CARROLLTON
TEXAS

STORMWATER AND FLOOD PROTECTION ORDINANCE

JUNE 2015

NDM NATHAN D. MAIER CONSULTING ENGINEERS, INC.
Dallas, Texas
(214) 739-4741

ORDINANCE NO. 3685

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF CARROLLTON, TEXAS, AMENDING THE ORDINANCES OF THE CITY OF CARROLLTON, TEXAS BY REPEALING ORDINANCE NO. 2581 IN ITS ENTIRETY; ADOPTING A NEW STORMWATER AND FLOOD PROTECTION ORDINANCE REGULATING DEVEOLPMENT WITHIN THE CITY NECESSARY TO PROVIDE AND MAINTAIN A SAFE, EFFICIENT, AND EFFECTIVE DRAINAGE SYSTEM WITHIN THE CITY OF CARROLLTON; ESTABLISHING A PENALTY IN ACCORDANCE WITH SECTION 10.99 OF THE CODE OF ORDINANCES; PROVIDING A SAVINGS CLAUSE; PROVIDING A SEVERABILITY CLAUSE; AND PROVIDING AN EFFECTIVE DATE.

WHEREAS, the City Council of the City of Carrollton, Texas ("City Council") adopted Ordinance No. 2581 relating to stormwater and flood protection within the City of Carrollton, Texas ("City"); and

WHEREAS, certain revisions to Ordinance No. 2581 are necessary to reduce conflicts with state and federal regulatory requirements and provide for environmentally responsible development within the City; and

WHEREAS, the City Council has determined that it would be advantageous and beneficial to the citizens of the City to adopt a new stormwater and flood protection ordinance; and

WHEREAS, the City Council desires to repeal Ordinance No. 2581, while retaining any existing cause of action ; and

WHEREAS, the City Council has investigated and determined that the above-referenced regulations are necessary to protect the health, life, and property of the citizens in the City and comply with state regulations.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF CARROLLTON, TEXAS, THAT:

SECTION 1.

The above and foregoing premises are found to be true and correct and are incorporated herein and made a part hereof for all purposes.

SECTION 2.

The Code of Ordinances of the City of Carrollton is hereby amended by repealing Ordinance No. 2581 in its entirety.

SECTION 3.

The "Stormwater and Flood Protection Ordinance", attached hereto as Exhibit "A" and incorporated herein by reference for all purposes, is hereby adopted as Chapter 174 of the Carrollton Code of Ordinances.

SECTION 4.

The sections, paragraphs, sentences, phrases, clauses and words of this Ordinance are severable, and if any section, paragraph, sentence, phrase, clause or word in this Ordinance or application thereof to any person or circumstance is held invalid or unconstitutional by a court of competent jurisdiction, such holding shall not affect the validity of the remaining portions of this Ordinance, and the City Council hereby declares that it would have passed such remaining portions of this Ordinance despite such invalidity, which remaining portions shall remain in full force and effect.

SECTION 5.

This Ordinance shall be cumulative of all other ordinances of the City, and shall not repeal any of the provisions of those ordinances except in those instances where the provisions of those ordinances are in direct conflict with the provisions of this Ordinance; provided, however, that any complaint, notice, action, cause of action, or claim which prior to the effective date of this Ordinance has been initiated or has arisen under or pursuant to such other ordinance(s) shall continue to be governed by the provisions of that ordinance or those ordinances, and for that purpose that ordinance or those ordinances shall be deemed to remain and shall continue in full force and effect.

SECTION 6.

This Ordinance shall take effect immediately upon its adoption and publication in accordance with and as provided by law and the City Charter.

DULY PASSED AND APPROVED by the City Council of the City of Carrollton, Texas, this 9th day of June, 2015.

CITY OF CARROLLTON, TEXAS

Matthew Marchant, Mayor

ATTEST:

Krystle Nelinson, City Secretary

CITY OF CARROLLTON CARROLLTON, TEXAS

APPROVED AS TO FORM:

Meredith Ladd, City Attorney

APPROVED AS TO CONTENT:

Cesar Molina,
Director of Engineering Services

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CODIFIED AS CHAPTER — OF THE CARROLLTON CITY CODE OF ORDINANCES

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CITY OF CARROLLTON, TEXAS

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Matthew Marchant, Mayor

ATTEST:

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Krystle Nelinson, City Secretary

APPROVED AS TO FORM:

_____
Meredith Ladd, City Attorney

APPROVED AS TO CONTENT:

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Cesar Molina,
Director of Engineering Services

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ARTICLE 1

SECTION 1

TITLE, FINDINGS OF FACT, STATEMENT OF PURPOSE, AND SCOPE OF AUTHORITY

ORGANIZATION OF THIS ORDINANCE

SECTION A. Title

This Ordinance shall be known as the "Stormwater and Flood Protection Ordinance" of the City of Carrollton, and shall include Exhibit "A", attached hereto and incorporated by reference for all purposes.

SECTION B. Findings of Fact

1. The drainage ways and flood hazard areas of the City of Carrollton, Texas, are subject to periodic inundation which may result in loss of life and property, health and safety hazards, disruption of commerce and governmental services, and extraordinary public expenditures for flood protection and relief, all of which adversely affect the public health, safety, and general welfare.

2. These flood losses are created by the cumulative effect of obstructions in floodplains that increase flood heights and velocities and by the occupancy of flood hazard areas by uses vulnerable to floods and hazardous to other lands because they are inadequately elevated, floodproofed, or otherwise protected from flood damage.

SECTION C. Statement of Purpose

This Ordinance sets forth the minimum requirements necessary to provide and maintain a safe, efficient, and effective drainage system within the City and to establish the various public and private responsibilities for the provision thereof. Further, it is the purpose of this Ordinance to:

1. Protect human life, health, and property;

2. Minimize expenditure of public money for drainage related projects;

3. Minimize damage due to drainage to public and private facilities and utilities such as water and gas mains, electric service, telephone and sewer lines, streets and bridges;

4. Help maintain a stable tax base and preserve land values;

5. Ensure that potential buyers are notified that property is in an area of special flood hazard;

6. Ensure that those who occupy the areas of special flood hazard assume responsibility for their actions;

7. Preserve the natural beauty and aesthetics of the community;

8. Control and manage all stormwater runoff and drainage from points and surfaces within subdivisions;

9. Provide for control measures for protecting stormwater quality;

10. Establish a reasonable standard of design for development that prevents potential flood and stormwater damage.

SECTION D. Scope of Authority

Except as exempted by Article 3, Section A; Article 7, Section A; and Article 9, Section C, any person, firm, corporation, or business proposing to develop land or improve property within the City is subject to the provisions of this Ordinance. The provisions of this Ordinance also apply to individual building structures, subdivisions, excavations and fill operations, and similar activities. The scope of authority extends to additional improvements on projects, developments, subdivisions, etc., which were previously permitted and/or constructed under the authority of prior ordinances or guidelines. The implementation of the requirements of this ordinance are intended to result in improvements that meet or exceed applicable State and Federal requirements.

SECTION E. Organization of This Chapter

This Ordinance revises the provisions of the former "Stormwater and Flood Protection Ordinance" (Ordinance No. 2581). Further, it expands and clarifies various aspects of the former ordinance. The following list is a synopsis of the contents of each article.

Article 1 - Title, Findings of Fact, Statement of Purpose, and Scope of Authority - Discusses the purposes, scope, and authority of this ordinance, and provides a penalty for noncompliance with this chapter.

Article 2 - Definitions - Lists and defines various terms used in this ordinance.

Article 3 - General Provisions - States general provisions related to implementation and enforcement of this ordinance.

Article 4 - Administration - Overviews the administrative procedures to be followed for obtaining the necessary City drainage approvals related to building on or improving property.

Article 5 - Runoff Calculations - Explains the methodologies to calculate runoff quantities.

Article 6 - Design of Local Drainage Systems - Gives the design standards for building local drainage systems (i.e., enclosed storm sewers).

Article 7 - Special Drainage Facilities - States additional design standards for specialty drainage system items.

Article 8 - Floodplain Guidelines - Presents the floodplain regulations, including the requirements to be met when reclaiming floodplain land.

Article 9 - Special Provisions: Trinity River Corridor Development Certificate Process - Presents additional regulations for activities within the Regulatory Zone of the Elm Fork Trinity River and tributaries.

Article 10 - Stormwater Discharge Quality - Provides requirements for controlling stormwater runoff quality for post-construction conditions using Permanent Best Management Practices.

SECTION F. Related Ordinances

In addition to this ordinance, the City of Carrollton has other ordinances, regulations, and specifications pertaining to drainage and storm sewer facilities. These other documents include, but are not limited to, the City's Comprehensive Zoning Ordinance ("CZO"), City's subdivision ordinance, the Standard Specifications for Public Works Construction by the North Central Texas Council of Governments, as amended by the City, and the General Design Standards for the City of Carrollton, which shall remain in full force and effect. Provided, however, if there is any conflict between such prior ordinances, regulations, or specifications and this Ordinance, this Ordinance shall prevail.

ARTICLE 2

DEFINITIONS

For purposes of this Ordinance, certain terms, phrases, words and their derivatives shall be construed as specified in this Ordinance, unless the context clearly indicates or requires a different meaning. Where terms are not defined, they shall have their ordinary, accepted meanings within the context with which they are used. Webster's Third New International Dictionary of The English Language, Unabridged, copyright 1986, shall be considered as providing ordinary, accepted meanings. Words in the singular shall include the plural and the plural the singular. Words used in the masculine gender shall include the feminine and the feminine the masculine

1. Appeal

   A request for review or interpretation of any provisions of this Ordinance or a request for a variance.

2. Area of Special Flood Hazard

   The land in the floodplain within a community subject to a one percent or greater chance of flooding in any given year.

3. Base Flood

   The flood having a one percent chance of being equaled or exceeded in any given year, determined based upon FEMA guidelines and as shown in the current effective Flood Insurance Study.

4. Base Flood Elevation

   The water surface elevation resulting from the base flood.

5. Bioengineering

   Bioengineering is the practice of including elements that involve the use of vegetation for the protection and stabilization of drainage improvements. Bioengineering improvements may include the combination of both structural and vegetation elements in an overall improvement plan.

6. Biologist/Botanist

   Biologist or Botanist shall mean a person with a minimum of a Bachelor of Science Degree in Biology, Botany, Ecology or Environmental Science from an accredited college or university.

7. City

   The City of Carrollton, Texas.

8. City Council

   The City Council of the City of Carrollton.

9. City Manager

   The person appointed to the position of City Manager by the City Council of the City of Carrollton, or his/her duly authorized representative.

10. Conduit

Any closed device for conveying flowing water.

11. Construction

Any human activity that involves clearing, grading, excavation, landfilling, or other placement, movement, removal, or disposal of soil, rock, or other earth materials.

12. Corridor Development Certificate ("CDC")

A required permit process managed by the City's Floodplain Administrator for activities within the Regulatory Zone of the Trinity River and its tributaries.

13. Design Flood

The flood having a one percent chance of being equaled or exceeded in any given year based upon fully developed watershed conditions.

14. Detention Basin

A dry basin or depression constructed for the purpose of temporarily storing stormwater runoff and discharging all of that water over time at a reduced rate than would have otherwise occurred. (See Retention Basin for wet basin, depression, or pond).

15. Developer

A person, partnership, or corporation engaged in the development of land and/or building of structures and not excluded by exemption sections of this Ordinance. For purposes of this Ordinance, the term developer shall include the owner.

16. Development

Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, drilling operations, grading, or clearing.

17. Discharge

Rate of stormwater runoff for flood waters flowing in a river, creek, channel, storm sewer system or other stormwater conveyance system.

18. Elevated Building

In the case of Zones A1-30, A, A99, AO, B, C, D, V1-V30, and any other designated FEMA Zone, an elevated building includes a building elevated by means of fill so that the finished floor of the building is at least two feet (2') above the water surface elevation of the design flood.

19. Entrance Head

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

20. Entrance Loss

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

21. Environmental Protection Agency (EPA)

The United States Environmental Protection Agency, the regional office thereof, any federal department, agency, or commission that may succeed to the authority of the EPA, any duly authorized official of EPA or such successor agency.

22. Equal Conveyance

Principle of reducing stream conveyance for a proposed alteration with a corresponding reduction in conveyance to the opposite bank of the stream. The right of equal conveyance applies to all owners and uses and may be relinquished only by written agreements.

23. Erosion

The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. In this Ordinance, erosion due to stormwater runoff is the primary design issue.

24. Existing Construction

For the purposes of determining rates, structures for which the "start of construction" commenced before the effective date of Ordinance 905. "Existing construction" may also be referred to as "existing structures".

25. Facility

Any building, structure, installation, process, or activity from which there is, or may be, a discharge of pollutant.

26. Federal Emergency Management Agency (FEMA)

Federal agency which administers the National Flood Insurance Program.

27. Flood or Flooding

A general and temporary condition of partial or complete inundation of normally dry land areas from:

(1) The overflow of inland waters and/or

(2) The unusual and rapid accumulation or runoff of surface waters from any source.

28. Flood Insurance Rate Map (FIRM)

The official map on which the Federal Emergency Management Agency has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

29. Flood Insurance Study

The official report in which the Federal Emergency Management Agency has provided flood profiles, the water surface elevation of the base flood, as well as the Flood Boundary-Floodway Map.

30. Flood Protection System

Those physical structural works 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, levees or dikes. These specialized flood modifying works are those constructed in conformance with sound engineering standards.

31. Floodplain or Flood-prone Area

Any land area susceptible to being inundated by water from any source (see definition of flooding).

32. Floodplain Administrator

The City Manager or his designee appointed to administer and implement this Ordinance and other appropriate sections of 44 CFR (Emergency Management and Assistance National Flood Insurance Program Regulations) pertaining to floodplain management.

33. Flume

Any open conduit on a prepared grade, trestle, or bridge.

34. Freeboard

The vertical distance between the design flood elevation and the top of an open channel, dam, levee, or detention basin to allow for wave action, floating debris, or any other condition or emergency without overflowing the structure.

35. Hard Mast Producing Trees

Hard mast producing trees are trees that produce a hard fruit for wildlife consumption. These trees would include Pecans, Oaks, Elms, etc.

36. Hydraulic Gradeline

A line representing the pressure head available at any given point within the drainage system.

37. Levee

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 so as to provide protection from temporary flooding.

38. Levee System

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.

39. Licensed Professional Engineer (LPE) or Professional Engineer (PE)

A person who has been duly licensed and registered by the Texas Board of Professional Engineers for Professional Engineers to engage in the practice of engineering in the State of Texas.

40. Lowest Floor

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 structure in violation of the applicable non-elevation design requirements of FEMA under 44 CFR, 60.3.

41. Manning Equation

The uniform flow equation used to relate velocity, hydraulic radius, and energy gradeline slope.

42. Manufactured (Mobile) Home Park or Subdivision, Existing

A manufactured (mobile) home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured (mobile) homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets and either final site grading or the pouring of concrete pads) is completed on or before December 31, 1974 or before the effective date of the community's initial Flood Insurance Rate Map (FIRM), whichever is later.

For floodplain management purposes, the term "manufactured home" includes manufactured homes, as defined by Texas Occupations Code, § 1201.003, park trailers, travel trailers, and other similar vehicles placed on a site for greater than 180 consecutive days. The term "manufactured home" does not include a "recreational vehicle".

43. Manufactured (Mobile) Home Park or Subdivision, Expansion to Existing Site

The preparation of additional sites by the construction of facilities for servicing the lots on which manufactured (mobile) homes are to be affixed (including the installation of utilities, the construction of streets and either final site grading or the pouring of concrete pads).

44. Manufactured (Mobile) Home Park or Subdivision, New

A manufactured (mobile) home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured (mobile) homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets and either final site grading or the pouring of concrete pads) is completed after December 31, 1974, or on or after the effective date of the community's initial Flood Insurance Rate Map (FIRM), whichever is later.

45. Master Drainage Plans

Master Drainage Plans are specific plans, developed by the City, to identify drainage improvements required for future development and redevelopment in these areas. These include Master Drainage Plans for the Transit Oriented Development areas.

46. Maximum Extent Practicable (MEP)

The goal of reducing adverse impacts through the appropriate design and management of improvements.

47. Mean Sea Level

For purposes of the National Flood Insurance Program, the National Geodetic Vertical Datum (NGVD) of 1988, as amended, or other datum, to which base flood elevations shown on a community's Flood Insurance Rate Map are referenced.

48. Natural Drainage

The dispersal of surface waters through ground absorption and by drainage channels formed by the existing surface topography which exists at the time of adoption of this ordinance.

49. Natural Floodway

The effective area of a channel of a river or other water course and the adjacent land areas that must be reserved in order to discharge the "design flood" without cumulatively increasing the water surface elevation.

50. New Construction

Structures for which the "start of construction" commenced on or after the effective date of Ordinance 905.

51. Notice of Intent (NOI)

The NOI that is required by either the Industrial General Permit or the Construction General Permit. Documentation of construction activity which is submitted to the EPA and the City prior to construction. It serves as notification of construction activity as well as a commitment by the owner that he/she understands the requirements of the NPDES General Permit for Storm Water Discharges From Construction Activities and that measures will be taken to implement and maintain a SWPPP at the site.

52. Notice of Termination (NOT)

The NOT that is required by either the Industrial General Permit or the Construction General Permit. A completed form sent to the EPA and City upon stabilization of the site that serves as notice that the site is no longer subject to the requirements of the NPDES General Permit for Storm Water Discharges From Construction Activities.

53. Open Channel

A channel in which water flows with a free surface.

54. Owner

The person who owns all or part of a facility or property. The terms Owner or Property Owner are used interchangeably and also applies to future owners, heirs, and assigns.

