location, dimensions, grade, and elevation of the lot, existing or proposed buildings and structures, fill, storage of materials, floodproofing measures, and the relationship of the above to the location, grade, elevation and location of the channel.

b. A typical valley cross section showing the channel of the stream, grade and elevation of land areas adjoining each side of the channel, and cross-sectional areas to be occupied by the proposed development and high-water information.

c. A profile showing the slope and elevation of the bottom of the channel or flow line of the stream. This profile shall cover a minimum of 300 feet upstream and downstream from the property limits unless additional information is requested by the City Engineer.

Commented [A22]: Profile 300' upstream and downstream of the property limits? This is excessive.

d. Specifications for building construction and materials, floodproofing, filling, dredging, grading, channel improvements, storage of materials, water supply and sanitary facilities.

e. Copies of all other permits required by State or Federal law, including but not limited to Section 404 of the Federal Water Pollution Control Act Amendments of 1972, 33 USC 1334.

f. Plans and/or specifications demonstrating that construction will incorporate methods and practices that minimize flood damage to upstream and downstream property owners and that material resistant to flood damage will be used for all new construction and substantial improvements.

g. Any other plans, surveys, grades, elevations, calculations, or computer studies that may be required by the City Engineer deemed necessary to determine the impact on and of the proposed development or building activity.

h. Buildings or structures located within the limits of the FEMA Floodplain are required to provide a FEMA Elevation Certificate upon completion of the building or structure.

i. Buildings or structures located within 200 feet of the FEMA Floodplain Boundary are required to provide a surveyor's certificate prior to the issuance of the second part of the building permit.

Commented [A23]: I appreciate that we are only requiring a surveyor's certificate here but why within 200' of FEMA floodplain boundary. Why not immediately adjacent to?

j. When floodway data has been provided by FEMA, the following control measures and restrictions will apply: The designation of the floodway by FEMA, shall be based on the principle that the area chosen for the floodway be designated to carry the waters of the 100-year frequency flood without increasing the water surface elevation of that flood by more than one foot at any point.

k. No structure, building, improvement, or development, whether temporary or permanent, may be constructed in the floodway, nor may any obstruction, fill or storage of goods, materials or equipment be permitted within the floodway.

l. Existing nonconforming uses in the floodway may not be expanded, but a floodway may be modified, altered or repaired to incorporate floodproofing measures provided such measures do not raise the level of the 100-year frequency flood with the appropriate FEMA permits and approvals.

m. An exception to Subsections 2.a. through 2.c. above may be made solely for oil and gas drilling operations performed within the floodways of the North Canadian and Canadian Rivers, provided the following special requirements are met:

i. A special permit, not to exceed 120 days in duration, is required from the City Engineer prior to commencement of such operations. A separate permit is required for every drilling operation and for each subsequent periodic drilling or maintenance operation performed on each well.

ii. All permanent well structures or appurtenances must be elevated to a minimum of 1 foot above the 100-year frequency flood elevation and located outside the limits of the floodway. A permanent completed well head may remain within the floodway, provided that the well head is located in a reinforced concrete vault constructed completely below ground with a protective cover so that no portion of the structure extends above the elevation of the natural ground surrounding the well site that existed prior to construction.

iii. Any fill placed for access road construction or site leveling may not exceed six inches in height above the existing natural ground elevation. Prior to issuance of the permit. Complete hydraulic calculations must be provided by the permit applicant to demonstrate that no increase in flood elevations will occur due to the proposed fill.

iv. Well site construction and drilling operations must be accomplished in a manner which will allow all facilities, equipment and materials to be dismantled, secured and/or evacuated from the floodway within a two-day time period during anticipated high waters.