City of Lawton
Public Works

Stormwater Drainage Policy

July 2007

CITY OF LAWTON · STORMWATER MANAGEMENT

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SECTION I
GENERAL DRAINAGE POLICY FOR THE CITY OF LAWTON

GOAL: It is the goal of this policy to establish minimally acceptable standards to be utilized in the design of stormwater drainage system improvements and where required by sections herein limit stormwater runoff rates after development to their historic value.

PURPOSE: The purpose of this Drainage Standard STD-400 is to establish standard practices for the design and construction of stormwater drainage systems within the City of Lawton. The design factors, formulas, graphs, and procedures are intended for use as a minimum standard in the design of stormwater drainage systems.

Methods of design other than those indicated herein should be considered where professional experience clearly indicates the minimum requirements as listed herein will not provide the level of service or the level of protection intended. However, there should be no variations from the practices established herein without the approval of the City Engineer.

PERFORMANCE REQUIREMENTS: The overall goal of these standards is to provide guidance in the design, construction, operation, and maintenance of drainage system improvements. As such, an adequate drainage system could be designed, approved by the City, and installed according to plan. However, the specific goal is not standards and specifications for practice, but the mandate that the improvements must function as intended.

MINIMUM SURFACE DRAINAGE REQUIREMENTS FOR THE CITY OF LAWTON: (A) General Design criteria:

(1) Drainage facilities shall be designed to provide a sufficient stormwater drainage system for the conveyance of stormwater runoff received from upstream and from the subject property with due allowance having been made for continued conveyance of stormwater runoff from adjacent properties as the drainage basin develops.

The drainage system including streets, bridges, culverts, open channels, detention/retention facilities, etc., shall be designed for all probable storm recurrence intervals up to and including the 100-year frequency storm event for the fully urbanized drainage

basin.

(2) All land determined to be in the floodway of a drainage channel as a result of a 100-year frequency storm event shall be dedicated to the City as right-of-way including such areas necessary for maintenance purposes and all land determined to be within the floodplain of a drainage channel as a result of a 100-year frequency storm event may be dedicated to the City as drainage easement including such areas necessary for maintenance purposes.

(3) Site improvement shall provide for the grading of all building pads to an elevation where the lowest finished floor elevations shall be one (1) foot above the water surface elevation generated by a 100-year frequency storm event. In all developments, the surface water from each lot will flow away from all structures in a controlled manner to an approved collection or disposal location as required under Section VII of this Standard.

(4) Erosion and sedimentation control facilities with construction specifications and operation and maintenance procedures detailing all erosion and sedimentation control measures which are established and the required maintenance during the life of the development shall be provided.

(5) No improvements shall be constructed which will increase the frequency or the water surface elevation during any storm event up to the 100 year frequency storm event upstream or downstream of the development.

(B) Existing Drainage Structures: Existing structures within and adjacent to a proposed development shall be evaluated in terms of hydraulic capacity and structural soundness. Those structures found to be structurally inadequate shall be modified or completely removed and replaced by the developer. Structures found to be hydraulically inadequate for flow and/or for protecting property as a result of the changing runoff characteristics shall be replaced or modified by the developer to provide the required capacity and/or protection.

(C) Utilities: All utilities located within the floodplain or any other open channel or swale shall be designed to prevent infiltration of floodwater and to protect against washouts. Location of the utilities shall not restrict flood flows.

DRAINAGE PLAN

PREPARATION: (A) Preparations:

(1) Plan and profile shall be drawn on sheets 24" X 36" to a horizontal scale of 1" to 20' or 1" to 40' and vertical scale of 1" to 2' or 1" to 4' (except that scales may vary on special projects, such as culverts and channel cross sections. However, these exceptions must be clearly marked and explained on the Plan and Profile sheets).

(2) Stationing shall proceed upstream with the North arrow pointing to the top of the sheet, or to the right. The 100-year frequency storm event water surface elevations on all channels shall be provided with cross sections at appropriate terrain changes. A stream profile shall also be provided to enable extrapolation of base flood elevations between the cross sections.

(3) Plans for the proposed drainage system shall include property lines, lot and block numbers, dimensions, right-of-way and easement lines, floodplains, flow rates, street names, paved surfaces (existing or proposed), contract limits, location, size and type of inlets, manholes, culverts, pipes, channels and related structures, outfall details, miscellaneous riprap placement, 2' contour lines, flow arrows, title block.

(4) Profiles shall indicate the proposed storm drainage system (size and material) with elevations, flow lines, gradients, left and right bank channel profiles, station numbers, inlets, manholes, ground line and curb line elevations, typical sections, riprap construction, filling details, open drainage features, pipe crossings, design flow capacities, and title block.

(5) Official floodplain designations and delineations of the floodplains and floodways denoting limits of permissible developments shall be shown on all preliminary plans and final plats submitted for approval wherever such plans and plats contain a floodplain segment. In any case in which official floodplains are not delineated, they shall be determined on the basis of these standards and shall be shown on all preliminary plans and final plats submitted for approval.

(6) The limits of the floodplains shown on regulatory floodplain maps are close approximations based on extrapolations made between widely-spaced cross sections. Therefore, the actual limits of the floodplain shall be determined by extracting base flood elevations from the streamwater surface profile and determining where each elevation intersects the adjacent existing

topography. If a conflict exists between the overlay of the regulatory floodplain map and the existing topography, a submittal of a Letter of Map Amendment (LOMA) or Letter of Map Revision (LOMR) by the Developer/Owner to the Federal Emergency Management Agency (FEMA) is required when the FEMA Flood Insurance Rate Map (FIRM) conflicts with proposed lots or other proposed structures or improvements.

(B) Submittals

(1) Computations and plans to support all drainage designs shall be submitted to the City Engineer for review. The computations and plans shall be in such form as to provide the basis for timely and consistent review and will be made a part of the permanent record for future evaluation. The computations and plans shall be accompanied by the certification of a registered professional engineer licensed to practice in the State of Oklahoma. Before final acceptance, the submitting engineer shall provide "as built" plans both digital and hard copy based on field survey data of the streets, storm sewers, detention facilities, and all other conveyances of stormwater; a revised set of drainage calculations that correspond with the "as-built" plans; and a letter of certification stating that the "as-built" site complies with all governing ordinances and adopted drainage standards of the City of Lawton.

SECTION I I
DETERMINATION OF STORM RUNOFF

GENERAL: Numerous methods of runoff computation are available on which the design of storm drainage and flood control systems may be based. The Rational Method will be accepted as adequate for drainage areas up to 320 acres. For larger areas, the U.S. Army Corps of Engineers Hydraulic Engineering Center HEC-1, HEC-HMS or other engineering programs or methods acceptable to the City Engineer shall be used. Any hydrological soil group data to be used when computing runoff shall be determined from the most current edition of the Comanche County, Oklahoma Soil Survey provided by the United States Department of Agriculture Natural Resources Conservation Service.