55. Owners Association

Owners Association, Homeowners Association, Property Owners Association, or any other entity or group established by the Developer/Owner, and approved by the City Council, to be the responsible party for performing maintenance of and repairs to approved drainage improvements.

56. Permanent Best Management Practices (PBMP)

Schedules of permanent practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. This also includes treatment requirements, operating procedures, and practices to reduce runoff and limit pollutants in runoff.

57. Person

Any individual, partnership, co-partnership, firm, company, corporation, association, joint stock company, trust, estate, governmental entity, or any other legal entity, or their legal representatives, agents, or assigns. This definition includes all federal, state, and local governmental entities.

58. Probable Maximum Flood (PMF)

The flood magnitude that may be expected from the most critical combination of meteorological and hydrologic conditions that are reasonably possible for a given watershed.

59. Rational Formula

The means of relating runoff with the area being drained and the intensity of the storm rainfall.

60. Recreational Vehicle

Means a vehicle which is (i) built on a single chassis; (ii) 400 square feet or less when measured at the largest horizontal projections; (iii) designed to be self-propelled or permanently towable by a light duty truck; and (iv) designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use.

61. Regulatory Floodway

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

62. Regulatory Zone

The area within the 100-year floodplain of the specified reach of the Trinity River as defined by the latest approved version of the digital Trinity River Corridor Map - CDC Regulatory and Review Zones maintained by NCTCOG.

63. Retention Basin

A pond or other water body which has been designed to have both a conservation pool for holding some water indefinitely and a flood storage pool for storing stormwater runoff on a temporary basis for the purpose of reducing the peak discharge from the basin. (See Detention Basin for a dry basin or depression)

64. Riparian Area

The area along the banks of a river or other natural watercourse.

65. Sanitary Sewer (or Sewer)

The system of pipes, conduits, and other conveyance which carry industrial waste and domestic sewage from residential dwellings, commercial buildings, industrial and manufacturing facilities, and institutions, whether treated or untreated, to the sewage treatment plant serving the City (and to which stormwater, surface water, and groundwater are not intentionally admitted).

66. Sediment

The soil particles uplifted by erosion and deposited through the process of sedimentation. These soil particles settle out of runoff at variable rates based on the size of the particle and soil type.

67. Site

The land or water area where any facility or activity is physically located or conducted, including adjacent land used in connection with the facility or activity.

68. Standard Project Flood

The flood that is developed on a case-by-case basis using the U. S. Army Corps of Engineers' current criteria.

69. Start of Construction

For other than new construction or substantial improvements, under the Coastal Barrier Resources Act (CBRA), this is the date the building permit was issued, provided that the actual start of construction, repair, rehabilitation, addition, placement or other improvement was within 180 days of the permit date. The actual start means either the first placement of permanent construction of a building on site, such as the pouring of a slab or footing, the installation of piles, the construction of columns or any work beyond the stage of excavation; or the placement of a manufactured (mobile) home on a foundation. For a substantial improvement, actual start of construction means the first alteration of any wall, ceiling, floor or other structural part of a building, whether or not that alteration affects the external dimensions of the building.

70. Stormwater

Stormwater runoff, snow melt runoff, and surface runoff and drainage.

71. Structure

A walled and roofed building, a manufactured home, a gas or liquid storage tank, or a substation that is principally above ground.

72. Substantial Damage

Damage of any origin sustained by a building whereby the cost of restoring the building to its before-damaged condition would equal or exceed 50% of the market value of the building before the damage occurred.

73. Substantial Improvement

Any combination of repairs, reconstructions, or improvements of a structure, the cumulative cost of which equals or exceeds fifty percent (50%) of the initial market value of the structure either:

(1) before the first improvement or repair is started, or

(2) if the structure has been damaged and is being restored, before the damage occurred.

For the purpose of this definition, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor, or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure. Incremental improvements over a period of time, the cumulative cost of which equals or exceeds fifty percent (50%) of the market value at the time of the first improvement, shall be considered as a "substantial improvement."

The term does not, however, include either:

(1) any project for improvement of a structure to comply with 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 structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

74. Time of Concentration

The estimated time in minutes or hours required for a drop of water to flow from the most remote point in the drainage area to the point at which the flow is to be determined.

75. Transit Oriented Development Areas

Transit Oriented Development (TOD) Areas are those areas defined by the City around the Dallas Area Rapid Transit corridor. The TOD areas may have specific Master Drainage Plans that have been developed for the areas.

76. Use

Any purpose for which a building or other structure or a tract of land may be designed, arranged, intended, maintained, or occupied; or any activity, occupation, business, or operation carried on, or intended to be carried on, in a building or other structure or on a tract of land.

77. Use Permit

The permit required before any use may be commenced.

78. Variance

A grant of relief to a person from the requirements of this ordinance when specific enforcement would result in unnecessary hardship. A variance, therefore, permits construction or development in a manner otherwise prohibited by this ordinance.

79. Violation

A structure or other development that is not fully compliant with this Ordinance. A structure or other development without the FEMA elevation certificate prior to a certificate of occupancy, other certifications, or other evidence as required by the Floodplain Administrator, is presumed to be in violation until such time as that documentation is provided.

80. Watershed

The area drained by a stream or drainage system.

81. Waters of the United States

All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; all interstate waters, including interstate wetlands; all other waters the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce; all impoundments of waters otherwise defined as waters of the United States under this definition; all tributaries of waters identified in this definition; all wetlands adjacent to waters identified in this definition; and any waters within the federal definition of "waters of the United States" at 40 CFR 122.2; but not including any waste treatment systems, treatment ponds, or lagoons designed to meet the requirements of the Federal Clean Water Act.

82. Water Surface Elevation

The height, in relation to the NGVD or 1929 datum (or other datum, where specified), of floods of various magnitudes and frequencies in the floodplains of riverine areas.

ARTICLE 3

GENERAL PROVISIONS

SECTION A. Lands to Which This Ordinance Applies

This Ordinance shall apply to all areas of land within the city limits of the City of Carrollton, Texas, as may be amended or expanded. Certain provisions of this Ordinance apply only to special flood hazard areas within the City, while other provisions exempt certain other tracts. These limited areas of application are explained in the relevant provisions (See Article 8, Section A). This Ordinance also extends the scope of authority to additional improvements on projects, developments, subdivisions, etc., which were previously permitted and/or constructed under the authority of prior ordinances or guidelines.

Some areas and projects shall be free from meeting selected requirements of this Ordinance. These include, and are limited to the following:

Existing Flood Control Districts, Levee Improvement Districts ("Districts"), and other related districts that have been established for the express purpose of flood control are exempt from meeting some requirements of this Ordinance. These districts are exempt from specific requirements as specified within this Ordinance. The following list sets forth the modified requirements for the Districts for design and maintenance projects:

1. Exempt from the following requirement:
Alterations of the floodplain, excluding ineffective flow areas, shall not increase the water surface elevation of the design flood of the creek beyond the limits established by the City for the "regulatory floodway". For the "regulatory floodway" the impacts cannot impact any upstream, downstream or adjacent property owner. Increases to the water surface elevations may be permitted if all increases are limited to the requirements of the "regulatory floodway" and are contained on the applicant's property and there are no adverse impacts to any property under other ownership. Any increase that exceeds the City's requirements for the "regulatory floodway" must meet the requirements of CFR 44 Section 65.12.

Districts shall meet the following requirement: Alterations of the floodplain, excluding ineffective flow areas, shall not increase the water surface elevation of the design flood of the creek beyond the limits established by the City for the "regulatory floodway". Modifications within the floodway cannot impact any upstream, downstream or adjacent property owner. Increases to the water surface elevations may be permitted if all increases are due to improvements beyond the limits of the FEMA "Regulatory Floodway" and are contained on the District's property or within District's easements and there are no adverse impacts to any property under other ownership. Any increase that exceeds the City's requirements for the "regulatory floodway" must meet the requirements of CFR 44 Section 65.12. Other State and Federal regulations must also be met.

2. Exempt from meeting the permissible velocity requirements.

Districts shall meet the following requirement: The District shall attempt to meet the permissible velocity requirements of this Ordinance for improvements proposed by the District on District property. The District shall be free from these requirements unless the impact extends to private property or areas not maintained by the District. The District shall provide for on-site erosion and sedimentation control for all projects.

SECTION B. Basis for Establishing the Areas of Special Flood Hazard

The areas of special flood hazard identified by FEMA in the Flood Insurance Studies for the City, with accompanying FIRM and Flood Hazard Boundary-Floodway Maps including Dallas County, Texas effective July 7, 2014; Denton County, Texas effective April 18, 2011; Collin County, Texas effective June 2, 2009; or the most recent versions of these studies and maps are hereby adopted by reference and declared to be a part of this Ordinance, as if written word for word herein. The Flood Insurance Studies are on file in the office of the Floodplain Administrator.

SECTION C. Penalty Clause

1. Criminal Penalty - any person, firm or corporation violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor and, upon conviction, shall be punished by a penalty or fine as defined by City code.

2. Civil Penalty - In addition, the violator shall pay all costs and expenses involved in the case. Nothing herein contained shall prevent the City of Carrollton from taking such other lawful action as is necessary to prevent or remedy any violation. Article 4, Section C.6 states an additional penalty against persons proceeding with construction without obtaining the necessary permits from the City.

SECTION D. Abrogation and Greater Restrictions

This ordinance is not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this ordinance and other ordinance, easement, covenant, or deed restriction conflict or overlap, whichever imposes the more stringent restrictions shall prevail.

SECTION E. Interpretation

In the interpretation and application of this ordinance, all provisions shall be:

1. Considered as minimum requirements;

2. Liberally construed in favor of the governing body; and,

3. Deemed neither to limit nor repeal any other powers granted under State statutes.

SECTION F. Warning and Disclaimer of Liability

The degree of flood protection required by this Ordinance is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur on rare occasions. Flood heights may be increased by man-made or natural causes. This Ordinance does not imply that land outside the area of special flood hazards or uses permitted within such areas will be free from flooding or flood damages. This Ordinance shall not create liability on the part of the City, any officer or employee thereof or the FEMA for any flood damages that result from reliance on this ordinance or any administrative decision lawfully made thereunder.

ARTICLE 4

ADMINISTRATION

SECTION A. Duties of City Officials

1. Duties of the Floodplain Administrator

The Floodplain Administrator is hereby appointed to administer and implement the floodplain management portions of this ordinance, including Articles 8 and 9 and other appropriate sections of 44 CFR (National Flood Insurance Program Regulations) pertaining to floodplain management. The duties of the Floodplain Administrator shall include, but not be limited to:

- Review and approval of all development permits to determine that the permit requirements of this ordinance have been met and that necessary State and Federal permits have been obtained;
- Obtain and record the actual elevation in relation to mean sea level of the lowest habitable floor (of structures adjacent to regulatory floodplain areas), including basement of all new or substantially improved structures, and whether or not the structure contains a basement;
- Maintain for public inspection all records pertaining to the provisions of this ordinance, including floodproofing certifications;
- Notify adjacent communities and the Texas Water Development Board ("TWDB"), or other State designated or successor agency, prior to any alteration or relocation of a watercourse that negatively impacts an adjacent community, and submit evidence of such notification to the FEMA;
- Notify adjacent communities prior to any alteration or relocation of a watercourse that requires approval through the CDC process;
- Require that maintenance is provided within the altered or relocated portion of said watercourse so that the flood-carrying capacity is not diminished;
- Make interpretations, where needed, as to the exact location of the boundaries of the areas of special flood hazards (for example, where there appears to be a conflict between a mapped boundary and actual field conditions); and
- Obtain, review, and reasonably utilize any base flood elevation data available from a Federal, State or other source, in order to administer this ordinance when base flood elevation data has not been provided; and
- Administer and implement the storm drainage system portion of this Ordinance, and to assist the City Manager with the technical aspects of the floodplain management portions of this ordinance.

SECTION B. Responsibilities of Developers

The developer of property to be developed shall be responsible for all storm drainage flowing through or abutting such property. This responsibility also includes drainage directed to the developer's property by ultimate development as well as the drainage naturally flowing through the property by reason of topography. It is the intent of this Ordinance that provisions be made for storm drainage at such time as any property affected is proposed for development, use, or

modification. This includes the necessary improvements and easements extended to the property line to allow for future upstream development.

A developer shall be responsible for all improvements required for the development, including any necessary offsite facilities and construction staking. The City may participate in construction costs of offsite, perimeter and oversized drainage, water or sanitary sewer improvements, in accordance with state law. In addition, should the required improvements exceed the expected impact from the development or are not for the primary benefit of the development and which are required to be oversized to serve developments other than the development submitted for approval, in the City's sole determination, only to the extent and according to the standards set forth in this Ordinance, the developer may apply for funding from the City, based upon the cost of oversize or non-required improvements. All requests for funding are subject to City Council approval and subject to available funding.

In the event that City funding is unavailable at the time of the improvements, then the developer may proceed with the improvements, but shall bear the entire costs of the improvements; provided, however, that the City Council may approve such improvements, subject to future funding, which may become a debt of the City due and payable fifty (50) years from and after the developer makes final payment to contractor for construction of the development. Such debt shall be noninterest bearing and City, at its discretion, may retire said debt prior to the expiration of the fiftieth year.

Where the improvement or construction of a storm drainage facility is required along a property line common to two or more owners, the owner hereafter proposing development of the property shall be responsible for the required improvements at the time of development, including the dedication of all necessary rights-of-way or easements, to accommodate the improvements.

Where a property owner proposes development or use of only a portion of the property, provision for storm drainage shall only be required in that portion of the property proposed for immediate development, except if construction or improvements of a drainage facility outside that designated portion of the property is deemed essential to the development of that designated portion.

Developers shall provide for stormwater runoff and shall design drainage related facilities in accordance with and/or in a compatible manner with any City master drainage study, regional drainage study and plan in effect at the time or any proposed capital improvement project when plans for drainage facilities are submitted to the City for approval.

In addition, developers may be required to provide at their expense a preliminary drainage study for the total area to be ultimately developed. This study shall be submitted to the Floodplain Administrator as a part of the submitted data for consideration of preliminary plat or site plan approval for the portion of the property proposed for immediate development.

The requirements of this ordinance shall meet or exceed the requirements of State and Federal Laws. In cases where the developer believes that requirements of this Ordinance may result in non-conformance, it is the developer's responsibility to clearly demonstrate, to the satisfaction of the Floodplain Administrator, that a specific requirement of the ordinance would result in a non-conforming situation.

The owner shall schedule and participate in a kick-off meeting with the City at the beginning of the design process. The purpose of the kick-off meeting is to define the scope and nature of the proposed project and to identify specific requirements that may impact the project design. The requirements of this ordinance shall be met, regardless of the specific issues identified in this meeting.

SECTION C. Permits

The City requires several different permits related to storm drainage. Some of these permits are listed below and explained in detail in the following paragraphs. A developer may be required to obtain other permits under the City's Code of Ordinances.

- Development Permit
- Floodplain Alteration Permit, formerly called the Fill Permit
- Tree Removal Permit
- Corridor Development Certificate (See Article 9)
- Building Permit

1. Development Permit

All developers within a Flood Hazard or Flood-Prone Area, shall obtain and submit for approval a development permit application for new construction, placement of fill, new manufactured home sites, alteration of a waterway, substantial improvement to existing structures or manufactured homes, or improvements to existing structures, or manufactured homes in the floodplain of the design flood that will result in increasing the overall outside dimensions of the structure or manufactured home. The application form can be obtained from the Floodplain Administrator's office. This form, along with duplicate copies of the accompanying engineering or architectural plans, shall identify those construction or renovation projects that would occur in a flood hazard area. As a minimum, the engineering or architectural plans will show, to scale:

a. The nature, location, dimensions, and elevations in relation to mean sea level of the area in question.

b. The elevation in relation to mean sea level and the location of existing or proposed structures, fill, storage of materials, and/or drainage facilities.

c. The elevation in relation to mean sea level to which an existing non-residential structure shall be flood-proofed, the location of the foregoing.

d. Any off-site facilities or conditions that may either affect on-site conditions or be affected by on-site conditions.

If an existing non-residential structure is proposed for flood-proofing, then a certification sealed by a licensed professional engineer in the State of Texas shall be submitted stating that all of the flood-proofing criteria listed in Article 8, Section B will be met. Construction or renovation projects cannot begin until the City issues a development permit.

2. Floodplain Alteration Permit

Developers shall obtain a floodplain alteration permit prior to filling in a floodplain; channelizing, impounding, realigning, deepening, or otherwise modifying a natural drainage way; making improvements, substantial or otherwise, to existing structures or manufactured homes in a floodplain if the improvements result in the increase of the overall outside dimensions of the structures or manufactured homes; or otherwise reclaiming floodplain land. A floodplain alteration permit application form can be obtained from the Floodplain Administrator's office. Article 4, Section D.2 identifies the information that must be submitted to the Floodplain Administrator. No floodplain alterations may begin until a permit is issued by the Floodplain Administrator.

3. Corridor Development Certificate

Developers shall apply for and obtain a CDC prior to commencement of work in a Regulatory Zone of the Trinity River Corridor (the floodplain). Work requiring a CDC within the floodplain includes, but is not limited to: (1) filling, channelizing, impounding, realigning, deepening, or otherwise modifying a natural drainageway; (2) making improvements, substantial or otherwise, to existing structures or manufactured homes in a floodplain if the improvements result in the increase of the overall outside dimensions of the structures or manufactured homes; or (3) otherwise reclaiming floodplain land. A CDC application form can be obtained from the Floodplain Administrator's office. Article 9 identifies the information that must be submitted to the Floodplain Administrator. No floodplain alternations shall begin until a CDC permit is issued by the Floodplain Administrator.

4. Elevation Certificate

Developers shall complete an elevation certificate prior to issuance of a certificate of occupancy by the City if constructing improvements in or adjacent to a Flood Hazard, Flood-Prone or Floodplain Area. Elevation certificate forms can be obtained at the Floodplain Administrator office.

5. Other State and Federal Permits

A development permit will not be issued until the developer acquires all necessary State and Federal permits. A copy of the necessary permits will be provided to the City prior to the issuance of any permits. The requirements of this ordinance shall not result in improvements that conflict with any State or Federal Laws. The necessary State and Federal permits may include:

a. Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA). A CLOMR is required for all activities that result in a modification of any FEMA regulatory floodplain or floodway of the City of Carrollton.

b. Permit related to Section 404 of the Clean Water Act (from U.S. Army Corps of Engineers).

c. 401 Water Quality Certification from the Texas Commission on Environmental Quality (TCEQ).

d. Any necessary antiquities or historical permits.

e. Notification of the TWDB of any proposed alteration to a watercourse.

For projects involving floodplain reclamation or a modification to the FEMA "Regulatory Floodway", a Letter of Map Revision (LOMR) must be secured from FEMA after completion of the project. For reclamation projects where a CLOMR was acquired, a LOMR must be received before a certificate of occupancy will be issued by the City. For reclamation projects that did not apply for a CLOMR, a LOMR must be received before the construction of any buildings will be allowed.

6. Proceeding without the Applicable Permits

Any developer who fails to obtain the applicable development, floodplain alteration and/or CDC permit before beginning the subject project is in violation of this ordinance. In addition to the penalties outlined in Article 3, Section C, no building permit, plat, site plan, or certificate of occupancy shall be issued for any construction, reconstruction, or development upon any land where such construction, reconstruction, or development is not in conformity with the requirements and intent of this ordinance. Anyone person who violates any of the terms and provisions of this Ordinance shall be denied a building permit, or any other development-related permit, until the violation is corrected.

7. Deviations from Permit Terms

Permits may be revoked by the Floodplain Administrator if, upon periodic inspection, he determines that the work is not progressing in accordance with the requirements and specifications of the approved plan and permit.

Field changes to storm sewer plans can be made only upon approval by the Floodplain Administrator. Record drawings shall be submitted to the Floodplain Administrator at the completion of the project.

8. Typical Permit Process

The typical permitting process for activities within floodplain and flood-prone areas may include the following steps. Each project may vary from the typical process shown below and it is the developer's responsibility to determine the permitting activities that are required for their project. The Floodplain Administrator may waive certain steps in the process or may require certain steps to be completed, depending on the nature of the proposed project.

a. Determine if the project is located within, or adjacent to, a floodplain or flood-prone area.

b. Setup and attend a kick-off meeting with the City to identify requirements related to the proposed improvements.

c. Complete the necessary technical studies to define the impacts of the project. Technical studies include the FEMA and City requirements.

d. Develop concept plans for proposed improvements.

e. Submit proposed plan as a part of the platting process.

f. Determine if improvements will result in any proportional division of costs. In the case where a proportional division of cost is anticipated, develop a conceptual cost and evaluate proportional division of costs. Coordinate with the City to determine availability of funding and impacts to project schedule.

g. Submit a CLOMR to the City for review and comment. A CLOMR submittal is required for any activity that will modify the FEMA Regulatory Floodway. CLOMR submittals may be required for other floodplain activities. The City will submit the CLOMR, with any necessary revisions, to FEMA.

h. Submit necessary hydrologic and hydraulic studies to the City based on ultimate watershed development.

i. Determine if any other State and/or Federal submittals, permits, or approvals are required and make appropriate submittals.

j. Receive approvals for State and Federal submittals, including CLOMR.

k. Submit application and receive CDC permit, if required for the project.

l. Prepare construction plans and update any submittals to the City.

m. Prepare easement documents and secure approval as a part of the final platting.

n. Set up an Owners Association (as required for future maintenance) and provide required funds for the maintenance agreement.

o. Update opinions of probable construction cost. Enter into a development agreement with the City in the event that proportional division of costs is expected. Determine updated schedule for City participation and funding.

p. Receive approval based on the City requirements, as provided in the Stormwater and Flood Protection Ordinances and other pertinent ordinances.

q. Secure a floodplain alteration permit, development permit and CDC permit from the City, as applicable.

r. Submit NOI to the City and TCEQ and begin project construction.

s. Complete project construction and file NOT with the City and TCEQ.

t. Complete necessary elevation certificates and secure any necessary building permits.

u. File a LOMR submittal with the City for all projects that alter the FEMA floodplain or "Regulatory Floodway". Make any necessary revisions and the City will submit the LOMR application to FEMA.

v. Receive LOMR acceptance from FEMA.

w. Secure certificate of occupancy from the City if the project is located in the FEMA floodplain.

x. Complete any actions related to the proportional division of project costs.

SECTION D. Plan Requirements

Plan requirements for stormwater drainage systems and floodplain alterations are listed below. All engineering plans shall be sealed by a professional engineer who is licensed in the State of Texas and experienced in civil engineering work. The total cost for such engineering plans and specifications shall be borne by the developer and shall be furnished to the Floodplain Administrator for review and approval. A kick-off meeting will be held with the Floodplain Administrator prior to the preparation and submission of project plans.

1. Drainage Plans

As part of the platting process, drainage plans shall be prepared. These plans shall include drainage facilities for both off-site and on-site drainage so that the proper transition between the two can be maintained. Criteria for on-site development shall also apply to off-site improvements.

The construction of all improvements shall be in accordance with the current General Design Standards (GDS) of the City of Carrollton and Standard Specifications for Public Works Construction by the North Central Texas Council of Governments (NCTCOG) as amended by the City.

The drainage plans shall include:

a. Drainage Area Map

1) Use up to 1"=200' scale for the development and up to 1"=1000' for creeks and off-site areas, provided that the scale is adequate for review, and show match lines between any two or more maps.

2) Show existing and proposed storm sewers and inlets.

3) Indicate sub-areas for each alley, street, off-site, etc.

4) Indicate contours on map for on- and off-site.

5) Indicate zoning on drainage area.

6) Show points of concentration.

7) Indicate runoff at all inlets, including any by-pass flows.

8) Provide runoff calculations for all areas showing acreage, runoff coefficient, inlet time, and storm frequency.

9) Provide detention calculations based on the criteria established herein.

10) Indicate all crests, sags, and street and alley intersections with flow arrows.

11) Show limits of each plan-profile sheet.

b. Plan-Profile Sheets

1) Show plan and profile of all storm sewers on separate sheets from paving plans.

2) Indicate concrete cushions or embedment where applicable.

3) Specify reinforced concrete Class III pipe unless otherwise noted. Use heavier pipe where crossing railroads, deep fill or heavy loads.

4) Indicate property lines along storm sewer and show easements with dimensions.

5) Show all existing utilities in plan and profile of storm sewers.

6) Indicate existing and proposed ground line and improvements on all street, alley, and storm sewer profiles.

7) Show hydraulic gradeline with computations.

8) Show laterals on trunk profile with stations.

9) Number inlets according to the number designation given for the area or sub-area contributing runoff to the inlet.

10) Indicate size and type of inlet on plan view, lateral size and flow line, paving station and top of curb elevation.

11) Indicate quantity and direction of flows at all inlets, stubouts, pipes and intakes.

12) Show future streets and grades where applicable.

13) Show design water surface at outfall of storm sewer, velocity, and typical section of receiving water body.

14) Where fill is proposed or trench cut in creeks or outfall ditches is proposed, specify compacted fill and compaction criteria.

15) Show size of pipe, length of each pipe size, and stationing at 100-foot intervals in the plan view.

16) Begin and end each sheet with even 100-foot or 50-foot stationing.

17) Show diameter of pipes, physical grade, discharge, capacity of pipe, slope of hydraulic gradeline, and velocity in the pipe in the profile view.

18) Show elevations of flow lines at 100-foot intervals on the profile.

19) Give bench mark information.

20) Show capacities, flows, velocities, etc., of the existing system into which the proposed system is being connected.

21) Show details of all connection boxes, headwalls on storm sewers, flumes or any other item that is not a standard detail.

22) Provide lateral profiles and where utilities are crossed, show all utilities in profile.

23) Show headwalls and specify type for all storm sewers at outfall.

24) Provide flat grade at alleys and streets to discharge into streets.

25) Show curve data for all storm sewers.

26) Tie storm sewer stationing with paving stations.

27) On all dead-end streets and alleys, show grades for drainage overflow path on the plan and profile sheets, and show erosion controls.

28) Specify concrete strength for all structures.

29) Provide sections for road, railroad and other ditches with profiles and hydraulic computations. Show design water surface on profile.

c. Bridge Plans

1) Show the elevation of the lowest member of the bridge and 100-year water surface elevation.

2) Indicate soil borings on plans.

3) Provide soils report.

4) Show bridge sections upstream and downstream.

5) Provide hydraulic calculations on all sections.

6) Provide structural details and calculations.

7) Provide vertical and horizontal alignment.

d. Creek Alteration and Channel Plans

1) Show stationing in plan and profile.

2) Indicate flow line, banks, design water surface, and freeboard. Show hydraulic computations.

3) Indicate nature of banks such as rock, earth, etc.

4) Provide cross-sections with ties to property lines and easements.

5) Show side slopes of creek, channels, etc.

6) Specify compacted fill where fill is proposed.

7) Indicate any adjacent alley or street elevations on creek profile.

8) Show any temporary or permanent erosion controls.

9) Indicate existing and proposed velocities.

10) Show access and/or maintenance easements.

11) As necessary, show ground elevations parallel to the top of bank to show how runoff is prevented from overland flow into the creek or channel.

e. Detention and Retention Facilities

1) Show plan view of detention/retention area and outlet structure.

2) Delineate limits of conservation pool, sediment storage area, flood storage pool, and/or freeboard.

3) Indicate size, dimension, total capacity, design discharge and velocity of the outlet structure.

4) Show any erosion control features at the discharge point of the outlet structure.

5) Specify side slopes of basin and outlet structure.

6) Show existing or proposed structures or other facilities downstream of the outlet structure and emergency spillway, and provide information sufficient to show that the downstream facilities will not be inundated or otherwise affected by the discharge from the basin.

7) Indicate locations and quantities of all inflows to the basin.

8) Provide design calculations for basins including inflow discharge, basin release rate, required storage volume, storage volume provided, time to empty the basin, basin by-pass flows, and other pertinent design data.

f. Levees

1) Show location, extent, nature, dimensions, etc., of levee embankments and associated interior and exterior drainage facilities.

2) Provide engineering analysis addressing potential erosion of the levee embankments during flood events.

3) Provide geotechnical engineering analysis of levee embankment stability and seepage through the levee during flood events.

4) Demonstrate that future settlement of the levee embankments will not result in freeboard dropping below the minimum requirements. Provide geotechnical reports showing anticipated levee consolidation.

5) Analyze interior drainage concerns. Identify sources of interior flooding, and extent and depth of such flooding, assuming a joint probability of interior and exterior flooding. Consider capacity of pumps and other drainage devices for evacuating interior waters.

6) Write an operations manual which discusses the flood warning system to trigger closures; closure operations, procedures, and personnel; operation plans for interior drainage facilities; at least an annual inspection program; and maintenance plans, procedures, and frequency.

7) Provide all other information required in Article 7, Section C, and any other information requested or required by the Floodplain Administrator and/or the FEMA.

2. Floodplain Alteration Plans

The materials listed below shall be submitted as part of the application for a floodplain alteration permit. It is recommended that applicants coordinate the application materials listed below with those needed for other City permits and with the data requirements of the FEMA. Such coordination will facilitate staff review, and drawings could be combined so as to save the applicant from multiple drawings.

a. An engineering report consisting of at least:

1) Project description.

2) Description of the hydrologic and/or hydraulic analyses used, including method used to determine historic rainfall and stream data, soils reports used to determine erosive velocity values, and discharges and water surface elevations for both the design and base floods.

3) Vicinity map.

4) Evaluation of the "natural floodway" and floodplain limits for the design flood. The "natural floodway" is the "regulatory floodway" for the City. The "natural floodway" is established to allow the City to effectively manage flood plain areas and allows no cumulative increase in flood elevations (0.00 feet), beyond the designated height.

5) If hydraulic analyses are being submitted, then a table of values for existing and proposed water surface elevations and velocities must be included.

6) Copies of computer input and output data, in electronic format, for existing and proposed conditions for both the base flood and design flood discharges.

b. Engineering drawings consisting of at least:

1) Water surface profile, including channel flow line, existing and proposed water surface elevations, recorded high water marks, and location and number designation of cross-sections.

2) Plan view on 24" x 36" paper, including:

a) Scale and north arrow.
b) Title block.
c) Boundary lines and nearest street intersections.
d) Existing and proposed contours.
e) Existing and proposed floodplain limits, and limits of the "natural floodway" /"regulatory floodway."
f) Area to be removed from the floodplain or area to be altered.
g) Top and toe of fill and/or side slopes and the numerical slope of the fill and/or side slopes labeled.
h) Location of all other associated improvements or alterations to the creek and/or floodplain, such as check dams, swales, channel modifications, etc.
i) Location of cross-sections.
j) Location of all existing and proposed easements and dedications.
k) Site vicinity map.

3) Plots of cross-sections, including:

a) Scale.
b) Title block.
c) Existing and proposed ground elevations.
d) Cut and/or fill areas labeled.
e) Limits of and numerical values for existing and proposed "n" values.
f) Equal conveyance removed from both sides.
g) Numeric slopes.

SECTION E. Maintenance Bonds

The developer shall guarantee through the issuance of a maintenance bond as provided below, that the work is free of defective workmanship and materials for a period that is dependent on the type of materials used. These periods shall be as follows.

1. For projects involving typical construction materials, the maintenance bond shall be in the amount of 100% of the contract price, for a period of two (2) years after the date of acceptance of the work to cover his guarantee as set forth. The bond shall be on a form supplied by the City.

2. For channel and drainage improvements and erosion control projects involving bioengineering improvements, the maintenance bond shall be in the amount of 150% of the contract price, for a period of three (3) years after the date of acceptance of the work to cover his guarantee as set forth.

Where defective workmanship, materials and/or bioengineering elements are discovered requiring repairs or replacements to be made under this guarantee, all such work shall be done by the developer at his own expense within ten (10) calendar days after written notice of such defect has been given to him by the City. Should the developer fail to make repair or correct such defective workmanship and/or materials within ten (10) calendar days after being notified, the City may make the necessary repairs and charge the developer with the actual cost of all labor and materials required.

SECTION F. Appeals and Variance Procedure

1. Appeal

   Any person aggrieved by a decision of the Floodplain Administrator may appeal to the City Manager for a variance. The decision of the City Manager shall be final.

2. Variances

   The City Manager shall hear and decide requests for variances from the requirements of this Ordinance.

   Variances concerning development permits may be issued for the reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic Places or the State Inventory of Historic Places, without regard to the procedures set forth in the remainder of this section.

   Variances shall not be issued within any designated natural/ regulatory floodway if any increase in flood elevations during the design flood discharge would result unless the increase will result in no negative impacts on adjacent properties.

   Variances may be issued only upon a determination that the variance is the minimum necessary to afford relief considering the flood hazard, drainage problems, and soil loss.

   Variances shall be issued only upon meeting all three of the following criteria:

   a. A showing of good and sufficient cause;

   b. A determination that failure to grant the variance would result in exceptional hardship to the applicant; economic or financial hardships are not classed as a hardship for this purpose; and,

   c. A determination that the granting of a variance will not result in increased flood heights (except as allowed by this Ordinance), additional threats to public safety, extraordinary public expense, create

nuisances, cause fraud on or victimization of the public, or conflict with existing local laws or ordinances.

Any applicant to whom a variance for building or renovating in a floodplain is granted shall be given written notice that the structure will be permitted to be built with a lowest floor elevation below the design flood elevation and that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced lowest floor elevation.

In order to grant a variance, the City Manager shall make the following findings:

- That there is no danger that materials may be swept onto other lands to the injury of others;
- That there is no danger to life and property due to drainage, flooding, or erosion damage;
- That there is no susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual developer;
- That there is importance of the services provided by the proposed facility to the community;
- That there is necessity to the facility of a waterfront location, where applicable;
- That there is no availability of alternative locations for the proposed use which are not subject to flooding damage;
- That there is compatibility of the proposed use with existing and anticipated development;
- That there is a relationship of the proposed use to the comprehensive plan and flood plain management program of that area;
- That there is safety of access to the property in times of flood for ordinary and emergency vehicles;
- That there is no increase in expected heights, velocity, duration, rate of rise, and the effects of wave action, if applicable, expected at the site; and,
- That there is no cost of providing governmental services during and after storm events, including maintenance and repair of public utilities and facilities such as sewer, gas, electrical, and water systems, and streets and bridges.

Upon making the findings above, the City Manager may attach such conditions to the granting of variances as it deems necessary to further the purposes of this Ordinance.

The Floodplain Administrator shall maintain the records of all appeal actions, including technical information, and report any variances of the floodplain management portions of this Ordinance to the FEMA upon request.

ARTICLE 5

RUNOFF CALCULATIONS

The selection of which method to use for calculating runoff depends upon the size of drainage area contributing runoff at the most downstream point of a project. The "Rational Method" is acceptable for situations in which the drainage area is less than 160 acres. A unit hydrograph method is required for situations with larger drainage areas.