RATIONAL METHOD OF RUNOFF COMPUTATION: The water surface elevation produced from a 100 year frequency storm event plus one foot of freeboard shall be used for the purposes of determining the sizing of drainage channels and structures for the drainage area, unless otherwise specified herein. Values used in formulas for runoff and size of drainage structures shall reflect the degree of urbanization set forth in the projected land use pattern contained in the comprehensive plan for the metropolitan area. The following formulas and values shall be used for calculating all stream flow and runoff for drainage areas up to 320 acres for the policies and regulations established herein:

(1) Runoff can be determined by the Rational Formula as follows:

Q = CIA, in which

Q = Runoff in cubic feet per second

A = Area to be drained in acres, as determined by field surveys, City contour maps or by the latest government quadrangle maps for larger areas

C = Runoff coefficient weighted for various ground covers, may vary between 0.35 and 0.95 (see Table 2.1)

I = Intensity of rainfall over entire drainage area in inches per hour, based on time of concentration (see Figure 1)

(2) The time of concentration is the time required for the entire

watershed to contribute runoff to the point of interest following the longest path of travel. It can consist of overland flow travel time and channel flow travel time. Street flow shall be considered as being in an open paved channel. Time of concentrations greater than 30 minutes should be carefully evaluated.

An acceptable formula for use in determining overland flow travel time is:

Time = $K (L^{0.37} / S^{0.2})$
L = Length of Flow path in Feet
S = Average Slope in Feet/Foot
K = Constant for Character of Surface

Values of K:

Pavement	.37
Bare Soil	.60
Poor Grass	.90
Average Grass	1.00
Dense Grass	1.13

An acceptable formula for determining channel flow time is:

Time = $K (L^2 / S)^{0.385}$
L = Channel length in feet
S = Channel slope in feet/foot
K = Character coefficient

Values of K:

Curbed street	.0035
Concrete Lined Channel	.006
Sodded Swale	.008
Bar Ditch	.012

The time of flow in a closed conduit is the quotient of the length of the conduit and velocity of flow as computed using the hydraulic factors of the conduit.

Manning's Equation is acceptable for analyzing open channel flows in prismatic channels without backwater control and for analyzing free water surface conduit flows. All other flow conditions/locations shall utilize energy equation calculations for sizing and evaluation purposes including sizing culverts at street crossings.

(3) Drainage Area: The size and shape of the watershed must be determined. Drainage areas shall be determined through the use of planimetric topographic maps, supplemented by field surveys. A drainage area map shall be provided for each project. The drainage area contributing to the system being designed and drainage sub-area(s)contributing to each inlet point shall be identified. The outlines of the drainage area/sub-area(s) must follow actual ridges rather than artificial land divisions. Each discharge point of all drainage areas shall be identified.

TABLE 2.1

Runoff Coefficients for Use in the Rational Formula:

LAND USE	BASIN SLOPE	
	Slope < 2%	Slope >= 2%
Undeveloped Land (Agri., Pasture, Etc.)	.35	.45
Single Family Residence < ½ Acre	.55	.65
Single Family Residence > = ½ Acre	.45	.55
Multi Family	.60	.70
Apartments	.75	.85
Commercial	.90	.95
Parks, Golf Courses	.35	.45
Other Land Uses	As Approved by the City Engineer	

SECTION I I I
FLOW IN STREETS

GENERAL: The location of inlets and permissible flow of stormwater in the streets should be related to the extent and frequency of interference to traffic and the likelihood of flood damage to surrounding property. Interference to traffic is regulated by design limits of the depth and spread of water into traffic lanes, especially in regard to collector streets and arterials.

DESIGN CRITERIA: (A) Flow in gutters which are on straight or parabolic crown pavement may be determined by using Manning's Formula for channel flow or acceptable nomographs.

(B) Minimum gutter slope on residential streets shall not be less than 0.006 ft/ft (0.6%). Maximum gutter slope should not be more than .06 ft/ft (6.0%).

(C) No lowering of the standard height of street crown shall be allowed for the purpose of hydraulic design unless approved by the City Engineer. In no case will it be allowed on collector streets or thoroughfares.

(D) All street sections shall have a positive crown except alleys unless approved by the City Engineer.

(E) The flow depth in the gutter of arterial streets shall not exceed 4" for the 100-year storm event for the area for a standard 6" barrier curbed street.

(F) The flow depth in the gutter of collector streets shall not exceed 5” during 25-year frequency storm event for the area and grades involved. However, the minimum finished grade at the building line shall be such that it will not be affected by storms equivalent to a 100-year frequency storm event plus one foot of freeboard.

(G) The flow depth in the gutter of residential streets shall not overflow a standard six (6) inch barrier curb during a rain of 10-year frequency storm event for the area and grades involved. However, the minimum finished grade at the building line shall be such that it will not be affected by storms equivalent to a 100-year frequency storm event plus one foot of freeboard.

(H) Drainage area allowed for surface flow on streets at point of diversion shall not exceed twenty (20) acres, regardless of flow.

(I) Where two (2) or more streets intersect, the flow shall be intercepted by appropriate stormsewer techniques prior to the intersection of said streets such that the depth of flow within the intersection will not exceed the most restrictive depth requirements of either of the two (2) streets, as indicated above.

(J) Design engineers are encouraged to cut roads in below the natural grade of the land to facilitate lot drainage toward the street and to maintain aesthetically pleasing elevation relationships among the residences on the block, particularly as they near the street's sump position.

SECTION IV
BRIDGES, CULVERTS AND ENCLOSED STORM SEWERS

GENERAL: An energy equation analysis shall be performed at all bridge and culvert locations for the design of these structures. For enclosed storm sewers, an energy equation analysis shall be utilized to design the structure if inlet control or backwater conditions exist. If inlet control or back water conditions do not exist, then the Mannings equation may be utilized for design purposes. Investigations of the capacity of all existing structures on the waterways shall be made.

In addition, runoff from storms exceeding the design storm shall be anticipated by the developer and disposed of with minimum damages to surrounding property. The storm sewer must be accessible for maintenance.

REQUIREMENTS: Bridge and culvert requirements are as follows:

(A) All flow of water across continuous streets or alleys shall be through culverts or bridges.

(B) Bridges and culverts on primary drainage channels shall be sized to accommodate a 100-year frequency storm event, plus one foot of freeboard to low chord on bridges or inside top of structure on culverts, based on the drainage area involved.

(C) Bridges and culverts on secondary drainage channels shall be sized to accommodate a hundred-year rain, plus one foot of freeboard to low chord on bridges or inside top of structure on culverts, based on the drainage area involved. However, a 50-year frequency storm event may be used when overflow provisions are incorporated to accommodate a 100-year frequency storm event.

(D) Design calculations shall be submitted to and have the approval of the City Engineer.

(E) Closed storm sewers shall be constructed of pre-cast or prefabricated pipe or built in-place of closed box design to serve a minimum 10-year frequency storm event for the drainage area involved. All storm sewers shall be designed for the 100-year frequency storm event flow capacity of the street so that buildings will have 1-foot of free-board as required in Section III (E.), (F.) and **(**G**.)**. Storm sewers placed in street rights-of-way shall be placed in relation to the curb, and installed with inlets as approved by the City Engineer.

DESIGN CRITERIA:

(A) Pipes which are a part of the storm sewer system shall have a minimum diameter of fifteen (15) inches. Laterals collecting flows from a single inlet may be twelve (12) inches.