No matter which method is used to calculate runoff, a developer of property greater than one acre in size, or any property that was platted as a part of an overall tract which was greater than two acres in size (including churches and schools), shall design new development of property so that the rate of runoff created by the proposed development as it leaves the property does not exceed the rate of runoff that would occur from the property in an undeveloped condition. In cases of property redevelopment, the rate of runoff created by the proposed development as it leaves the property does not exceed the rate of runoff that would occur from the property in its previously developed condition. However, additional detention/retention is required if it is necessary to reduce the runoff rate from the redeveloped site to the runoff rate less than the site prior to redevelopment due to downstream system limitations (see Article 6, section F.5). Article 7, Section D discusses design criteria for detention/retention facilities.

Runoff computations for the design of all drainage improvements shall be based upon fully developed watershed conditions in accordance with the land use projections in the latest comprehensive land use plan for the City. The design engineer shall size drainage facilities by disregarding the detention/retention effects of upstream property and calculating the runoff as if the off-site property was developed without any detention. If an approved regional detention/retention facility is in operation or designed as a part of the project, then the design engineer may size downstream receiving drainage facilities based on consideration of the detention/retention effects of the regional facility.

SECTION A. Procedure for Drainage Areas Less Than 160 Acres

1. Rational Method

Computation of Stormwater Runoff for drainage areas less than 160 acres shall be by the "Rational Method," which is based on the principle that the maximum rate of runoff from a given drainage area for an assumed rainfall intensity occurs when all parts of the area are contributing to the flow at the point of discharge. The formula for calculation of runoff by the "Rational Method" is:

(Equation 1)

$$Q = C_f CIA$$

Where: Q = the maximum rate of discharge, expressed in cubic feet per second.

C_f = frequency factor coefficient for adjustment of the rational method C value. This factor varies from 1.00 to 1.25 for the 10-year and 100-year storms respectively. (Note: The product of C_f*C shall have a maximum value of 1.0).

C = a runoff coefficient which varies with the topography, soil, land use and moisture content of the soil at the time the runoff producing rainfall occurs. This runoff coefficient shall be based on the ultimate use of the land as recommended by the comprehensive land use plan for the City and shall be selected from Table 1 herein on the basis of the use shown on land use and zoning map of the Comprehensive Zoning Ordinance (CZO) for the City. If an area has been granted a zoning change that gives the area a land use classification for which the "C" in Table 1 is higher than the use shown on the existing land use and zoning maps, the higher "C" factor shall be used.

TABLE 1

VALUES OF "C" FOR USE IN "RATIONAL METHOD" FORMULA Q = CIA

Land Use From Master Plan	Value of "C" (Runoff Coefficient)	Value of "C" (Runoff Coefficient)	Value of "C" (Runoff Coefficient)
	Slope - Flat 0% to 1%	Slope - Moderate 1% to 3.5%	Slope - Steep 3.5% and Over
Park Areas - No Developed Land	0.2	0.3	0.35
Developed Park Sites	0.3	0.4	0.45
Single Family Residential	0.45	0.55	0.65
Townhouse, Duplex and Zero Lot Line SF	0.5	0.6	0.7
Multiple Family	0.55	0.7	0.8
Schools *	0.6	0.7	0.8
Churches *	0.7	0.75	0.85
Commercial	0.8	0.85	0.9
Industrial	0.75	0.8	0.9

- Schools and Churches may support alternate "C" values based on specific site plans.

A = The drainage area, expressed in acres, contributing to the runoff at the point in question. Calculation of the drainage area shall be made from an accurate topographic map, a copy of which shall be submitted with the engineering plans for approval.

I = Rainfall intensity in inches per hour for the time period that it takes for flow from the farthest point of the drainage area to reach the point of design. The rainfall intensity is found by referring to the applicable curves of Figure 1. Time of Concentration or Duration of Rainfall for use in Figure 1 shall be calculated by velocity data shown in Table 2.

Time of concentration is the longest time, without interruption of flow by detention devices, that a drop of water takes to flow from the farthest point of the drainage area to the point of concentration (i.e., the point of design). The time of concentration is composed of the "inlet time" and the flow time in a conduit or channel to the point of design. Equation 2 shows how to calculate the time of concentration.

TABLE 2

AVERAGE VELOCITY FOR USE IN DETERMINING TIME OF CONCENTRATION

Description of Water Course	0% to 3% V. in f.p.s.	4% to 7% V. in f.p.s.	8% to 11% V. in f.p.s.	Over 12% V. in f.p.s.
Surface Drainage	5	9	13	15
Channels	Determine V. by Manning's Equation			
Storm Sewers	Determine V. by Manning's Equation			

(Equation 2)

$$T_c = \text{Inlet Time} + \frac{L}{V \times 60 \text{ sec/min}}$$

Where: T_c = Time of concentration in minutes.

Inlet time = 10 minutes for property zoned multiple family, churches, schools, local business, central business, commercial, or industrial

or

Inlet time is calculated based on the percentage ratio of the specific types of development within a mixed-use development

or

15 minutes for property zoned for parks, cemeteries, agricultural, and single family residential.

and

$$\frac{L}{V \times 60 \text{ sec/min}}$$

L = Length of conduit or channel, in feet.

V = Velocity of flow in conduit or channel, in feet per second.

When designing inlets and laterals, the time of concentration is simply equal to the inlet time. The design engineer will compare the above specified inlet times to the actual calculated inlet time by computing the flow time overland and along the gutter to the first inlet. The Manning equation, along with the velocity information in Table 2 (or other acceptable procedures such as the NRCS method), shall be used to determine flow time to the inlet. The design engineer may use the actual calculated or specified inlet time. In no case shall an inlet time longer than 10 minutes be used for multiple family, commercial, churches, schools, industrial and business areas, the calculated inlet time for mixed-use developments, and 15 minutes for parks, cemeteries, agricultural, and single-family areas.

When sizing storm sewers and channels, the time of concentration shall be calculated by adding the actual calculated inlet time (but not greater than the specified inlet times) to the flow time in the conduit and/or channel. The design engineer may use the combined times, as described, or the specified inlet times (without travel times) for storm sewer sizing. When using a time of concentration greater than the set inlet times, the calculation of the actual inlet and travel times must be provided in the plans.

SECTION B. **Procedure for Drainage Areas Greater than 160 Acres and Detention/Retention Basins.**

For drainage areas in excess of 160 acres where the use of the "Rational Method" does not provide reliable results, the unit hydrograph method shall be used. The unit hydrograph calculation used will be based upon standard and accepted

engineering principles normally used in the profession subject to the approval of the City Engineer. Acceptable methods include the Natural Resources Conservation Service (NRCS) Technical Release Number 55 for drainage areas from 160 acres to 2,000 acres, and NRCS's TR20 or the U. S. Army Corps of Engineers (USACE) HEC-HMS and HEC-1 models for drainage areas 160 acres or more.

The unit hydrograph method shall be based upon fully developed watershed conditions assuming no effects from the small on-site detention/retention facilities for maintaining the rate of runoff as if the property was in an undeveloped state. The detention/retention effects of large regional detention/retention facilities can be taken into account by using the unit hydrograph method. The impacts of regional detention/retention facilities must be evaluated using the unit hydrograph method of analysis.

Circumstances that may require the use of a unit hydrograph method include sizing open channels, reclaiming floodplains, creating lakes, or building other types of drainage-related facilities on major drainage courses. Design engineers of these types of facilities should be aware that the requirement of designing for fully developed watershed conditions will mean that they will have to calculate these fully developed flows instead of using the flows calculated in FEMA's flood insurance studies for the City. FEMA's flows cannot be used because the flows are based upon existing watershed conditions (For more information, see Article 7 on the sizing of channels and other major drainage facilities and Article 8 for floodplain alteration procedures). Use of the Rational Method is allowed for design of storm sewers within the project area, provided that the contributing area is less than 160 acres.

ARTICLE 6

DESIGN OF LOCAL DRAINAGE SYSTEMS

SECTION A. Drainage Systems

The design requirements of drainage systems vary with the size and type of system. Improvement standards vary based on the type of improvements proposed. The following describes the requirements for these systems.

Storm Sewer Systems – Drainage shall be placed in closed conduits when the design flows can be conveyed in a 72" RCP or smaller, unless this requirement would result in improvements that cannot meet State and Federal laws. The developer must clearly demonstrate that this requirement cannot be met, while conforming to State and Federal laws, before other types of drainage improvements will be approved by the Floodplain Administrator. For projects where it is demonstrated to the City's satisfaction that the design of a storm sewer system will result in non-conformance with State and Federal laws, then drainage improvements shall be designed under the requirements established for local drainage channels.

Local Drainage Channels – Open drainage systems for contributing flows that can be conveyed in a 72" RCP or smaller and the City agrees that an open system is necessary to conform with State and Federal laws.

Major Drainage Systems – Open channel drainage systems, box culverts, or multiple pipes with design flows that cannot be conveyed in a 72" RCP or smaller.

The specific requirements of each drainage system are outlined in this Article 6 and Article 7.

SECTION B. Design Storm Frequencies

The calculations of runoff quantities that must be accommodated in drainage facilities require the selection of the design storm frequency. The design storm frequencies for various drainage structures are given below.

DRAINAGE FACILITY	DESIGN RECURRENCE INTERVAL
Closed Storm Sewer Systems in streets and Inlets at Street Low Point or Sag, Closed Storm Sewer Systems not in street right-of-way	100-year with positive overflow at low points (addresses possible inlet blockage)
Culverts and Bridges	100-year
Channel Improvements	100-year within channel right-of-way or easement
Levees	Standard Project Flood (See Article 7, Section C)
Dams Above Natural Ground/Spillways	Spillway design flood varies with the class of structure (see Article 7, Section B).

The approved drainage system shall provide for positive overflow at all low points. The term "positive overflow" means that when the inlets do not function properly or when the design capacity of the conduit is exceeded, the excess flow can be conveyed overland along a grassed or paved course. This could be along a street or alley, or otherwise, and shall require the dedication and acceptance of all necessary, applicable property interests from the developer.

Local drainage and overland flow shall be directed away from onsite waster disposals systems and related improvements.

SECTION C. Street and Alley Capacities

1. Streets

Assuming parkway slopes to be 1/4 inch per foot behind the curbs, the depth of flow in the streets shall not exceed the top of curb. For standard street widths, Figure 2 shows the capacity of streets with a straight cross slope that varies from 1/8 inch per foot to 1/2 inch per foot, which are the minimum and maximum allowable street cross slopes. Figures 3 and 4 show the capacity of streets with parabolic crowns.

2. Alleys

The flows created by the 100-year storm shall be contained within the capacity of all paved alleys. Figure 5 shows the capacity of various alley sections.

Alley capacities shall be checked at all alley turns and "T" intersections to determine if curbing is needed or grades should be flattened. Alley sections shall be super-elevated as required at corners and curves to ensure that flow remains in the alley through these changes in alignment.

Curbing shall be required for at least 10 feet on either side of an inlet in an alley and on the other side of the alley so that the top of the inlet is even with the high edge of the alley pavement.

3. Finished Floor Elevations in Relation to Positive Overflows

The first floor elevations of all residential and other structures shall be set at an elevation to allow positive flow away from the structure at all locations. Positive overflow sections, flowing adjacent to a structure, shall provide a minimum vertical distance of 1.5 feet from the maximum overflow invert elevation adjacent to the structure as compared to the corresponding finished floor elevation of all residential and other structures.

SECTION D. Placement of Inlets

Storm sewer inlets shall be located and built along paved streets at such intervals that the depth of flow, based upon the 100-year storm, does not exceed the top of curb. If, in the opinion of the Floodplain Administrator, the flow in the gutters would be excessive using the above design criteria, the storm sewers or inlet locations could be altered to relieve adverse conditions.

Inlets shall be placed upstream of an intersection whenever possible. At any intersection, only one street shall be crossed with surface drainage and this street shall be the lower classified street. When an alley intersects a street, inlets shall be placed in the alley whenever flow down that alley would cause the capacity of the intersecting street to be exceeded.

SECTION E. Inlet Capacities and Sizes

Figure 6 shows the various types of inlets allowed for use along various kinds of streets. Other types of inlets may be used upon the approval of those inlets by the Floodplain Administrator. The minimum inlet size shall be eight feet. Figures 7 through 21 show how to determine the capacity of inlets. No more than 20 feet of inlets shall be placed along one gutter at any given location.

Minimum sizes of laterals shall be 18-inches for use with 8-foot inlets, and 21-inch laterals with 10-foot, 14-foot, and drop inlets, and 24-inch laterals for 20-foot inlets. Where laterals tie into trunk lines, place the laterals on a 60-degree angle with the trunk line and connect them so that the longitudinal centers intersect.

SECTION F. Pipe Design Standards

1. The Manning Equation

Storm sewer conduit shall be sized to flow full, when possible. Manning's Equation shall be used to determine the conduit size. Manning's equation is expressed as:

(Equation 3)

$$Q = \frac{1.486}{n}(A)(R)^{2/3}(S)^{1/2} \quad \text{or} \quad V = \frac{1.486}{n}(R)^{2/3}(S)^{1/2}$$

Where: Q = Flow in cubic feet per second.

V = Velocity of flow in conduit in feet per second.

A = Cross-sectional area of the conduit in square feet.

R = Hydraulic radius of the conduit, which is the area of flow divided by the wetted perimeter (R = A/P).

S = Slope of the hydraulic gradeline.

n = Roughness coefficient of the conduit.

P = Wetted perimeter.

Figure 22 is a graphical solution of Manning's Equation, which allows sizing of concrete pipe, assuming an "n" value of 0.013.

2. Minimum and Maximum Velocities in Pipes

The minimum velocities in conduit shall be 2.5 feet per second. The minimum slopes for various pipe sizes that will maintain this minimum velocity are given in Table 3. The maximum velocities of flow in the conduit and channels are given in Table 4.

The maximum discharge velocities in the pipe shall also not exceed the permitted velocity of the receiving channel or conduit at the outfall to prevent erosive conditions, as shown in Table 4. The maximum outfall velocity of a conduit in partial flow shall be computed for partial depth and shall not exceed the maximum permissible velocity of the receiving channel unless controlled by an appropriate energy dissipater (e.g. stilling basins, impact basins, riprap protection).

TABLE 3

MINIMUM SLOPES FOR CONCRETE PIPES

(to produce a velocity of 2.5 f.p.s. or greater)

(n = .013)

Pipe Diameter (inches)	Slope (Feet/100 Feet)	Pipe Diameter (inches)	Slope (Feet/100 Feet)
18	.180	51	.045
21	.150	54	.041
24	.120	60	.036
27	.110	66	.032
30	.090	72	.028
33	.080	78	.025
36	.070	84	.023
39	.062	90	.021
42	.056	96	.019
45	.052	102	.018
48	.048	108	.016

3. Roughness Coefficients for Conduits

In general, stormwater shall be carried in concrete pipe conduit, but other types of conduit can be used to carry stormwater. However, prior permission to use other pipe materials must be obtained from the Floodplain Administrator. Table 5 shows recommended roughness coefficients for various types of conduits. If, in the opinion of the design engineer, other values for the roughness coefficient should be used, the different value can be used with the permission of the Floodplain Administrator. Appropriate notes of the approved roughness coefficient shall then be shown on the engineering plans.

4. Hydraulic Gradeline of Conduits

Conduits must be sized and slopes must be set such that runoff flows smoothly down the drainage system. To ensure this smooth passage, the hydraulic gradeline must be at the proper elevations.

The proper starting elevation of the hydraulic gradeline shall be set according to the applicable criteria listed as follows:

TABLE 4

MAXIMUM VELOCITIES IN CONDUITS FLOWING FULL AND CHANNELS

Flow Through:	Maximum Velocity (fps)
Culverts	12.5
Inlet Laterals	10
Storm Sewers	12.5
Earthen Channels	See Table 9
Concrete Channels	12
Shale	6
Rock	6 - 10*

* Depends upon exact type of vegetative cover, soil, or rock for the location in question.

TABLE 5

ROUGHNESS COEFFICIENTS FOR CLOSED CONDUITS

Materials of Construction	Recommended Roughness Coefficient "n"
Concrete Pipe Storm Sewer	
Good Alignment, Smooth Joints	.013
Fair Alignment, Ordinary Joints	.015
Poor Alignment, Poor Joints	.017
Concrete Pipe Culverts	.012
Monolithic Concrete Culverts & Conduit	.012
Corrugated Metal Pipe	.024
Corrugated Metal Pipe (Smooth Lined)	.013

a. When a proposed conduit is to connect to an existing storm sewer, the hydraulic gradeline of the proposed storm sewer shall start at the elevation of the hydraulic gradeline of the existing storm sewer based on an evaluation of the existing storm sewer with respect to the requirements found in this Ordinance. This criterion will be used for existing systems when the existing receiving systems has adequate capacity based on the requirements of this Ordinance.

b. When a proposed conduit is to connect to an existing storm sewer, and the hydraulic gradeline and capacity of the existing system is inadequate to handle the existing and/or proposed flow, based on current criteria, then additional improvements are required to prevent flooding. See Article 6, Section F.5.

c. When a proposed conduit enters an open channel, creek, or flood control sumps, the hydraulic gradeline of the proposed conduit shall start at the 10-year water surface elevation of the channel or creek when the ratio of the drainage area of the receiving creek (at the development) to the development area is 15 or greater. For ratios of less than 15, the 100-year water surface will be used on the receiving creek.

Not only is it important to use the proper starting elevation for the hydraulic gradeline, but proper hydraulic gradeline elevations must be maintained for the length of the conduit. The inside top of the conduit should be at or near the hydraulic gradeline. Pressure flow is permitted within storm sewers, conduits, and culverts. An effort should be made to keep the top of the pipe as close to the hydraulic gradeline as possible so that deep excavations to lay pipe are not required.

When the conduit is flowing partially full, the hydraulic gradeline shall be shown at the inside crown of the conduit.

The hydraulic gradeline shall be kept two feet below the top of curb. If this cannot be obtained, the hydraulic gradeline shall be at least $1.5\ V_l^2/2g$ feet below the gutter line, where V_l is the velocity in the lateral.

5. Inadequate Receiving Drainage Systems

In some instances, the downstream receiving drainage system may be inadequate to handle the design flows based on the current ordinance requirements. The developer may not construct any improvements that would increase flooding in downstream receiving systems that are currently inadequate. Various options are available to the developer in this situation.

a. In the case where the downstream receiving system is adequate to convey the existing conditions discharges (based on current criteria), but not adequate to receive additional flow then the developer must construct the necessary improvements to prevent flooding that would occur from the proposed improvements. These improvements may include providing increased detention/retention volume with resulting reduced release rates, increasing the size of the limiting downstream system, or other appropriate approach that is verified by technical analyses and approved by the City.

a. In the case where the downstream receiving system is inadequate to convey the existing conditions discharges (based on current criteria), then the developer must delay the proposed improvements that would increase downstream flooding until the City has improved the downstream receiving system to increase the system capacity or has constructed regional retention/detention facilities to address the capacity issue.

b. In the case where the downstream receiving system is inadequate to convey the existing conditions discharges (based on current criteria), then the developer may select to

participate with the City in constructing improvements that would increase the capacity of the downstream receiving system or constructing regional retention/detention facilities to address the capacity issue. In this instance the appropriate guidelines for cost sharing shall be used.

6. Minor Head Losses

When establishing the hydraulic gradeline of a storm sewer, minor head losses at points of turbulence shall be calculated and included in the computation of the hydraulic gradeline.

Entrance Losses

Entrance losses to a closed storm sewer system from an open channel or lake shall be calculated using Equation 4.

(Equation 4)

$$H_L = K_e \frac{(V_1)^2}{2g}$$

Where: H_L = Head loss in feet.

V_1 = Velocity in the downstream pipe in feet per second.

K_e = Head loss coefficient (see Table 6).

The resulting hydraulic gradeline shall be compared to inlet control conditions for the storm sewer as described in Section F. The higher of the two values will be used as the controlling upstream hydraulic gradeline.

Expansion Losses

For pipe size expansions, head loss shall be calculated using the following equations:

(Equation 5)

$$H_L = \left(1 - \left(\frac{D_1}{D_2}\right)^2\right)^2 \frac{V_1^2}{2g}$$

Where: H_L = Head loss in feet.

V_1 = Upstream velocity in feet per second.

D_1 = Upstream pipe diameter.

D_2 = Downstream pipe diameter.

TABLE 6

ENTRANCE LOSS COEFFICIENTS

$$\text{Entrance head loss } H_L = K_e \frac{V_1^2}{2g}$$

Type of Structure and Design of Entrance	Coefficient K_e
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
End-section conforming to fill slope	0.5
Beveled edges, 33.7- or 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End-section conforming to fill slope	0.5
Beveled edges, 33.7- or 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension or beveled edges on 3 sides	0.2
Wingwalls at 30- to 75-degrees to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10- to 25-degrees to barrel	
Square-edged at crown	0.5
Wingwall parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Manhole and Bend Losses

Head losses associated with manholes for pipe direction changes and bends in pipes of equal diameter shall be calculated using:

(Equation 6)

$$H_L = K_b \frac{V_2^2}{2g}$$

Where: H_L = Head loss in feet.

V_2 = Velocity in the downstream pipe in feet per second.

K_b = Head loss coefficient from Table 7.

Junction Losses

Head losses associated with wye connections or manholes with branch laterals entering the main line shall be calculated by using Equation 7.

(Equation 7)

$$H_L = \frac{V_2^2}{2g} - K_j\left(\frac{V_1^2}{2g}\right)$$

Where: H_L = Head loss in feet.

V_1 = Velocity in the upstream pipe in feet per second.

V_2 = Velocity in the downstream pipe in feet per second.

K_j = Head loss coefficient from Table 7.

7. Storm Sewer Laterals

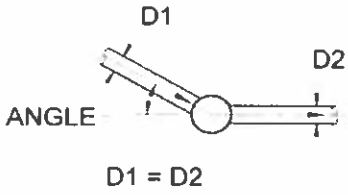
Laterals for storm sewer systems shall be sized to control the flooding depth at the inlets. The depth shall not exceed the limits previously established for storm sewer systems. Calculation of the flooding depth shall be determined based on the addition of the velocity head of the lateral to the computed HGL of the lateral at the inlet:

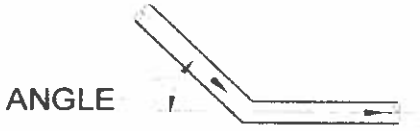
$$ELEV = HGL + \frac{V_L^2}{2g}$$

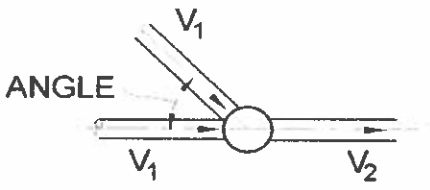
This calculated elevation shall be compared to the elevation determined based on inlet control nomographs as developed by the Department of Transportation. The higher of the two elevations shall be used to establish the capacity of laterals and the corresponding depth of flooding.

TABLE 7

VELOCITY HEAD LOSS COEFFICIENTS FOR CLOSED CONDUITS

MANHOLE AT CHANGE IN PIPE DIRECTION		
DESCRIPTION	ANGLE	HEAD LOSS COEFFICIENT Kj
	90°	0.55
	60°	0.48
	45°	0.42
	30°	0.3
	0°	0.05

BENDS IN PIPES		
DESCRIPTION	ANGLE	HEAD LOSS COEFFICIENT Kj
	90°	0.5
	60°	0.43
	45°	0.37
	30°	0.25

JUNCTION		
DESCRIPTION	ANGLE	HEAD LOSS COEFFICIENT Kj
	0°	1
	22 1/2°	0.75
	45°	0.5
	60°	0.35
	90°	0.25

8. Outfalls to Open Channels and Lakes

The flow lines of storm sewer conduits that discharge into open channels shall match the flow line of the channel. One exception to this requirement of matching the flow line is when a storm sewer discharges into a concrete-lined channel, or when the outfall is submerged below the normal water surface of a lake. In the case of a pipe discharging to a lined channel, the top of the outlet must be below the top of the channel lining. The second exception pertains to storm sewer discharges that must cross wide floodplain areas. Under this condition, the storm sewer could discharge into a lined ditch which would convey runoff to the flow line of the channel without creating an erosive condition. Permissible velocities within the ditch will be based on the type of lining used and the velocities provided in Tables 4 and 9. Flumes to bring the discharge down to the flow line of earthen creeks shall not be permitted. Drop structures shall be allowed upon written approval of the Floodplain Administrator.

The velocity at the discharge end of the conduit shall be computed based on partial flow depth and shall be sufficiently low so as to not cause downstream erosion problems. Tables 4 and 9 show the maximum velocities allowed in various types of channels, which are also the maximum discharge velocities from storm sewer outfalls.

In some circumstances, the configuration of the storm sewer in relation to the flow line of the creek may cause excessive velocities to be reached unless provisions are made to slow the velocity. One recommended method of slowing the velocity is to have a sufficient length of pipe (a length of at least ten times the diameter) be on a slope that will reduce the partial flow outlet velocity to the values shown in Tables 4 and 9 for the receiving stream. Stilling basins shall also be allowed to reduce discharge velocities.

The discharge pipe shall also intersect minor creeks at an angle not to exceed sixty (60) degrees. Minor creeks are defined as those creeks, channels, or drainageways where the distance from the pipe outlet to the opposite creek bank at the bottom of the channel is twenty feet (20') or less. Pipes entering minor creeks shall provide erosion protection on both the banks adjacent to and opposite from the pipe outlet. Pipes may intersect major creeks (greater than twenty feet (20') to opposite bank) at a 90-degree angle. The Floodplain Administrator may require that pipes intersect major creeks at an angle not to exceed 60 degrees, when a 90-degree angle would result in an erosive condition

Figure 23 shows how a storm sewer should be configured to discharge into a creek.

9. Easements for Enclosed Storm Sewers, Positive Overflow Areas and Lot Drainage

All storm sewer conduits required to be dedicated to the City shall be located in an easement or public right of way dedicated, subject to acceptance of such dedication, to the City at the time of final platting of the property. The easement shall be at least fifteen feet (15') wide for storm sewers or wider if the Floodplain Administrator requires it for maintenance or other purposes. Drainage easements for positive overflows on private property shall be a minimum of ten feet (10') wide or wider if the Floodplain Administrator requires it for maintenance or other purposes.

Lot to lot drainage is not permitted without specific approval from the Floodplain Administrator. If lot to lot drainage is permitted by the Floodplain Administrator, then requirements established by the Floodplain Administrator shall be met. No fences, buildings or other structures and improvements shall be placed within areas that may impede approved lot to lot drainage.

SECTION G. Culvert Design Standards

Culverts shall be designed in accordance with this ordinance and the Texas Department of Transportation (TxDOT), Hydraulic Design Manual, Chapter 48 - Culverts. In the event of any discrepancy between these documents, this Ordinance shall control. The calculation of hydraulic gradelines will consider both inlet and outlet control for the culvert. Starting water surface elevations for gradeline calculation will be the same as required for storm sewers; as described in Section F of this ordinance.

ARTICLE 7

SPECIAL DRAINAGE FACILITIES

SECTION A. Channels

1. Channel Design

Open channels may be used instead of enclosed storm sewer systems when the contributing flow from the drainage area cannot be conveyed in a 72" RCP. Open channel sections may also be used for Local Drainage Channels in accordance with Article 6, Section A. Tables 4 and 9 show the maximum velocities allowed for certain types of channels. Roughness coefficients for the design of open channels are provided in Table 8. The following criteria shall be used in determining the nature of open channel improvements.

a. Requirements for Channel Improvements

1. Drainage improvements shall be in compliance with all applicable State and Federal Laws. The developer shall be responsible for determining if improvements meet appropriate laws. The Floodplain Administrator may allow drainage improvements that do not meet all requirements of this Ordinance when strict adherence would result in improvements that do not conform with State or Federal Laws. The applicant must clearly demonstrate, to the satisfaction of the Floodplain Administrator, that an improvement would not be in conformance due to a specific ordinance requirement prior to the waiver from any drainage requirement.

2. Drainage improvements shall minimize the disturbance to natural channel sections, while meeting the requirements of this Ordinance.

3. Channels may be left in their natural state provided that the channel velocities meet the requirements of Tables 4 and 9 and are not experiencing signs of erosion. The Floodplain Administrator may require the inclusion of erosion control improvements when the channels exhibit signs of on-going erosion, regardless of the velocity requirements of this ordinance.

4. For natural channels and improved channels, the flow from the 100-year design flood must be contained within a public right-of-way or easement for the overall floodplain or improved channel section while providing for one foot of freeboard. An improved channel shall meet the floodplain alteration regulations presented in Article 8.

5. Excavated earthen channels shall not be permitted without protective measures to prevent erosion.

6. Bioengineering elements may be used to stabilize the sideslopes of drainage improvements, when the channel velocity range is from 6 to 8 fps. The engineer must demonstrate the adequacy of the bioengineering approach for the specific application. Bioengineering alternatives shall meet the requirements of Article 7, Section A.1.b.

7. Improved channels shall include a lined section if the design channel velocity is greater than the permissible velocities for vegetated channels as shown in Tables 4 and 9. Lining types such as concrete, rock walls and gabions, may be used upon approval of the Floodplain Administrator. Improved channels with design channel velocities of less than the permissible velocities shown in Tables 4 and 9 may be earthen if the channels are protected by bioengineering elements.

8. For improvements requiring lined sections, all of the channel bottom and at least the first three feet (3') (vertical height) of the side slopes up from the channel bottom shall be lined, unless approved by the Floodplain Administrator. The minimum allowable bottom width for a lined section is eight feet (8'), unless approved by the Floodplain Administrator.

TABLE 8

ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS FLOW AREAS

Channel Description	Roughness Coefficient "n" Minimum	Normal	Maximum
MINOR NATURAL STREAMS (Top Width at Flood Stage Less Than 100 Feet)			
Moderately Well-Defined Channel			
Grass and Weeds, Little Brush	0.025	0.030	0.033
Dense Weeds, Little Brush	0.030	0.035	0.040
Weeds, Light Brush on Banks	0.030	0.035	0.040
Weeds, Heavy Brush on Banks	0.035	0.050	0.060
Weeds, Dense Willows on Banks	0.040	0.060	0.080
Irregular Channel with Pools and Meanders			
Grass and Weeds, Little Brush	0.030	0.036	0.042
Dense Weeds, Little Brush	0.036	0.042	0.048
Weeds, Light Brush on Banks	0.036	0.042	0.048
Weeds, Heavy Brush on Banks	0.042	0.060	0.072
Weeds, Dense Willows on Banks	0.048	0.072	0.096
Floodplain, Pasture			
Short Grass, No Brush	0.020	0.030	0.035
Tall Grass, No Brush	0.025	0.035	0.050
Floodplain, Cultivated			
No Crops	0.025	0.030	0.035
Mature Crops	0.030	0.040	0.050
Floodplain, Uncleared			
Heavy Weeds, Light Brush	0.035	0.050	0.070
Medium to Dense Brush	0.070	0.100	0.160
Trees with Flood Stage Below Branches	0.080	0.100	0.120
MAJOR NATURAL STREAMS (Top Width at Flood Stage Greater Than 100 Feet)			
The roughness coefficient is less than that for minor streams of similar description because banks offer less effective resistance.			
Moderately Well Defined Channel	0.025	---	0.060
Irregular Channel	0.035	---	0.100

TABLE 8, continued

Channel Description	Roughness Coefficient "n" Minimum	Normal	Maximum
MANMADE VEGETATED CHANNELS			
Mowed Grass, Clay Soil	0.025	0.030	0.035
Mowed Grass, Sandy Soil, or Easily Erodible Soils	0.025	0.030	0.035
MANMADE NON-VEGETATED CHANNELS			
Clean Gravel Section	0.022	0.025	0.030
Shale	0.025	0.030	0.035
Smooth Rock	0.025	0.030	0.035
LINED CHANNELS			
Smooth Finished Concrete	0.013	0.015	0.020
Riprap (Larger Pieces)	0.030	0.040	0.050

9. An alternative approach may be allowed by the Floodplain Administrator for improvements that have channel velocities of 8 to 9 fps, but do not incorporate lined sections due to considerations related to State and Federal laws. The alternative approach to lining the channel bottom, that may be acceptable, shall include the following:

    a) Perform appropriate geomorphology analyses establishing the future stable channel slope without protection;

    b) Design improvements to include grade control structures to limit the vertical difference between the existing channel slope and the calculated stable slope to a maximum of two feet (2').

    c) Design sidewalls to be constructed on footings that are placed such that the top of the footing of any adjacent structure is placed at a distance below the elevation of the future stable channel slope, such that the structure will remain stable should the anticipated erosion occur.

10. All disturbed areas must be grassed with a low-maintenance and drought tolerant species as listed in Table 9.

11. All improved channels sections shall have a side slope of four feet (4') horizontal to one foot (1') vertical for earthen grassed side slopes, or flatter.

TABLE 9

MAXIMUM PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH GRASS

COVER	SLOPE RANGE * (%),* %	PERMISSIBLE VELOCITY, FPS Easily Eroded Soils Clay Soils
Bermuda Grass	0-5	6
	5-10	5
	>10	4
Buffalo grass, Kentucky bluegrass,Smooth brome, Blue grama	0-5	5
	5-10	4
	>10	3
Grass Mixture	0-5	4
	5-10	3
	>10	Do not use
Lespedeza sericea, Weeping love grass, Ischaemum (yellow blue-stem), alfalfa, crabgrass	0-5	3
	5-10	Do not use
	>10	Do not use
Annuals, used on nild slopes or as temporary protection until permanent covers are estalished, Common lespedeza, Sudan grass	0-5	3
	5-10	Do not use
	>10	Do not use

* Longitudinal bed slope of the channel bottom.

Remarks: The values apply to average, uniform stands of each type of cover. Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained. Based on past experience, all soils within the City have been found to be easily eroded soils.

TABLE 9.A

TEMPORARY VEGETATION

Temporary Vegetation - The following plants are commonly used for temporary cover in Texas. For optimum planting dates and adaptations for a specific soil or site, contact your local field office of the USDA, Soil Conservation Service.

Species	Planting [1] Rate/Acre	[2] Planting Date	[3] Source
Cane, Redtop	30#/S	8/15-9/30	C
Millet, German	40#/s	4/1-5/15	C
Oats	3 bu/S	8/15-9/30	C
Panicum, Texas	25#/S	3/15-5/15	C
Prosomillet	40#/S	4/1-5/15	C
Rye, Elbon	1-1/2 bu/S	8/15-9/30	C
Ryegrass, Annual	30#/S	8/15-9/30	C
Sprangletop, Green	3.4#PLS/S	2/1-5/15	C
Sudangrass	40#/S	4/1-5/15	C

1 Planting Rate/Acre: S - # Commercial Seed/AC, bu - bushels/AC, #PLS - Pure Live Seed/AC

2 Planting Date: This represents a statewide spread in planting dates. Refer to local guides for specific dates.

3 Source: C - Commercial

TABLE 9.B

PERMANENT VEGETATION - LOW AREAS

Permanent Vegetation - Because of wide variations in growing conditions within a planned area, permanent vegetation has been selected for the following conditions. For optimum planting dates and adaptations for a specific soil or site, contact your local field office of the USDA, Soil Conservation Service.