(B) Closed storm drains will be designed for open-channel (free water surface) flow.

(C) Minimum Grades: The slope shall maintain a minimum full flow velocity of 2.5 fps.

(D) The Manning Formula may be used to size culverts when inlet control (pressure flow) or backwater conditions do not exist as follows:

$$Q = 1.486 AR^{2/3} S^{1/2}$$

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

S = Mean slope of hydraulic gradient, in feet of vertical rise per foot of horizontal distance

n = Roughness coefficient, based on condition and type of material of conduit lining, but not less than 0.013

(E) Acceptable Roughness coefficient "n" for storm sewers:

Materials of Construction	*Design Coefficient Mannings "n"*
Box Culverts	.013
Concrete Pipe	.013
HD Polyethylene pipe	as approved by City Engineer
Coated Corrugated Metal pipe	as approved by City Engineer

(F) General rules to be observed:

1. Do not discharge a larger pipe into a smaller one.

2. At change in pipe size, match top of pipe.

3. A one (1) foot freeboard shall be maintained below the proposed finish grade of all buildings during a 100-year frequency storm event.

4. An energy equation analysis shall be performed at all bridge and culvert locations for the design of these structures. For enclosed storm sewers, an energy equation analysis shall be utilized to design the structure if inlet control (pressure flow) or backwater conditions exist. If inlet control (pressure flow) or backwater conditions do not exist, then the Mannings equation may be utilized for design purposes. The calculations or other documentation demonstrating that the inlet control and backwater check has been made shall be submitted.

(G) Manhole/Junction Boxes: Manholes or junction boxes shall be located at intervals not to exceed 350 feet for pipe sizes 42" or less. Above 42", manholes shall be located as determined by the City Engineer. Manholes or junction boxes shall be located at all conduit junctions, changes of grade, changes of alignment, and changes in conduit size. Standard 4’ diameter manholes shall be allowed for pipe sizes of 15” diameter and less. Standard 5’ diameter manholes shall be allowed for pipe sizes of 21” diameter and less. Manholes for pipe diameters larger than 21” shall utilize modified bases per City standard details or junction boxes as approved by the City Engineer.

(H) Pipe Connections: The use of one material to extend a storm sewer constructed of a different material shall not be allowed except at manholes, junction boxes, or inlets.

(I) Pipe Laid on Curves: Degree of curvature shall be as per manufacturer's recommendations.

(J) All storm sewer outlets shall have headwalls, flared end sections, curtain walls, or other approved outlet treatment and rip rap for erosion protection.

(K) All storm sewer pipe under pavement shall be "0-ringed" reinforced concrete pipe.

(L) Water-tight seals shall be required for all storm sewer pipe in the right-of-way.

(M) A minimum of 2' of cover is required for storm sewer pipe unless approved by the City Engineer.

(N) A drainage easement of satisfactory width to provide working room for construction and maintenance shall be provided for all storm sewers. The width of the easement shall be the outside dimension of the structure plus 10’ on each side with a minimum width of 25'.

INLET SYSTEM:

(A) Inlet design and location in street sections must be compatible with the allowable depth of water on the street section.

(B) Inlet location shall not interfere with vehicular or pedestrian traffic.

(C) Whenever possible, inlets shall intercept water before it reaches a pedestrian crosswalk or street intersection.

(D) Inlets at intersections shall not be located in a curb radius.

(E) Inlets shall be located to prevent water from minor streets spilling over and flooding major streets.

(F) All hoods in a sump condition shall have 8" openings with the gutter lowered to accommodate the inlet. Transition section shall be 10' in each direction.

(G) Where a curbed street crosses a bridge or reinforced concrete box structure, gutter flow shall be intercepted and not allowed to flow onto the structure.

(H) Inlets for arterial or section line streets, shall be installed to ensure that the street ponding depth does not exceed 4" in a 100-year storm event. Inlets on non-arterial streets shall be installed to ensure the street ponding depth does not exceed 6" in a 10-year storm event for a standard 6" barrier curbed street. However, the minimum finished grade of structures shall be one (1) foot above the 100-year storm event water surface elevation.

(I) All storm sewer systems located at a low point ("sump") shall provide for an emergency overflow channel with a designated drainage easement sufficiently sized to contain within its boundaries the 100-year frequency storm event under the assumed conditions that the sump position storm sewer inlets / grates are 100% blocked, and in addition provide sufficient working room for future maintenance.

(J) Inlet Capacities: No method of determining capacity is

prescribed in this standard. Theoretical capacities using clear water in nomograph form have been published by various sources such as the American Society of Civil Engineers (ASCE) & Highway Research Board. When using nomographs, submit the source along with drainage calculations. Due to the potential for clogging and changes in street cross section due to future street resurfacing, the following efficiency factors shall be applied:

Inlet	*Condition*	*Efficiency*
Curb Opening	Continuous grade	0.8
	Sump	0.8
Grate	Continuous grade	0.6
	Sump	0.5
	Transverse bars	0.5
Combination	Continuous grade	0.7
	Sump	0.7

Street slope, street cross-slope, and flow velocities shall be taken into account when sizing inlets and grates with their efficiencies reduced accordingly. The receiving storm sewer pipes shall be sized for flows to which the inlet and grate clogging factors have not been applied.

(K) Any inlet grates over which a bicyclist can ride shall be of a design considered bicycle safe.

SECTION V
OPEN DRAINAGE CHANNELS

NATURAL DRAINAGE FLOW:

The creation of swales, alteration of small channel capacity or direction, changing of ground cover, and the lining of existing channels with other material natural or man-produced, may be necessary in some parts of the system to achieve the objectives of this standard.

The two (2) types of drainage channels shall be as follows:

(1) Primary drainage channels shall be those streams, creeks and channels which have been designated as primary drainage channels on Figure 2 and/or with drainage areas of five hundred (500) acres or more; and

(2) Secondary drainage channels shall include all channels with drainage areas less than five hundred (500) acres.

OPEN STORM DRAINAGE REQUIREMENTS:

(A) All primary drainage channels with a floodway located within or adjacent to a development i.e. subdivision, individual tract or building site shall be protected and improved by the developer as follows:

(1) All land in the floodway of a 100-year flood, shall be dedicated to the City as right-of-way for the purpose of providing drainage and shall include sufficient access locations as indicated by the City Engineer. The developer shall dedicate to the City as right-of-way, or drainage easement the area of the 100-year flood event adjacent to the floodway for landscaping and maintenance purposes. If private ownership of the land in the floodway of a 100-year flood is desired, the developer must enter into an agreement with the City of Lawton requiring that the private entity which owns said floodway will provide proper maintenance such that the area does not create a hazard or nuisance to the community and does not increase 100-year flood elevation. Failure to provide said maintenance will result in fines to be levied by the City, as set forth in said agreement, which will constitute a lien against the property.

(2) The existing channel shall be cleaned to provide for the free flow of water; and the channel shall be straightened, widened and improved to the extent required to prevent overflow

from the 100-year flood event beyond the limits of the dedicated drainage easement. All State and Federal permits shall be obtained in complying with this requirement.

(3) Whenever channel improvement is carried out, sodding, backsloping, cribbing and other bank protection shall be designed and constructed to control erosion for all the anticipated conditions of flow for the segment of channel involved.