Note: Low areas are subject to ephemeral and intermittent flows.

Species	Moisture Tolerance[1]	Planting Rate/Materials[2]	Planting Date[3]	Source[4]
Bermudagrass,				
	Coastal or Selection C	3A/2	50 cu.ft/Ac/Sp	12/1-5/30
	Common C	A/2	4.6#/Ac/S	3/1-5/30
Buffalograss	A/3	32#/Ac/S	1/1-4/30	C or PMC
Bushy Beard				
	Grass -	C/3	---	Spring
Cordgrass, Prairie	B/2	1/sq.ft/R	1/1-5/30	L
Eastern	Gamma grass -	C/3	---	Spring
Knotgrass	A/2	1/sq.ft/R&St	2/1-5/30	L
Marshmillet	B/1	1/sq.ft/R	4/1-5/30	L
Reedgrass, Common	A/2	1/sq.ft/R	2/1-5/30	L or PMC
Vine-mesquite	A/2	1/sq.ft/St	2/1-1/30	L

[1] Moisture Tolerance:

Total Submergence	Soil Saturation
A - 20 days or more	1 - Require a saturated soil
B - 10 - 20 days	2 - Will tolerate prolonged saturation and frequent drought.
C - Less than 10 days	3 - Will not tolerate a constantly saturated soil.

[2] Planting: Rate - #PLS/AC, Plant Parts/sq.ft.
Materials - S - Seed, R - Rhizomes, Sp - Sprigs, St - Stolons

[3] Planting Date: This represents a statewide spread in planting dates. Refer to local guides for specific dates.

[4] Source: C - Commercial, L - Locally Collected, PMC - Plant Material Center (as available)

TABLE 9.C

PERMANENT VEGETATION - SIDE SLOPES

Species	Soils[2]	Planting Rate/Materials[3]	Planting Date[4]	Source[5]
Grasses				
Bermudagrass,				
Common	All	4.6#/Ac/S	3/1-5/30	C
Selection [3]				
or Coastal	All	50 cu.ft/Ac/Sp	12/1-5/30	C
Bluestem,				
K.R.*	M-F	4#/Ac/S	12/1-5/30	C
Old World*	M-F	2.4#/Ac/S	2/1-5/30	PMC
Buffalo grass*	M-F	32#/Ac/S	1/1-5/15	C or PMC
Dallis grass	M-F	7#/Ac/S	2/1-5/30	C
Knotgrass[1]	All	1/sq.ft/R&St	2/1-5/30	L
Vine-mesquite	All	1/sq.ft/St	2/1-4/30	L
Wildrye	All	25#/Ac/S	9/1-10/1	L
Forbs:				
Bushsunflower*	All	10#/Ac/S	4/1-5/20	L or PMC
Englemandaisy*[1]	All	30#/Ac/S	9/1-2/30	L or PMC
Legumes:				
Trailing wildbean*	C-M	25#/Ac/S	2/15-5/15	L or PMC
Vetch*	All	20#/Ac/S	9/1-10/1	C

*Mixtures only: Reduce rates according to percentage of mixture desired.

1 Lower portion of slope only, frequently inundated.

2 Soils: C - Coarse, M - Medium, F - Fine

3 Planting: Rate - #PLS/AC, Plant Parts/sq.ft.
Materials - S - Seed, R - Rhizomes, Sp - Sprigs, St - Stolons

4 Planting Date: This represents a statewide spread in planting dates. Refer to local guides for specific dates.

5 Source: C - Commercial, L - Locally Collected, PMC - Plant Material Center (as available)

TABLE 9.D

PERMANENT VEGETATION

BERMS, SPOIL BANKS, AND SIMILAR AREAS

Species	Soils[1]	Planting Rate/Materials[2]	Planting Date[3]	Source[4]
Grasses				
Bermuda grass, Common	All	4.6#/Ac/S	3/1-5/30	C
Selection [3] or Coastal	All	50 cu.ft/Sp	12/1-5/30	C
Bluestem, Caucasian*	M-F	4#/Ac/S	12/1-5/30	C
K.R.*	M-F	4#/Ac/S	12/1-5/30	C
Little*	All	6.8#/Ac/S	2/1-5/15	C
Buffalo grass*	All	6#/Ac/S	2/1-5/15	C
Fescue	M-F	20#/Ac/S	9/1-10/30	C
Harding grass "Wintergreen"	M-F	6#/Ac/S	9/1-10/30	C
Indian grass*	All	9#/Ac/S	2/1-5/30	C
Klein grass, "Selection 75"*	M-F	4#/Ac/S	1/1-5/30	C
Wildrye*	All	30#/Ac/S	9/1-10/1	L
Winter grass, Texas*	M-F	30#/Ac/S	9/1-10/30	C
Forbs:				
Bushsunflower*	All	10#/Ac/S	4/1-5/30	L or PMC
Englemandaisy*	All	30#/Ac/S	9/1-2/30	L or PMC
Partridgepea*	C-M	10#/Ac/S	2/15-5/15	C or PMC
Sunflower, Maximilian*	All	16#/Ac/S	4/1-5/30	L or PMC

TABLE 9.D, continued

Species	Soils[1]	Planting Rate/Materials[2]	Planting Date[3]	Source[4]
Legumes:				
Clover,				
Crimson*	M	20#/Ac/S	9/1-10/30	C
White*	M-F	3#/Ac/S		C
Trailing wildbean*	C-M	10#/Ac/S	2/15-5/15	PMC
Vetch*	All	20#/Ac/S	9/1-10/1	C

*Mixtures only: Reduce rates according to percentage of mixture desired.

[1] Soils: C - Coarse, M - Medium, F - Fine

[2] Planting: Rate - #PLS/AC, Plant Parts/sq.ft.
Materials - S - Seed, R - Rhizomes, Sp - Sprigs, St - Stolons

[3] Planting Date: This represents a statewide spread in planting dates. Refer to local guides for specific dates.

[4] Source: C - Commercial, L - Locally Collected, PMC - Plant Material Center (as available)

12. The developer shall provide permanent drainage and maintenance easements as are required under this Ordinance (see Article 7 Section A.4) which shall be dedicated to and are subject to acceptance by the City.

13. Any plan including modification of a natural channel section shall be in accordance with the City of Carrollton Tree Preservation Ordinance No. 3388, including any subsequent amendments or revisions, or a Section 404 permit, if required, when mitigation is required as a part of the permit.

14. Maintenance activities performed within drainage channels, including mowing, brush clearing, tree removal, sediment removal, etc., are not considered as drainage improvements, and are exempt from the requirements established in this ordinance.

b. Bioengineering Requirements for Channel Improvements

Drainage channel improvements that incorporate bioengineering elements in lieu of or in addition to structural channel elements shall meet the following requirements. The following requirements are in addition to the requirements provided in Article 6, Section A.1.a.

1. A detailed landscape plan shall be provided that shall show the proposed tree replacement, grass cover and other bioengineering elements.

2. Any required tree replacement shall be in accordance with local, State and Federal requirements and shall be from the approved list, provided in the Tree Preservation Ordinance. Willow trees, trees

that are not native to North Texas, and trees that are not suitable for riparian areas shall not be allowed as a part of a landscaping plan for drainage improvement projects. The replacement shall include a minimum of 75% hard mast producing trees.

3. Bioengineering improvements, in floodplain areas with velocities over 6 fps, shall include vegetated channel sections and the use of geo-fabrics as a minimum requirement. The geo-fabrics shall be designed to promote and protect the bioengineering elements during the establishment period.

4. Irrigation shall be required during the establishment period.

5. Temporary bioengineering elements may be allowed when the planting season is not appropriate for the installation of permanent bioengineering elements. Permanent bioengineering elements shall be installed at the beginning of the next growing season and shall obtain an 80% survival rate for a minimum period of the greater of six (6) months from the date of installation or one full growing season prior to final acceptance of the project.

6. Bioengineering elements used in channel sections shall include the use of grade control structures or other protective linings when required due to channel velocity considerations. The requirements for grade control structures established in Article 7 Section A.2 shall be met.

7. Maintenance schedules shall be submitted for improvement plans that incorporate bioengineering elements. The maintenance schedule shall project the type and frequency of maintenance activities and associated costs.

8. Bioengineering plans, for areas where the velocity exceeds 6 fps, shall be prepared by a biologist or botanist and sealed by a Professional Engineer.

2. Erosion Prevention

All channel sections must consider and account for channel stabilization in their design. This requirement pertains to all sections whether they are left in their natural condition or are modified in any manner. Three sets of requirements are provided depending upon the relationship of the existing channel to the limits of the developer's property boundaries. The Floodplain Administrator shall have the discretion to require the implementation of the portion of these requirements as deemed necessary, depending on the specifics of the property being developed or improved.

a. In cases where the entire channel section is contained within the limits of the developer property boundaries, the developer shall:

   1. Provide an improved stabilized channel cross-section which reduces all velocities to 6.0 fps or below for vegetated channels. The channel improvements must meet all requirements of this Ordinance.

   2. Design vegetated channel sections with channel velocities ranging from 6 to 8 fps, using bioengineering elements and construct grade control structures within the channel and overbank areas to prevent erosion. Grade control structures shall have a minimum effective depth of 3.0 feet below existing or proposed grades with an adequate number of structures to limit future degradation to less than one foot (1').

b. In cases where the property boundary follows the centerline of the channel or incorporates only a portion of the channel cross-section, the developer shall:

   1. Determine the design section required to provide for an improved stabilized channel cross-section which reduces all velocities for vegetated channels to 6.0 fps or below. The design channel section must meet all requirements of this ordinance.

2. Design sections that include vegetated channel sections with channel velocities ranging from 6 to 8 fps, using bioengineering elements and grade control structures are included within the channel and overbank areas to prevent erosion. Grade control structures shall have a minimum effective depth of 3.0 feet below existing or proposed grades with an adequate number of structures to limit future degradation to less than one foot (1').

3. Construct the portion of the design improvements required on their property for the ultimate channel design. The Floodplain Administrator shall have the discretion to determine the portion of the design improvements to be constructed by the developer. In most instances, the developer shall construct one-half of the improvements on their property.

4. Coordinate with adjacent developers when grade control structures are incorporated into the design and the construction impacts the adjacent property. These features are to be constructed in their entirety at the time of the initial portion of the channel improvements.

5. Provide for a drainage easement and access/maintenance easement consistent with the portion of the improvements to be completed by the developer or as required for the proposed future construction which will be completed by the City with escrowed funds.

c. In cases where the developer owns property adjacent to channel or floodplain areas but does not own a portion of the channel or floodplain area, the developer shall (at the discretion of the Floodplain Administrator):

1. Determine the channel improvement configuration necessary to meet the requirements of Item (2a) above; and,

2. Provide a dedicated easement to the city for the portion of the future improvement configuration, including necessary maintenance and access easement, which will include the developer property.

A procedure for spacing grade control structures is provided in Figure 24. The developer must also meet all requirements related to erosion control for construction activities.

3. Starting Water Surface Condition

When performing hydraulic analyses for channel or drainageway design, the starting water surface shall be based on the following criteria.

a. When the ratio of the drainage area of the receiving creek (at the confluence location) to the drainage area of the channel or drainageway being designed is fifteen (15) or greater, the 10-year water surface of the receiving creek shall be used as the starting water surface for hydraulic design calculations. For creeks where the 10-year water surface is not available, the slope-area method will be used for starting design calculations.

b. When the ratio of the drainage area is less than fifteen (15), the 100-year elevation on the receiving creek shall be used as the starting water surface for design calculations.

4. Easements Required for Open Channels

Drainage and/or floodway easements for all channel improvements, including open channels, creeks and flumes shall be dedicated to, and are subject to acceptance by, the City. Easements shall encompass all areas having a ground elevation below the higher of one foot (1') above the water surface elevation associated with the design flood or the top of the high bank or channel edge. Residential lots shall not extend into easement and floodplain areas. Fences, buildings, or other structures shall not be placed within floodplain and dedicated drainage easement areas. In all cases, the easement shall also include at least a 15-foot wide

maintenance strip along both sides of the channel or, if the Floodplain Administrator so allows, at least a 20-foot wide maintenance strip along one side of the channel. Streets, alleys, bike paths, etc., alongside the channel can serve as all or part of the maintenance easement.

Drainage easements for flumes shall be located with sufficient width to permit future maintenance accessibility, and in no case shall be less than fifteen feet (15') wide.

5. Maintenance Access

Maintenance access areas will be provided along drainage channel improvements as defined in Article 7, Section A.4. The improvements will also include maintenance access ramps in the improvements when the sideslopes are steeper than 4 to 1. The location and number of the maintenance access ramps will be established by the Floodplain Administrator. Typically, each reach of improvement must have facilities to allow access for maintenance equipment.

6. Easements, Dedications, and Maintenance Responsibilities

a. The City shall have the maintenance responsibility for all easements and/or rights-of-way that are dedicated and accepted by the City.

b. The City shall not be responsible for the maintenance of improvements placed in lots, open spaces, common areas, etc. that are not within dedicated and accepted easements. Maintenance of improvements placed in these lots, open spaces, common areas, etc. shall be the responsibility of an Owners Association, or other approved association that is established by the developer. The Owners Association shall have the sole maintenance responsibility for these areas. The developer will enter into a maintenance agreement that will bind the Owner's Association to the maintenance of these areas. The City reserves the right to enter these areas should it be necessary due to the lack of maintenance by the responsible Owners Association.

1. An approved maintenance agreement will be develop prior to acceptance of the project.
2. The maintenance agreement shall be assured by either a private entity, trust fund, or other mechanism as approved by the City Council.
3. In the event that the Owners Association does not provide proper maintenance, as determined by the Floodplain Administrator, then the Floodplain Administrator shall notify such Owners Association of the required corrections and or maintenance to bring the drainage improvements up to the standards as originally approved by the City and in accordance to the original improvement plan. If such maintenance is not accomplished within a reasonable time, then the City may contract for such work and levy an assessment to the Owners Association for costs incurred and impose any other appropriate penalties (Article 3, Section G) on the Owners Association.

SECTION B. Lakes and Dams

In the event that a developer desires to modify an existing pond or lake or desires to impound stormwater by filling or constructing an above-ground dam, thereby creating a lake, pond, lagoon or basin as part of the planned development of that property, the criteria listed below shall be met before City approval of the impoundment can be given. Ponds or lakes created by excavation of a channel area without erecting a dam above natural ground elevation or in-stream, low water checkdams are also subject to the criteria listed below, with the exception of spillway capacity requirements. The Floodplain Administrator has the final authority to determine the design criteria for a proposed dam, checkdam or excavated lake. The requirements of the State of Texas must also be met for the construction of dams, lakes, and other impoundments.

The design criteria for a dam is dependent on the size and hazard classification of the dam. The size and hazard classification will be based on Title 30, Texas Administrative Code, Chapter 299 and will be determined by the

Floodplain Administrator based on information furnished by the developer. The following criteria will be used to classify a dam:

1. Size

The classification for size is based on the height of the dam and storage capacity, whichever gives the larger size category. Height is defined as the distance between the top of the dam (minus the freeboard) and the existing streambed at the downstream toe. Storage is defined as the maximum water volume impounded at the top of the dam (minus the freeboard).

Impoundment Size Classification

Category	Storage (acre-feet)	Height (feet)
Minor	<100	<10
Small	≥100 and < 1,000	≥10 and < 40
Intermediate	≥1,000 and < 50,000	≥40 and < 100
Large	≥50,000	≥100

2. Hazard Potential

The hazard potential for a dam is based on the potential for loss of human life and property damage downstream from a dam in the event of failure. The following categories will be used:

Hazard Potential Classification

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Significant	Possible, but not expected (No urban developments and no more than a small number of inhabitable structure)	Appreciable (Notable agricultural, industry, or commercial development)
High	Expected (Urban development or large number of inhabitable structures)	Excessive (Extensive public, industrial, or agricultural development)

3. Spillway Design Flood

The classification of a dam based on the above criteria will be used to determine the Spillway Design Flood (SDF). The total capacity of a dam structure, including principal and emergency spillways,

shall be adequate to pass the SDF without exceeding the top of dam elevation at a minimum. The SDFs for various dam classifications are as follows:

Spillway Design Flood

Hazard	Size	SDF
Low	Minor	100-year
	Small	1/4 PMF
	Intermediate	1/4 PMF to 1/2 PMF
	Large	PMF
Significant		
	Small	1/4 PMF to 1/2 PMF
	Intermediate	1/2 PMF to PMF
	Large	PMF
High		
	Small	PMF
	Intermediate	PMF
	Large	PMF

In all cases, the minimum principal spillway design capacity is the 100-year design flood. In certain cases, a dam breach analysis may be required to determine the proper classification of the structure. For all structures requiring a spillway design flood equal to the Probable Maximum Flood (PMF), a dam breach analysis is required to determine the downstream consequences of a failure. All dams designed for a SDF of 1/2 PMF or less shall be constructed with a minimum freeboard of two feet above the SDF elevation.