(4) Concrete trickle channels shall be constructed for all primary channels. A minimum of a 12 ft wide area adjacent to the top of bank with a maximum cross-slope of 12:1 shall be provided on each side of the channel for maintenance purposes and shall be within a dedicated right-of-way or easement.

(5) A drainage channel shall not be located in a street right-of-way or easement unless it is placed in an enclosed storm sewer, or unless a paved street surface is provided on both sides of the paved channel to give access to abutting properties.

(6) Bridges or reinforced concrete box structures shall be constructed in accordance with the specifications of the City at all locations where drainage channels intersect with continuous streets or alleys.

(7) All drainage swales, channels, berms, and other drainage improvements shown on the approved plans shall be constructed prior to the acceptance of the subdivision final plat or to the issue of an occupancy permit for other types of developments.

(8) No private wet detention facility (lake) may be constructed upon a primary channel. However, this provision shall not prohibit the City from constructing a detention facility upon a primary channel.

(B) Secondary channels with a floodway located within or adjacent to a development shall meet the following conditions:

(1) When a development is traversed by or adjacent to a secondary drainage channel, watercourse or stream there shall be provided a right-of-way or drainage easement adequate to contain all of the floodway of a 100-year flood, including sufficient access locations. The developer shall dedicate a drainage easement for the area of the 100-year flood event adjacent to the floodway for landscaping and maintenance purposes, or said area shall be platted

as Common Area and have a maintenance program carried out by the property owners association.

(2) A drainage channel shall not be located in a street right-of-way or easement unless it is placed in a closed storm sewer or unless a paved street surface is located on both sides of a paved drainage channel to give access to abutting properties.

(3) All secondary channels shall be improved by one of the following methods:

(a) Open channels may be improved by providing a minimum five foot (5') concrete trickle channel with a sodded section to carry the runoff from a ten-year frequency rainfall in accordance with the Standard Detail sheet for drainage channels. See Standard Details. However, the maximum water surface elevation resulting from a 100 year frequency storm event shall be one (1) foot below the finished floor elevation of any adjacent habitable structure; or

(b) Open channels may be improved by the construction of a concrete channel liner with a sodded section to carry the runoff from a minimum 10-year frequency storm event in accordance with the Standard Detail sheet for drainage channels. However, the maximum water surface elevation resulting from a 100 year frequency storm event shall be one (1) foot below the finished floor elevation of any adjacent habitable structure.

(4) Open paved storm drainage channels shall be designed and constructed in accordance with specifications approved by the City Engineer.

(5) All drainage easements shall remain clear of obstructions and encroachments. Prohibited obstructions and encroachments shall include, but are not limited to, fences, driveways, mechanical and electrical equipment, storage sheds, trees and retaining walls.

(6) Any channel improvements shall be approved by the City Engineer prior to the commencement of any work thereon.

(7) Whenever channel improvements are carried out, sodding, backsloping, cribbing and other bank protection shall be designed and constructed to control siltation and erosion for the

anticipated conditions and flow resulting from a 10 and100-year frequency rainfall. (See Section IX.)

(8) Any channel grading shall be such that water will not gather in pools.

(9) Drainage easements sufficient in width to provide a buffer and provide working room for construction and access for channel maintenance shall be provided. A minimum of a 10-foot wide area in accordance with City of Lawton Standard Details shall be provided on each side of the channel for maintenance purposes. A minimum drainage easement width of 25 feet shall be provided.

(10) All drainage swales, channels, berms, and other drainage improvements shown on the approved plans shall be constructed prior to the acceptance of the subdivision final plat or to the issue of an occupancy permit for other types of developments.

DESIGN CONSIDERATIONS:

(A) The use of Mannings Equation in the calculations of hydraulic characteristics of open channel flows in prismatic channels without backwater control will be acceptable. When analyzing natural channels or when analyzing any overland conveyance system that has downstream control that could affect the 100-year event water surface elevations, the use of the HEC-RAS (U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System) modeling program or other approved water surface profile modeling program shall be required. The "n" value(s) used for channels shall be based on the individual channel characteristics. When submitting calculations, include the source for the "n" value.

(B) Channel Geometry: The minimum bottom width shall be 5' for concrete trickle channels with side slopes not steeper than 12:1(horizontally:vertically) for adjacent sodded areas and a minimum bottom width of 5' with side slopes of not steeper than 1:1 for paved sections with side slopes not steeper than 12:1 for adjacent sodded areas. See figures for additional section details. Care must be exercised by the engineer to provide a safe design in relation to public areas.

(C) Flow Velocities in Channels: Velocities shall not exceed 4 fps for sections sodded in grass. Velocities in concrete lined or paved sections shall not exceed 15 fps. The dissipation of energy

shall be required at the confluence of improved channels with natural channels through the use of energy dissipaters, stilling basins, etc.

(D) Trickle Channels: All primary and secondary channels within or adjacent to the development shall have a concrete trickle channel to prevent erosion, permanently set the flowline, and facilitate maintenance. Sodding or other methods of erosion control shall be required adjacent to the concrete trickle channel.

(E) Concrete Flumes: Concrete flumes shall be allowed as overflow protection for stormsewer systems and in lieu of enclosed pipe to drain areas not exceeding two (2) acres in size. All concrete flumes shall extend to the rear of adjacent lots, have scour protection at their point of discharge, and shall discharge into a dedicated drainage area or channel without creating drainage or erosion problems.

(F) Concrete flumes that serve as overflow protection at a sump-position stormsewer system shall be designed for the 100-year storm event flow under the conditions that all upstream inlets and grates are experiencing clogging in accordance with the STD-400 clogging factors and the sump position inlets / grates are totally clogged. The weir length of the entrance to the flume shall be sufficiently sized to convey that flow from the street gutter to the flume without allowing overtopping of the street curb or exceeding street water depth design criteria.

(G) Concrete flumes that serve as the primary conveyance avenue in a sump position shall be designed for the 100-year storm event flow under the conditions that all upstream inlets and grates are partially clogged. The weir length of the entrance to the flume shall be sufficiently sized to convey that flow from the street gutter to the flume without allowing overtopping of the street curb or exceeding street water depth design criteria.

(H) The weir length of the entrance to a flume on grade shall be designed for the amount of flow intercepted by the flume considering the street slope, etc.

(I) Bar ditches (often referred to as "drainage ditches") are an acceptable method to convey stormwater runoff along unimproved section line roads. All bar ditches and driveway culverts shall be designed by the engineer to convey the 100-year storm event. The minimum acceptable driveway culvert diameter is 15"along roadways.

(J) Reinforced concrete box structures shall have an apron reinforced with rebar. The apron shall be tied to the box structure with rebar and have a toe wall. Adequately sized riprap shall be provided to protect the end of the apron and toe wall. Energy dissipaters also shall be used where riprap alone is inadequate to reduce discharge velocities. The reinforced concrete box structure shall be designed to have a minimum freeboard at its inlet from the 100-year storm event water surface elevation to its low chord equal to 1' to help compensate for potential blockage from debris during flooding. The use of Manning's Equation for sizing reinforced concrete box structures at street crossings shall not be acceptable. Engineering programs such as HY-8, Hec Ras, Hec-2 and others utilizing the energy equation and approved nomographs will be considered acceptable.