4. Additional Design Requirements

a. An engineering plan for such construction, accompanied by complete drainage design information and sealed by a licensed professional engineer, shall be approved by the City.

b. The spillway and any emergency overflow areas shall be located so that flood waters will not inundate any buildings, roadways, or other structures.

c. All Federal, State and City laws pertaining to impoundment of surface water shall be complied with, including the design construction and safety of the impounding structure. Copies of any Federal, State, and City permits issued for the proposed impoundments shall be submitted to the Floodplain Administrator.

d. Any existing structure, which is included in the project area shall be improved to comply with the applicable Federal, State, and City safety requirements for structures.

e. Before removing, enlarging, or altering any existing lake, the developer will furnish a study of the effects of the alteration upon flooding conditions both upstream and downstream. The study shall be prepared by a Professional Engineer and submitted to the City for approval prior to making the proposed alteration. Compensatory storage shall be provided in some manner such that equal or comparable flood retention capacity is maintained.

f. Any improvements to existing dams or lakes or construction of new impoundments shall be made at the expense of the developer, prior to acceptance of the adjacent street, utilities

and drainage improvements as provided for under the Subdivision Ordinance No. 1849, and any amendments thereto.

5. Maintenance and Liability Criteria

   a. The developer shall agree to retain private ownership of the lake, pond, or lagoon or basin constructed and to assume full responsibility for the protection of the general public from any health or safety hazards related to the lake, pond, lagoon or basin constructed.

   b. The developer shall agree to assume full responsibility for the maintenance of the lake, pond, lagoon or basin constructed and shall enter into a maintenance agreement as required in Article 7, Section A.6. The developer shall keep the Floodplain Administrator advised of the current responsible agent for this maintenance.

SECTION C. Levees

The requirements established in this section for levee improvements apply to new levee systems. The requirements do not apply to existing levee systems or modifications to existing levee systems. In the event that developers wish to build new levees to protect an area from flooding, applicable FEMA and State of Texas guidelines and the following criteria apply:

1. Levees shall be designed to have four feet of freeboard above the Standard Project Flood (SPF) for the fully developed watershed flows.

2. Levees shall be designed according to the U. S. Army Corps of Engineers (USACE) design criteria whether or not they are federally authorized levees.

3. Levees systems shall be submitted to FEMA for a levee certification. A levee certification must be obtained prior to the construction of residential or non-residential structures inside the levee system.

4. Levee systems shall be designed with interior drainage systems to prevent flooding from local runoff contained within the system for the 100-year design flood.

5. Levee systems shall have written operation procedures that address gate closure conditions and an emergency warning plan. A copy of these procedures shall be furnished to the Floodplain Administrator.

6. Automated gate closure systems shall have power from two independent sources and shall be capable of being operated manually.

7. Ring levees protecting individual structures proposed for construction after the enactment date of this ordinance shall not be permitted.

8. All new levee systems shall have permanent positive closures to the required design elevation. Temporary closures involving sandbagging or other procedures requiring manual operations shall not be permitted.

9. Provisions shall be made for ensuring the permanent maintenance of levees either by a flood control district or similar governmental organization or by the existing property developer and all future developers, heirs, or assigns.

10. Additional plan requirements include water surface profiles for the design flood and SPF; top of levee profile, definition of interior drainage facilities, including pump station and ponding areas;

location of gravity outlets, gatewells and closure structures; and elevation-duration data on the receiving system.

New levee systems shall only be approved if they are established as a subdivision of the State of Texas with taxing authority to offset improvement, operation and maintenance costs. The City shall have no responsibility or liability for the levee system, other than review and approval authority.

SECTION D. Detention and Retention Facilities

As previously described in Article 5 of this Ordinance, runoff rates for all land uses shall be limited to the rates that would be produced from undeveloped property (prior to any development). This requirement applies to the development of all sites including churches, schools, and other institutional uses. In cases of property redevelopment, detention/retention is required only if it is necessary to reduce the runoff rate from the redeveloped site to the runoff rate of the site prior to redevelopment. Additional detention/retention may be required for any site if the downstream drainage system is inadequate to handle the design flows. The Floodplain Administrator may elect to waive the detention/retention requirement if the developer presents the necessary hydrograph analyses that demonstrate that the resulting downstream discharges with the proposed development, without detention, are no greater than would be experienced with the undeveloped site.

The City shall require additional detention when the existing downstream drainage system is inadequate to handle any increased flood discharges. The requirements for this condition are addressed in Article 6, Section F.5.

Detention/retention facilities are not required within existing flood control districts for the portion of the district that:

1. is located within an area that is protected by a levee system: and

2. drains to dedicated interior sumps and storage areas that provide adequate detention/retention storage to offset the impacts of development to runoff rates equal to a predeveloped condition.

The need for detention/retention facilities may be reduced or eliminated by the implementation of Permanent Best Management Practice (PBMP) approaches. The implementation of PBMP approaches can reduce the resulting runoff anticipated from proposed development. In the event that the use of PBMP approaches reduces the proposed runoff to that equivalent of an undeveloped condition, and there are no limitation related to downstream receiving systems, then detention/retention would not be required.

Detention/retention facilities shall be designed for the 100-year design flood according to the following criteria:

1. The minimum amount of effective storage volume of the detention/retention basin shall be that volume required to reduce runoff rate to an undeveloped rate.

2. Dedicated regional detention/retention basins shall also include an additional one foot of freeboard and two feet of sediment storage. Sediment storage volume is not used in determining the discharge attenuation that occurs from basins.

3. The volume of runoff storage for drainage areas greater than 160 acres shall be computed using unit hydrograph procedures. Unit hydrograph procedures shall be based on the Snyder's Unit Hydrograph method. Manual methods or the use of the computer program HEC-1 or HEC-HMS are allowed for runoff hydrograph computation and flood routings.

   For drainage areas less than 160 acres, the above methods are recommended; however, an approximate routing method based on the rational formula is allowable, as outlined in Figure 25.

4 Detention areas in parking lots shall not be:

- In required parking spaces, but rather in extra spaces.
- Behind speed bumps unless the speed bumps are made with reinforced concrete.
- Deeper than six inches unless warning signs are posted.

5. Drainage easements shall be provided for all regional detention/retention facilities and for other detention/retention facilities where two or more developers are involved.

6. Detention/retention facilities shall be designed to empty in less than 24 hours, unless it is also serving as an erosion control facility.

7. Detention/retention facilities shall not be counted as an erosion control technique unless: (1) the basins are designed to empty a minimum of 24 hours from the storm event; and (2) adequate sediment storage areas in the basin have been set aside and are maintained.

8. Detention/retention facilities shall be maintained by the developer unless the facilities are designed as regional detention facilities and dedicated to the City.

9. Landscaping improvements are required for detention/retention basins. The minimum landscape requirement is to establish grass on all slopes, basin bottom and surrounding area. The City may require additional landscaping based on the location of the facility and any zoning/platting requirements. Landscaping involving trees, shrubs, etc. is permitted in the surrounding area. These type of landscaping improvements are not permitted in areas that would hinder future maintenance. This includes the bottom of the basin and within two feet (2') of the top of slope.

SECTION E. City Master Drainage Plans

The City may have developed Master Drainage Plans for specific portions of the City. This may include, but is not limited to, the defined Transit Oriented Development (TOD) areas. The Master Drainage Plans may provide specific guidelines for completing future drainage improvements in these areas. The plans may include additional or specific requirements for detention/retention, storm sewer improvements, culvert and bridge improvements, and/or channel improvements. Proposed development and redevelopment are required to meet the guidelines established for these areas, when a master plan has been developed. The performance of these improvements may require participation of the City.

SECTION F. Flumes

Flumes are not recommended for widespread use. Flumes shall not be permitted when the purpose of a permanent flume is to carry runoff down the sides of earthen channels. A flume may be used to direct overflow runoff along property lines until the runoff can be intercepted by streets or conduit flows. Flumes crossing sidewalks shall be covered or bridged in order to minimize danger to pedestrians.

SECTION G. Connections from Buildings to Storm Sewers

Drainage from residential areas, such as roof tops, should be allowed to flow overland before joining the storm sewer system.

Seepage into basements or sub-surface structures that is pumped to ground level, seepage from springs, and runoff from roof drains on non-residential buildings that would flow onto or across driveways, sidewalks, or other areas commonly crossed by pedestrians can create hazards or nuisances to pedestrians. Thus, if hazards or nuisances would be created, the basement and rooftop drains shall be tied directly to the nearest storm sewer, provided that pumped lines from basements have backflow preventers and the water is uncontaminated.

ARTICLE 8

FLOODPLAIN GUIDELINES

SECTION A. Lands to Which This Article Applies

A person shall comply with the requirements of this article for floodplain areas before making substantial improvements to or increasing the outside dimensions of an existing structure or developing land within the design flood line of a creek or stream, whether or not the land has been formally designated as a floodplain. Floodplain areas shall also include all areas inundated by the design flood and as shown as Areas of Special Flood Hazard on Flood Insurance Study maps.

SECTION B. General Floodplain Regulations

1. Permitted Uses of Floodplain Areas

To minimize possible losses of life and property, the following uses are permitted in a floodplain area provided they are also permitted in the underlying zoning district:

- Farm or ranch;
- Local utilities, electrical substation, water reservoir or pumping station, and water treatment plant;
- Public park or playground, private recreation club or area, private community center, and golf course;
- Outside commercial amusement approved by a specific use permit;
- Helistop approved by a specific use permit; and
- Radio, television, or microwave tower, and amateur communications tower with a special use permit.

Structures customarily associated with the above uses may be constructed within a floodplain area only if the proposed structure meets the same engineering requirements applicable to filling in a floodplain (See Article 8.C).

Open private recreation clubs or areas and private community centers, without exterior walls which would incur structural damage during flood conditions, are permitted in floodplain areas. Private facilities listed above, with enclosed walls that would incur damage, are not permitted in floodplain areas.

Uses and structures other than those mentioned above shall not be permitted in floodplain areas.

2. Residential Construction

All new construction, including areas adjacent to floodplains, in reclaimed floodplain areas and substantial improvements of any existing residential structure in floodplain areas shall have the lowest floor (that is at ground level) of any new or substantial improvement construction, elevated to at least two feet (2') above the design flood elevation.

All new construction, including areas adjacent to floodplains, in reclaimed floodplain areas and substantial improvements of any existing residential structure in floodplain areas shall have the lowest floor that consists of a basement or fully enclosed area below ground level of any new or substantial improvement construction:

a. elevated to at least two feet (2') above the design flood elevation; or

b. floodproofing of residential construction is not permitted.

c. for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

Natural ground or fill elevations for the entire residential lot shall be at least one foot above the elevation of the design flood. Incremental improvements, either at one time or over a period of time, the cumulative cost of which equals or exceeds fifty percent (50%) of the market value at the time of the first improvement, shall be considered as a substantial improvement. New residential structures or substantial improvements on stilts or behind ring levees serving individual lots shall not be permitted.

Improvements to an existing structure that increase the outside dimensions, but do not result in a substantial improvement, must meet the requirements of Article 8.C.

Table 10 presents a synopsis of the requirements for residential construction in floodplain areas.

3. Non-residential Construction

All new construction, including areas adjacent to floodplains, in reclaimed floodplain areas and substantial improvements of any existing non-residential structure in floodplain areas shall have the lowest floor (that is at ground level) of any new or substantial improvement construction, elevated to at least two feet (2')above the design flood elevation.

All new construction, including areas adjacent to floodplains, in reclaimed floodplain areas and substantial improvement of any existing commercial, industrial, or other non-residential structure in floodplain areas shall have the lowest floor that consists of a basement or fully enclosed area below ground level, of any new or substantial improvement construction, together with attendant utility and sanitary facilities, shall be:

a. elevated to at least two feet (2') above the design flood elevation; or

b. floodproofed to an elevation that is at least two (2') feet above the design flood elevation so that the area is watertight, with walls substantially impermeable to the passage of water. Floodproofed areas shall have structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. These areas shall also be certified by a licensed professional engineer or architect that the standards of this subsection are satisfied. Such certifications shall be provided to the official set forth in Article 4, Section A.1.

c. for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

Incremental improvements, either at one time or over a period of time, the cumulative cost of which equals or exceeds 50 percent of the market value at the time of the first improvement, shall be considered as a "substantial improvement." Improvements to an existing commercial, industrial or other non-residential structure that increase the outside dimensions, but do not result in a "substantial improvement," must meet the requirements of Article 8.C.

4. Manufactured Homes

a. All manufactured homes shall be anchored to resist flotation, collapse, or lateral movement by providing over-the-top and frame ties to ground anchors. Special requirements shall be that:

- Over-the-top ties be provided at each of the four corners of the manufactured home, with two additional ties per side at intermediate locations, with manufactured homes less than fifty feet (50') long requiring one additional tie per side;

- Frame ties be provided at each corner of the home with five (5) additional ties per side at intermediate points, with manufactured homes less than fifty feet (50') long requiring four (4) additional ties per side;

- All components of the anchoring system be capable of carrying a force of 4,800 pounds; and,

- Any additions to the manufactured home be similarly anchored.

b. For all manufactured homes that are placed or substantially improved within a floodplain and flood-prone area that are on sites for: new manufactured home parks and manufactured home subdivisions; for expansions to existing manufactured home parks and manufactured home subdivisions; for existing manufactured home parks and manufactured home subdivisions where the repair, reconstruction or improvement of the streets, utilities and pads is planned; and for manufactured homes not placed in a manufactured home park or manufactured home subdivision; for manufactured homes moved onto a site in an existing manufactured home park in which a manufactured home has incurred substantial damage as a result of a flood, require that:

- All manufactured homes meet the minimum FEMA, Housing of Urban Development, and Office of Rural Community Affairs requirements;

- Stands or lots are elevated on compacted fill such that the fill is at or above the FEMA base flood elevation and the lowest floor of the manufactured home is at least 1 foot above the design flood elevation; and,

- Adequate surface drainage and access for a hauler are provided.

Manufactured homes may be supported to the required height of one foot (1') above the design flood elevation by stands or foundation features as accepted by FEMA, and with a maximum height of thirty-six inches (36").

c. For all manufactured homes that are placed or substantially improved within a floodplain and flood-prone area that are moved onto sites for manufactured homes within an existing manufactured home park in which a manufactured home has not incurred substantial damage as a result of a flood, require that:

- All manufactured homes meet the minimum FEMA requirements;

- Stands or lots are created so that and the lowest floor of the manufactured home is at or above the design flood elevation;

- Adequate surface drainage and access for a hauler are provided; and,

- Manufactured homes shall be placed in a floodplain area on a pad site created by compacted fill or supported to the required design flood elevation by stands or foundation features as accepted by FEMA.

Table 10 overviews the requirements for placing manufactured homes in flood hazard areas.

5. Recreation Vehicles

Recreational vehicles located on a site within a designated floodplain area shall: (1) not be located on the site for more than 180 consecutive days; (ii) be fully licensed and ready for highway use, or (iii) meet the elevation and anchoring requirements for "manufactured homes" outlined in this section. A recreational vehicle is ready for highway use if it is on its wheels or jacking system, is attached to the site only by quick disconnect type utilities and security devices, and has no permanently attached additions.

6. Streets, Parking Lots, Culverts and Bridges

The top of curb of all new streets, including those built in reclaimed floodplain areas, shall be at least one foot (1') above the design flood elevation. The low beam of all new bridges to be constructed across floodplains shall be a minimum of one foot (1') above the design flood elevation. Box culvert improvements shall be designed to have the top of curb elevation, at the box culvert, two feet (2') above the design flood elevation. All new private bridges to individual homes shall have their low beams at one foot (1') above the design flood elevation. Parking lots associated with all residential, commercial and industrial uses, including within reclaimed floodplain areas, shall be at least at the design flood elevation. Parking lots for public parks or playgrounds, private recreation clubs or areas, private community centers and golf courses may be located below the design flood elevation.

7. Utilities

All new and replacement water supply systems, sanitary sewer facilities, and other public utilities shall be designed to minimize or eliminate flood damage and infiltration of flood waters into the system.

8. Fences

Fences (Private and Public Screening) shall be constructed such that blockage of surface water flow does not occur. Fences shall not be allowed in floodplain areas. Fences are not permitted within dedicated easements involving positive overflow from storm sewer systems. These requirements include the requirement that erosive conditions shall not be created around, under or near a fence structure.

9. Additional Construction Standards for Structures

All improvements and construction permitted in a floodplain area must comply with the following requirements:

a. Structures must be securely anchored to the foundation to prevent flotation and collapse during inundation and designed to prevent damage to nonstructural elements during inundation.

b. Thermal insulation used below the first floor elevation must be of a type that does not absorb water.

c. Adhesives must have a bonding strength that is unaffected by inundation.

d. Doors and all wood trim must be sealed with a waterproof paint or similar product.

e. Mechanical, electrical, and utility equipment shall be located above the design flood elevation. Water heaters, furnaces, electrical distribution panels, and other critical mechanical or electrical installations must not be placed in basements. Electrical circuits for basements shall be separate from circuits serving floors above the basement, and circuits for basements shall be installed lowered from above.

f. Basements are permitted for non-residential structures only if they are designed to preclude inundation by the design flood elevation, either by:

1) The elimination of exterior openings below the design flood elevation; or

2) The use of water-tight closures, such as bulkheads and flood shields. However, no basements are permitted in soils whose permeability meets or exceeds the minimum local standards of permeability established for the installation of individual sewage disposal systems.

g. Plywood used at or below the lowest floor elevation must be of an "exterior" or "marine" grade and of a water-resistant or waterproof variety.

h. Wood flooring used at or below the lowest floor elevation must be installed to accommodate a lateral expansion of the flooring, perpendicular to the flooring grain, without incurring structural damage to the building.

i. Basement ceilings for non-residential structures must be of sufficient wet strength and be so installed as to survive inundation.

j. Paints or other finishes used at or below the lowest floor elevation must be capable of surviving inundation.

k. All air ducts, large pipes and storage tanks located at or below the lowest floor elevation must be firmly anchored to prevent flotation.

l. Tanks must be vented at a location above the design flood elevation.