SECTION VI
SUMP POSITION FLOOD PROTECTION

PURPOSE: The following criteria shall be used to help prevent the flooding of structures which are situated adjacent to sump positions in streets.

DESIGN CRITERIA: (A) In a location where the stormsewer improvements already have been constructed, the builder/owner shall provide to the City a hydrologic and hydraulic drainage study and model prepared by a professional engineer licensed to practice in the State of Oklahoma. The study shall be based on surveyed data accompanied by a proposed grading plan, proposed site plan, and any proposed drainage structures or alterations of existing structures. The study shall demonstrate that all of the following design criteria have been met:

(1) The proposed structure shall have at least 1' of freeboard on all sides above the 100-year storm event water surface elevation including all mechanical and electrical equipment servicing the structure, but excluding ductwork. A proposed structure with a basement or walk-out shall be reviewed by the City Engineer to determine if the 1' freeboard requirement shall apply to it; the decision shall be based on the proposed building plans, site plan, location of the sump position, and the likelihood of flooding.

(2) This study shall be done with runoff quantities calculated as specified in Section II under the conditions that all of the upstream inlets and grates are partially clogged as per the design criteria in Section IV, while any existing inlets and/or grates at the sump position are totally clogged. The study shall demonstrate where and at what depth the flow overtops any curbs and the flowpath(s) the runoff will take via flumes, swales, and overland in the vicinity of the property. Flow velocities also shall be provided.

If the above are adequately demonstrated, the City Engineer shall be allowed to approve the building of the proposed structure in accordance with the submitted study and plans. The City Engineer may require a drainage easement or other remedies to help ensure that the structure shall be safe from flooding.

Before the issuance of a Temporary Certificate of Occupancy or Certificate of Occupancy, the following shall be required:

(1) Certified surveyed as-built plans of the structure,

grading, and all required drainage structure alterations or improvements to demonstrate compliance with the model shall be submitted to the City and approved; and

(2) The submittal and acceptance of a FEMA Elevation Certificate as applicable demonstrating compliance with the model; and

(3) Any other requirements placed upon the Building Permit by the City Engineer such as drainage easements shall be met.

(B) For new developments and site plans, the sump position locations shall be designed with an emergency overflow flume. The overflow flume shall be sized to handle the 100-year storm event under the conditions that the existing inlets and/or grates at the sump position are 100% blocked and all upstream inlets and grates are partially clogged per design standards. The flume entrance shall have sufficient weir length to capture this flow and the flow shall remain within the flume to the back of the lot(s). A sufficiently sized drainage easement, minimum 25', shall be provided. Certified surveyed as-builts shall be provided to document that the streets, stormsewer, and flume(s) in this drainage basin were constructed in accordance with the approved plans and drainage study and function in accordance with STD-400.

SECTION VII
DEVELOPMENT GRADING

PURPOSE: The purpose of this section is to require proper planning and execution of grading layouts to ensure that the street grades, floor elevations, and lot grades are in proper relation to each other and to existing topography, considering property protection, appeal, and use.

DESIGN CONSIDERATIONS: (A) Non-Residential and Residential Multi-Family Structures: All roofs, paved areas, yards, courts and courtyards shall drain into a stormsewer system or to an approved place of disposal not generally including existing streets.

Site plans detailing the layout and design of the stormwater runoff system shall be submitted for approval prior to the issuance of a Building Permit. All design submittals shall detail the location and features of a proposed drainage system. The submittals shall include, but not be limited to, grading plans, drainage plans, utility plans, and erosion control plans.

(B) Residential One-Family or Two-Family Structures:

(1) In single family residential, duplex, or mobile home developments, stormwater runoff from each dwelling lot may be discharged onto flat areas such as streets or lawns if sufficient slope is provided so that the stormwater will flow away from the building.

(a) Grading shall be carried out in such a manner that surface water from each lot will flow directly to a storm sewer, improved channel or paved street without crossing more than two (2) adjacent lots.

(b) It shall remain the responsibility of the Builder /Developer of a lot to ensure proper and prudent lot grading. The Builder /Developer shall follow the grading plan established for that lot, or in the absence of such a plan the Builder/Developer shall grade the lot following the existing, natural drainage patterns for the area. In no case shall a Builder/Developer direct, redirect, or change the historic patterns of the stormwater runoff entering or exiting the lot.

(2) Development Grading Plans: The submittal of a

Grading Plan shall be required as part of Final Plan submittal. The Grading Plan shall incorporate but not be limited to the following:

(a) Determine the type (front to rear, side to rear, rear to front, etc.) of grading for each block, lot, or portion of a development and indicate the grading type for each area by identifying letter or drainage arrows.

(b) Determine the necessity for easements and other provisions needed for satisfactory drainage, maintenance and erosion control.

(c) Determine general grading limitations for local conditions, such as minimum gradients for grass slopes and swales.

(d) For each area, determine the necessity for specific grading limitations along a typical grading control line from street to the house and determine the minimum street-to-floor rise (if applicable).

(e) For each development, determine reference elevations for key points giving due consideration to street elevations and existing topography.

(f) The Owner/Developer shall provide a Builder/Developer with the approved grading plan.

(3) Building Permit Applicant

(a) The Permit Applicant (Builder) shall become familiar with the various lot grading types proposed for a particular development.

(b) The Builder shall submit, along with the Building Permit Application, a detailed site plan showing the proposed grading by identifying letter or drainage arrows.

(c) Establish key elevations or other referenced markers to the grading type and anticipated stormwater runoff for the development area.

(d) Prior to finish grading, establish grade stakes as necessary. Provide a 5% positive slope away from all sides of the structure as per the International

Building Codes and check the entire lot for proper drainage according to the Grading Plan.

SECTION VIII
STORMWATER STORAGE

GENERAL:

The purpose of stormwater storage is to not cause damage to adjacent or downstream property not owned by a developer who is changing the flow rate, location of discharge points or duration of flooding of stormwater leaving his property by limiting stormwater runoff rates after development to their historic value.

Detention basins can be used in an attempt to replicate the characteristics of natural infiltration, storage, and the attenuation of flow that is lost through urbanization. The objectives are to provide a volume of storage to compensate for that lost by development of the land, and to control the detention basin discharge so that the peak flow after urbanization remains below the pre-urban peak for a given year.

The terms, detention, retention, and sedimentation basin shall have the meanings used below:

(A) DETENTION FACILITY - A surface water runoff storage facility that is normally dry but is designed to hold (detain) surface water temporarily during and immediately after a runoff event.

(B) RETENTION FACILITY - A surface water runoff storage facility that normally contains (retains) a substantial volume of water to serve recreational, aesthetic, water supply, or other function. Surface water runoff is temporarily stored above the normal stage during and immediately after runoff events.

(C) SEDIMENTATION BASIN - A surface water runoff storage facility intended to trap suspended solids, suspended and buoyant debris, and reduce potential pollutants which are carried by surface water runoff. The basin may be part of an overall multipurpose stormwater drainage system.

LOCATION CONSIDERATIONS FOR STORMWATER STORAGE:

(A) Private wet detention facilities or lakes may be constructed by the developer on a secondary channel, and such will be owned and maintained by the developer or property owner(s) within the subdivision. These private detention facilities shall be designed and constructed in accordance with all applicable sections of City code and this policy. The private wet detention facilities shall be

maintained in perpetuity by the property owner(s), their assigns and successors so that they do not create a public nuisance. Standards for maintenance are set out in City code Chapter 15. Property owners abutting the wet detention facility or lake shall not create any encroachment upon the facility within the 100-year flood elevation and a restrictive covenant of the subdivision shall provide for this prohibition. The restrictive covenants shall set out that the property owner(s) shall be responsible for all costs related to maintenance and liability and also insure perpetual access to the wet detention facility for maintenance and repair purposes.

(B) When a private wet detention facility includes any designated floodplain it shall also be constructed in accordance with Chapter 19A of City code.

(C) Construction plans for a public or private wet detention facility or lake shall be prepared and signed by a licensed engineer and include a hydrologic and hydraulic study showing that peak release rates for the 10, 50 and 100-year storm events do not exceed the historic rates for that drainage area. In addition, the study shall show that the outflow from the detention facility or lake shall have no adverse impact on the receiving channel or any upstream, downstream or adjacent properties. Adverse impacts would include but are not limited to increasing velocities to erosive levels, causing an increase in flooding of upstream, downstream or adjacent properties that currently flood and/or cause flooding of upstream, downstream or adjacent properties that currently do not flood. This study will be included with the building permit application or in the construction plat stage of a subdivision's development. If the private detention facility is part of a phased construction plat, then the consulting engineer must indicate the phase in which the private detention facility will be constructed based upon the standard set forth herein.

(D) The record plat which includes the private detention facility or lake shall assign the facility a lot and block number for clarification and shall also have embossed on the face of the plat a declaration that the private detention facility or lake is privately owned and maintained.

(E) Design of stormwater storage facilities by a licensed professional engineer shall include an analysis of the downstream effects on peak flows as follows:

(1) Residential developments including duplex and mobile home developments of 20 acres and larger shall submit a

model of the stormwater storage outflow hydrograph.

(2) Non-residential and all other developments, not included in (1) above, of 10 acres and larger shall submit a model of the stormwater storage outflow hydrograph.

(F) Hydrologic and hydraulic modeling and routing of outflow hydrographs downstream shall be required under criteria above and will be accomplished through the use of HEC-1, HEC-HMS and HEC-2, HEC-RAS computer programs or similar models acceptable to the City Engineer.

(G) The length of a stream reach requiring modeling shall be either (1) to a point where no increase in peak flow is demonstrated or (2) to a point where an increase in peak flow does not increase the depth of flooding.

(H) The City shall make available all existing data on stormwater flows in its possession from sources such as Master Drainage Studies or Flood Insurance Studies (FIS).

(I) In the event peak flow studies indicate a development cannot comply with the criteria stated in "C" above, then alternative methods of stormwater runoff control may be allowed if the developer pays a fee-in-lieu of detention. Alternative methods may include but not be limited to: release of larger peak flows, decrease of peak flows released, release of all or certain storm events in lieu of detention, and/or provide channel improvements in lieu of detention.

DESIGN CONSIDERATIONS FOR RAINFALL AND RUNOFF STORAGE:

Storage may be accomplished by the detention or retention of water in reservoirs, parks, side channels, or ponds either on or off-site.

Stormwater storage shall be required where the proposed development will be changing the existing state of the drainage area and subsequent stormwater runoff.

However, in the event a complete drainage study by a licensed professional engineer demonstrates that an increase in downstream flooding would occur if on-site stormwater detention was provided or that there would be no detrimental effect to all upstream, adjacent, and downstream properties if stormwater detention was

not provided, the requirement for stormwater storage may be waived by the City Council providing that a fee in-lieu of detention may be required.

Possible conditions where stormwater storage may not be required could be as follows:

(1) The lower reaches of a drainage basin where a well-defined floodplain or major water body provides potential stormwater storage needs.

(2) Areas where channel improvements are existing which provide the capacity and flooding protection required for basin development.

(3) Areas where the confluence of two or more tributaries of a drainage channel might produce unfavorable increases in flooding depths.

(4) Changes in existing timing patterns such that peak flows are cumulative and might produce increases in flooding depths downstream.

The above examples should not be considered the only cases where stormwater storage might be waived nor should the above be considered only those conditions requiring review. An engineer submitting a request to waive the stormwater storage requirement will be required to produce a detailed drainage study containing any information necessary for the City to make a determination. No limits of the extent of a study should be assumed by an engineer as none are provided.

(A) The sizing of storage facilities shall be by an approved method such as HEC-HMS, American Public Works Association (APWA) Unit Hydrograph, SCS, HEC-1, etc. All stormwater storage facilities shall be analyzed by routing an inflow hydrograph through the storage outlet structure(s). All data, calculations and assumptions shall be provided in report form.

(B) The detention facility shall be designed based upon the maximum allowable release rates. The release rates will be established based upon natural state runoff characteristics from the development site. A continuous probability or recurrence interval criterion shall be used in designing the outlet control structure. As a minimum the outlet control structure shall be designed for the 10, 50 and 100-year recurrence intervals.

(C) Rooftop storage, if used, shall be designed into the original building plans and not added to existing structures as an afterthought due to possible structural failure as well as water damage to the building contents through leakage. Such plans shall bear the seal of a registered architect or registered professional engineer. The roof should drain within twelve (12) hours. Temporary roof dams of loose gravel shall not be allowed.

(D) When a combination of storage facilities are used to control runoff, the system as a whole shall be designed with discharge rates in accordance with (B) above.

(E) All storage facilities shall be provided with a paved or otherwise scour-protected emergency spillway sized to handle the entire 100-year storm event and with scour protection at its downstream end. Earth embankments shall have side slopes not steeper than 4:1 (horizontally:vertically). Proper materials shall be specified with the corresponding optimum compaction according to standards to provide stability and minimum seepage.

(F) The outlet to a detention pond should extend to the storm sewer, creek, or other suitable location covered by a drainage easement.

(G) The engineer shall take into account the flow that would be discharged through the emergency overflow spillway during the 100-year storm event with total blockage of all other outlets of the detention pond when designing the emergency spillway, and shall provide a safe means to convey said water without adversely affecting downstream properties.

(H) The storage volume of a storage facility shall be oversized 10% to allow for sedimentation.

(I) Erosion control for storage and/or detention facilities shall be in accordance with Section IX Erosion and Sedimentation Control.

(J) A paved access road shall be provided to all storage areas for maintenance purposes. For those owned and maintained by the City, the access road shall be dedicated as part of the storage area.

(K) Earth dams or other earth embankments shall be designed by a licensed professional engineer in accordance with accepted engineering practices to assure that dam or embankment failure

will not occur. Design criteria used by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service, in the selection of materials and construction procedures will be acceptable.

(L) Property line swale ponding and small on-site ponds, if used, shall be examined for possible adverse effects on building foundations due to saturation of the soil.

(M) Parking lot storage may be considered for providing the required detention. The use of parking lots for storage shall be well designed to minimize the potential damage and/or threat to pedestrians, emergency responders and vehicles, and parked vehicles. In no case shall the depth of ponding in a parking lot exceed six inches (6") during a 10-year storm**.**

(N) Structures adjacent to a detention and/or retention basins shall have their finished floors (excluding ductwork) set at a minimum of one foot (1') above the top of the projected 100-year water surface elevation in the emergency spillway calculated under the conditions that all other outlets of the basin are blocked.

(O) Public safety of the detention pond and outlet works, both in a passive condition and when functioning shall be addressed in design.

(P) All detention bypass areas on the development must be identified. Increased runoff from bypass areas shall not detrimentally affect adjacent and downstream properties.

(Q) Detention facilities to be dedicated to the City shall be designed and constructed to City standards as a visual amenity consistent with the existing topography and proposed development and should be designed with multi-use potentials related to recreation taken into consideration.

The use of large unnatural depressions which disrupt the continuity of the landscape shall be avoided. Length to width ratios should be investigated in relation to depth of the proposed facility to improve the aesthetic appearance of storage facilities. The geometric layout of detention facilities shall be such that multi-purpose use is available.

Outlet control facilities shall include headwalls, slopewalls, energy dissipaters, and any additional outlet erosion and scour control measures approved by the City Engineer. The outlet facilities, as a

visible part of any storage facility, shall include landscape plantings to improve aesthetics and provide a more pleasant and appealing appearance.

SECTION IX
EROSION AND SEDIMENTATION CONTROL

PURPOSE: The purpose of this section is to provide guidance in the design of effective management of erosion and sedimentation and to protect water quality and the general health, safety, and welfare of the residents of the City of Lawton.

GENERAL REQUIREMENTS:

(A) Development activity shall not be conducted unless appropriate erosion and sedimentation facilities are designed, installed, and maintained throughout the life of the development.

(B) All erosion and sediment control methods shall be indicated on the final construction and/or building permit plans.

(C) All earthen slopes and areas, new or existing, subject to erosion, including areas adjacent to trickle channels, inlet structures, and outlet structures, within any area designated for detention or drainage shall be solid slab sodded with Bermuda grass sod from a local source or have a permanent established growth of vegetation (grass). All sodded areas shall be fertilized, watered, and in an established growing condition with permanent vegetation prior to completion or acceptance of any stormwater drainage facility, and/or development.

DESIGN CONSIDERATIONS:

(A) General Design Principles. Practical combinations of the following principles shall be utilized, as a minimum, in planning measures to be installed for any land disturbing activity.

(1) The land disturbing activity shall conform to existing topography and soil type so as to create the lowest practicable erosion potential.

(2) The disturbed area and the duration of exposure of bare earth to erosive elements shall be kept to a practicable minimum through construction scheduling and management.

(3) Cut and fill operations should be kept to a minimum.

(4) Disturbed soil shall be stabilized as quickly as practicable.

(5) Natural vegetation shall be retained, protected, and

supplemented whenever feasible.

(6) Temporary vegetation or mulching shall be employed in a timely manner to protect exposed critical areas during development.

(7) Permanent vegetation and structural erosion control measures shall be installed prior to final acceptance of developments or as soon as seasonal planting restrictions allow. Temporary sediment/erosion control measures shall be constructed and maintained until the permanent measures are fully established.

(B) General Practice: soil and water conservation measures include but are not necessarily restricted to vegetation, mulches, sediment basins, dikes, grade stabilization structures, sediment traps, land grading, diversions, waterways or outlets, and riprap.

Vegetative practices shall be applied to control erosion. The practice can be either temporary and/or permanent depending on the site specific needs.

EROSION AND SEDIMENT CONTROL CRITERIA:

(A) Long term permanent vegetative cover obtained through seeding, mulching, sprigging or sodding of Bermuda grass shall be used to control erosion on a permanent basis.

(B) Short term vegetative cover through seeding or mulching using small grains like oats, rye and wheat, and sundans and sorghums, shall be used to control immediate erosion. This practice may be effective for areas where soil is left exposed for a period of 6 to 12 months and shall not be deemed permanent erosion control.

Straw bale dikes may be utilized where no other practice such as silt dikes or silt fences are feasible. This temporary barrier with a life expectancy of three months or less can be installed across or at the toe of a slope for the contributing drainage areas in accordance with the adopted standards.

Hay and sod mulching, as a temporary measure, may be used for embankment stabilization in areas where surface runoff is to be directed down a slope.

Erosion matting shall be used for channel embankment and slope

stabilization where a permanent erosion control cover has not been established prior to use. The specified material shall be installed as recommended by the manufacturer of the proposed material.

(A) A coarse rock stabilized construction entrance shall be built in accordance with the adopted standards to reduce or eliminate the tracking or flowing of sediment onto the public right-of-way.

(B) A concrete or stone outlet structure shall be constructed in areas where the entire drainage area to the structure is not stabilized or where there is a need to dispose of runoff at a protected outlet or where concentrated flow for the duration of the period of construction needs to be diffused.

(C) A grade stabilization structure in the form of a paved chute or flume shall be constructed to prevent erosion where concentrated flow of surface runoff is to be conveyed down a slope of 3% or greater.

(D) Stormwater detention facilities may be used temporarily as sediment basins. A temporary outlet structure for the stormwater detention facility to work as a sediment pond shall be constructed. At the end of the construction activity, the developer shall remove all collected sediment from the detention facility and outlet structure and restore / construct the facility to the approved detention design plans.

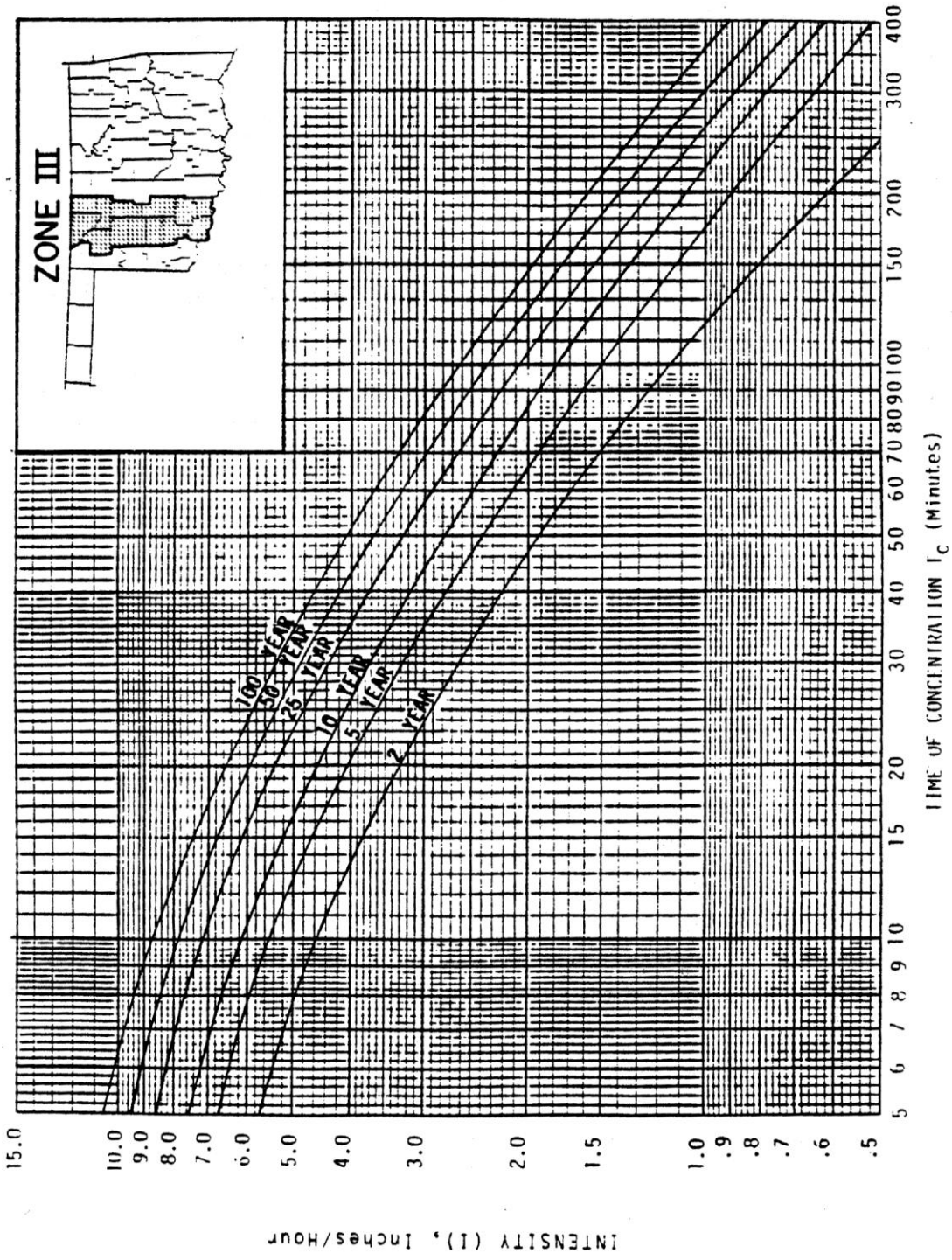
ZONE III
100 YEAR
50 YEAR
25 YEAR
10 YEAR
5 YEAR
2 YEAR
INTENSITY (I), Inches/Hour
15.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.5
1.0
.9
.8
.7
.6
.5
5 6 7 8 9 10 15 20 30 40 50 60 70 80 90 100 150 200 300 400
TIME OF CONCENTRATION T_C (Minutes)

Figure 1

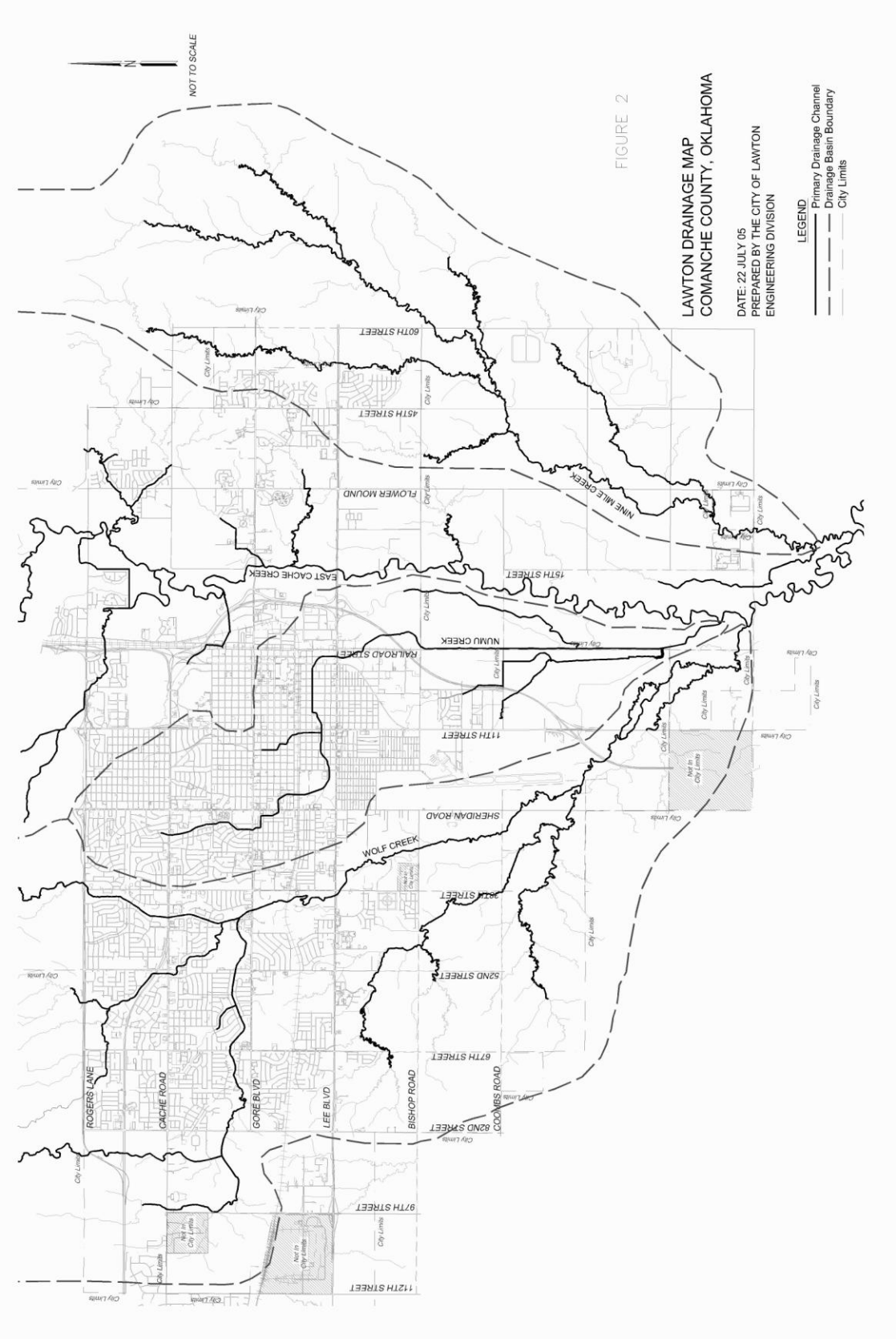
FIGURE 2
LAWTON DRAINAGE MAP
COMANCHE COUNTY, OKLAHOMA
DATE: 22 JULY 05
PREPARED BY THE CITY OF LAWTON
ENGINEERING DIVISION
LEGEND
Primary Drainage Channel
Drainage Basin Boundary
City Limits
N
NOT TO SCALE
NINE MILE CREEK
EAST CACHE CREEK
NUMU CREEK
WOLF CREEK
FLOWER MOUND
RAILROAD SIDE
SHERIDAN ROAD
COOMBS ROAD
BISHOP ROAD
LEE BLVD
GORE BLVD
CACHE ROAD
ROGERS LANE
60TH STREET
45TH STREET
15TH STREET
11TH STREET
92ND STREET
82ND STREET
67TH STREET
97TH STREET
112TH STREET
City Limits
Not in City Limits

Figure 2