SECTION C. Floodplain Alterations

As stated previously in Article 8, Section B, no new construction is allowed in floodplain areas, but construction is allowed in those areas that can be reclaimed from the floodplain. The City has adopted a "natural floodway". The City's criteria allows a zero increase in cumulative impacts to flood elevation, beyond the designated height, due to modifications within the "natural floodway". The "natural floodway" consists of the natural channel and floodplain that is effective in conveying the design flood. Areas of ineffective flow around bridges, topographic constrictions, and other constrictions are excluded from the "natural floodway." The effective flow area and limits of the "natural floodway" are generally determined using 4:1 flow expansions downstream of constrictions and 1:1 flow expansions upstream of constrictions. Figure 26 displays an example of effective flow areas at a typical bridge location.

A Floodplain Alteration Permit for floodplain reclamation or other types of alterations shall be allowed only if all of the following criteria are met:

1. Alterations of the floodplain, excluding ineffective flow areas, shall not increase the water surface elevation of the design flood of the creek beyond the limits established by the City for the "regulatory floodway". For the "regulatory floodway" the impacts cannot impact any upstream, downstream or adjacent property owner.

2. Alterations shall be in compliance with FEMA guidelines and other State and Federal regulations.

3. Alterations of the floodplain shall not create an erosive water velocity on or off-site.

4. Alterations of the floodplain shall not significantly increase downstream discharges.

5. Alterations within the CDC regulatory zone shall be in compliance with Article 9 of this Ordinance.

6. The effects of existing improvements or public and private improvements for which a future commitment has been made by the City, State, or Federal agencies, shall be used in determining water surface elevations and velocities.

7. Any alteration of floodplain areas shall not cause any additional expense in any current or projected public improvements.

8. Maximum slopes of filled areas shall not be steeper than three (horizontal) to one (vertical). Slopes of any excavated areas, not in rock, shall not be steeper than four to one, except for transition areas to natural ground.

   Fill slopes, vertical walls, terracing, and other slope treatments may be considered provided no unbalancing of stream flow results and only as a part of a grading permit application.

9. A grading permit shall be required so that proper provisions for protecting against erosion losses will be made.

These criteria shall be met before a Floodplain Alteration Permit can be issued for a proposed project. Typical projects requiring a Floodplain Alteration Permit include placing fill whether or not it actually raises the property out of the

floodplain, constructing a dam, straightening channel sections, making improvements, substantial or otherwise, to existing structures in a floodplain in which the existing outside dimensions of the structure are increased, and temporary storage of fill materials, supplies, and equipment.

The required submittals for a Floodplain Alteration Permit are listed in Article 4, Section D.2. In general, the information needed for the application can be obtained by running a backwater model, such as HEC-2 or HEC-RAS, and a HEC-1 or HEC-HMS flood routing model. Necessary models shall be run by permit applicants. The backwater information shall be used to determine that upstream water surface elevations and erosive velocities have not increased. Starting water surface conditions for backwater calculations are outlined in Article 7, Section A.3. Flood routing information shall be used to ensure that the cumulative effects of the reduction in floodplain storage of flood waters will not cause downstream increases in water surface elevations and erosive velocities.

Applicants can obtain copies of the existing conditions backwater models and flood routing where available from the Floodplain Administrator. The Floodplain Administrator shall keep the models current with modifications to the floodplain.

SECTION D. Verification of Floodplain Alterations

Prior to final acceptance by the City of utilities and street construction for projects involving floodplain alterations or adjacent to defined floodplains, creeks, channels and drainageways, a certified statement shall be prepared by a Registered Public Land Surveyor showing that all lot elevations, as developed within the subject project, meet or exceed the required minimum finished floor elevations shown on the final plat of the subdivision. This certification shall be filed with the Floodplain Administrator before issuance of a certificate of occupancy.

In addition, at any time in the future when a building permit is desired for existing platted property which is subject to flooding or carries a specified or recorded minimum finished floor elevation, a Registered Public Land Surveyor shall survey the property prior to obtaining a building permit. The survey data showing the property to be at or above the specified elevation shall be furnished to the Floodplain Administrator for approval. Compliance with the provisions of this ordinance pertaining to specified finished floor elevations shall be required.

The developer shall furnish, at his expense, to the Floodplain Administrator sufficient engineering information to confirm that the minimum floor elevations proposed are as required by this section. Construction permits will not be issued until (1) a conditional letter of map revision or amendment has been issued by FEMA, and (2) lots and/or sites are certified by a Registered Public Land Surveyor and are elevated from the floodplain according to the FEMA-approved revisions to the floodplain and the requirements of this Ordinance.

ARTICLE 9

SPECIAL PROVISIONS

TRINITY RIVER CORRIDOR DEVELOPMENT CERTIFICATE PROCESS

SECTION A. Trinity River Corridor Interlocal Agreement

This article recognizes the Trinity River Corridor Interlocal Agreement effective January 1, 1990 (and any subsequent revisions thereto), between cities and counties which acknowledge that the Trinity River Corridor ("Corridor"), is a unique regional resource. Local governments are responsible for the overall health, safety, and welfare of their citizens and must take the lead as stewards of the Corridor. Actions of upstream and downstream communities within the Corridor directly affect each other such that individual local goals for floodplain management, transportation, greenway, waste management, conservation, and development can only be achieved through cooperative management of the Corridor.

SECTION B. Trinity River Corridor Area

For the purpose of the Corridor Development Certificate (CDC) process, the Corridor is defined as the bed and banks of the river segments from the dams of Lewisville Lake, Grapevine Lake, Lake Worth, Benbrook Lake, Lake Arlington, and Mountain Creek Lake downstream to the point of the main stem of the Trinity River near Post Oak Road in southeast Dallas County, and all of the adjacent land area and all watercourses contained within the boundaries of the river floodplain as designated by the approved Trinity River Corridor digital map maintained on computer by NCTCOG.

SECTION C. Establishment of Development Permit

In order to ensure adequate management of the Corridor, a unique certification process has been developed and adopted. To distinguish it from other requirements, the development permit within the Corridor issued by the community will be referenced as a CDC. Any public or private development within the Regulatory Zone of the Corridor must obtain a CDC. The Regulatory Zone is the area within the ultimate development 100-year floodplain of the specified reach of the Trinity River as defined by the latest approved version of the digital **Trinity River Corridor Map - CDC Regulatory Zone.** This map is maintained by NCTCOG.

Any public or private development within the Regulatory Zone of the Corridor must obtain a CDC prior to start of any development activity, unless specifically exempted as discussed below. A development activity is defined "any manmade change to improved or unimproved real estate, including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations." To assure consistency with TCEQ requirements, development activity also includes "any levee or other improvement".

It is the expressed purpose of this cooperative certification process to satisfy the requirements of FEMA and the TCEQ regarding City floodplain permit actions within the Corridor and to effect close coordination with the USACE and other state or federal agencies that have their own permit processes. The CDC process does not supersede other City, State and Federal programs.

VARIANCES:

A variance may be sought by any public or private development that cannot meet the established common criteria as detailed in the CDC Manual. A variance shall be any modification of the literal provisions of the CDC Manual when strict enforcement of the CDC process would cause undue hardship, owing to circumstances unique to the individual property on which variance from the process is requested. Variances may be issued for projects deemed to be in the overall regional

public interest, as determined by the City Manager and meet the variance requirements established in Article 4, Section F. The decision of the City Manager shall be final.

SECTION D. Approval Process

The standard CDC form will be used to record the actions taken and will be sent to NCTCOG for permanent recordkeeping. Approval will be based on compliance with the following steps.

Step 1. Determination of Applicability by City

Step 2. Jurisdictional Review by USACE

Step 3. Notice of Intent to Process by City

Step 4. Parallel USACE, FEMA, TCEQ, and Regional Review

Step 5. Formal City Action

SECTION E. Appeals Process

The Applicant may seek relief from this process. Appellant relief of this permit process shall be sought from the City as an independent permitting authority.

SECTION F. Technical Updates

The latest technical hydrologic and hydraulic information concerning the Corridor may be obtained by the Floodplain Administrator of the respective communities from the NCTCOG and the USACE - Fort Worth District.

SECTION G. CDC Manual

The most recent CDC Manual (and any subsequent revisions) shall be adopted as a part of this Ordinance. The CDC Manual outlines the detailed requirements of this Article and is adopted in its entirety with the following exceptions:

1. Any provisions in direct contradiction to this ordinance.

2. The term of the CDC permit may be extended for multiple three-year periods as deemed appropriate by the Floodplain Administrator.

3. The applicant is not required to officially file the CDC permit in the county records.

4. The concept of equal conveyance shall not apply in areas where the opposing side of the channel has already been developed to the maximum extent practicable as determined by the Floodplain Administrator.

5. New levee systems shall have a minimum of four feet (4') of freeboard above the SPF elevation even if a relief system is provided. The levee requirements shall not apply to existing levee systems or improvements to existing systems.

6. All fill elevations shall have the minimum freeboard above the ultimate 100-year elevation as required by this ordinance.

7. Resource Data and Maintenance and Operation Data are not required unless specifically required by this ordinance.

8. Changes in State and Federal regulatory programs will not require a re-evaluation or reapplication unless:

   a) construction on the project has not begun or;

   b) until the term of the current permit or extension expires.

ARTICLE 10

STORMWATER QUALITY

SECTION A. General Requirements for Construction Sites

All developers shall use best management practices to control and reduce the discharge, to the municipal separate storm sewer system (MS4) and to waters of the United States, of sediment, silt, earth, soil and other material associated during construction activities based on related City requirements.

SECTION B. General Requirements Post Construction

1. Permanent Best Management Practices (PBMP)

   All developers of new development and redevelopment sites shall meet or exceed the minimum PBMPs requirements to control and reduce the discharge, to the MS4 and to waters of the United States, of sediment, silt, earth, soil, and other materials associated with developed sites by incorporating permanent stabilization and flow reduction measures into the site plan. The goals of incorporating PBMPs include the following:

   1. To conserve natural resources that inherently control and filter stormwater.
   2. To decrease impervious surface area, increase infiltration, and decrease overall runoff.
   3. To instill natural processes, emulating pre-development hydrologic conditions, for stormwater to infiltrate and recharge groundwater.
   4. To reduce pollution in stormwater runoff.
   5. To treat the runoff resulting from the first flush of storms.
   6. To potentially decrease the Developer's cost for necessary stormwater structural controls.

Such permanent PBMPs shall include, but are not limited to, the following measures as appropriate:

a. Buffers and Undisturbed Areas

   - Use natural site topography for meanders and natural stormwater infiltration.
   - Reduce amount of grading through excavating and filling.
   - Use natural drainageways for stormwater retention instead of storm sewer pipe systems for stormwater detention and conveyance.

b. Bioretention Systems

   - Design a landscaped area or shallow stormwater basin to collect and filter runoff.
   - Ponding must not exceed forty-eight (48) hours.

c. Gravity Separator

   - Remove or strain sediment, trash, oils and debris from collected stormwater.

d. Preservation of Natural Creeks (where applicable). See Article 7, Section A for requirements when preserving natural creeks.

- Use bioengineering erosion elements to preserve channels and natural creeks that are in a non-erosive state.

e. Permeable and Semi-pervious Pavement

- Decrease surface runoff by decreasing surface area of impermeable surfaces on site.
- Incorporate porous paver systems or porous concrete for parking lots, pedestrian paths, and low-traffic applications.

f. Low Impact Development Methods

- Implement LID Methods such as rainwater harvesting, rain gardens, rain barrels, cisterns on individual lots, green roofs, planters, tree box filters, and/or bioretention or biodetention facilities which treat all post-construction areas.
- The vegetated LID features shall consist of native plantings or plantings consistent with Texas Smart-Scape recommendations.

g. Stream Restoration

- Restore the natural functioning state of a stream through techniques such as channel modification, bank stabilization, and slope stabilization.

h. Vegetative Filter Strips

- Design an area of permanent vegetation next to a waterway or drainage path to help trap sediment and other pollutants from reaching the surface waters and slow down runoff.

i. Vegetative Swales

- Design a drainage pathway with permanent vegetation designed to convey water at a lower, non-erosive velocity and to trap sediment and pollutants.

j. Native Landscaping

- Plant live, native plants for immediate pollution uptake and erosion control.

k. Stormwater Retention

- Utilize stormwater retention basins instead of stormwater detention basins for flow detention.

l. Aeration Features within Retention Basins

- Providing fountains or other features in retention basins to aerate the stored water.

m. Additional Approved Methods

- Additional PBMP methods may be used if the effectiveness, performance, and maintenance procedures are approved by the City.

2. Permanent Best Management Practices Requirement

Not every site is the same. Thus, every development shall be evaluated to determine the most feasible approach to limit the development's impact. The design criteria to be used for development and redevelopment sites, such as site planning, LID, and PBMPs, will be discussed at the kick-off meeting. It is the responsibility of the design engineer to select and design PBMPs that address site specific conditions

using appropriate design criteria for the North Central Texas region. The source of the design criteria shall be referenced in the plans. Additional guidance for selecting PBMPs and devising operations and maintenance plans may be sought during the kick-off meeting.

The developer should prepare for the kick-off meeting with the following:

- Exhibits of the project area with topographic information; and,
- A list of proposed PBMPs.

To preserve the existing natural resources in Carrollton and promote sustainable development, demonstration of compliance with the following minimum number of PBMPs shall be provided:

PBMP Requirements

Disturbed Area Size	Minimum Number of PBMP Points*
12,000 sq. ft $\leq$ Disturbed Area < 5 acres	2
5 acres < Disturbed Area < 10 acres	4
10 acres < Disturbed Area < 20 acres	6
$\geq$ 20 acres	8

* Single family lots are excluded.
* Subdivisions with paved alleys shall provide one PBMP above minimum.

3. Permanent Best Management Practices Point System

The following Point System summarizes the contribution of each PBMP toward the minimum number of PBMP points required.

Permanent Best Management Practice Point System

Permanent Best Management Practice	Size Criteria	Number of Points
Buffers and Undisturbed Areas (varies by size)	1 Point for every 4 acres of buffer/undisturbed area. Minimum of 50 feet in width.	1 to 4
Bioretention Systems	Landscape areas and enhanced swales to filter runoff from a minimum of 10% of the developed site area.	2
Gravity Separator	Solids and oils removal device. A minimum of 2 devices per 10 acres of development.	3
Preservation of Natural Creeks (in a non-erosive state)	Preserve a minimum length of 70% of existing creeks	2
Permeable and Semi-pervious Pavement	A minimum of 50% of site pavement is pervious	2

Low Impact Development Methods	Green roof, rainwater harvesting, rain gardens, etc. as approved by the City.	2
Stream Restoration	Restoration performed on a minimum of 70% of existing creek length.	3
Vegetative Filter Strips	A minimum of 20-feet of strips along site boundaries and discharge to creeks	1
Vegetative Swales	A minimum of 50 feet of grass swale length to discharge locations	1
Native Landscaping	A minimum of 10% of site area stabilized using native plants.	1
Stormwater Retention	Use of stormwater retention basins	1
Aeration Features within Retention Basins	Aeration fountain in retention basins	1
Additional Approved Methods	To be determined by City	To be determined by City

4. Operations and Maintenance Form Requirement

Submittal of an Operations and Maintenance (O&M) Form is required to demonstrate the long-term preservation and performance of PBMPs. The O&M Form must be accepted by the City before the final plans are approved for construction. The Applicant shall agree to the operations and maintenance procedures and frequency of Maintenance for each PBMP specified in the O&M Form.

5. Operations and Maintenance Responsibility

A developer is responsible for the establishment and maintenance of PBMPs during the two-year warranty period. During this time developer, or established Owners Association, must perform necessary operations and maintenance activities. The developer representative must submit an annual inspection report identifying the success of the PBMPs.

The developer/ may request that the City accept maintenance responsibility of PBMPs after the completion of the two-year warranty period. This request must be made during the planning, design and platting phases. The developer must dedicate maintenance easements, subject to City acceptance, for all PBMPs that the City accepts as a maintenance responsibility. If approved, the developer will contribute to a general stormwater maintenance fund. The contribution shall be equal to the estimated present cost, including inflation, for twenty (20) years of operations and maintenance.

6. PBMP Easements

A developer shall place all PBMPs within the limits of private property and the maintenance shall remain the developer responsibility. PBMP's that include regional Stormwater Retention basins and any other PBMP that the City accepts long-term maintenance responsibility for shall be placed in an easement and be dedicated to the City.

7. Inspections and Monitoring

Inspections and monitoring of PBMPs is the responsibility of the developer representative, as identified on the O&M Form, during the established maintenance period. The frequency of inspections for the PBMPs is required annually, as a minimum. If PBMPs include structural controls, maintenance of the controls must be performed at the following minimum frequency:

- Quarterly for the first 3 years
- Twice a year thereafter
- Within 48 hours of major rainfall events (more than 3 inches of rain over a 24-hour period, approximately an annual rainfall event)

Maintenance activities shall include, but is not limited to:

- Maintaining PBMPs in a good working condition,
- Repairing damage to PBMPs,
- Removal and legal disposal of trash, debris, and accumulated sediment.

The developer representative must provide guidance to maintenance personnel to prevent system deterioration and failure. The developer representative must maintain inspection and maintenance logs. The developer must provide the City with copies of the inspection and maintenance logs, upon written request.

The City reserves the right to inspect the PBMPs at any time. If the PBMPs fails the inspection, then the developer representative is notified of the deficiencies and allowed a 30-day period to correct the noted issues. In the event that the deficiencies are not corrected within the 30-day period, then the City reserves the right to perform any work necessary to correct deficiencies. The developer representative shall to responsible for reimbursing the City for any costs incurred in resolving the deficiencies.

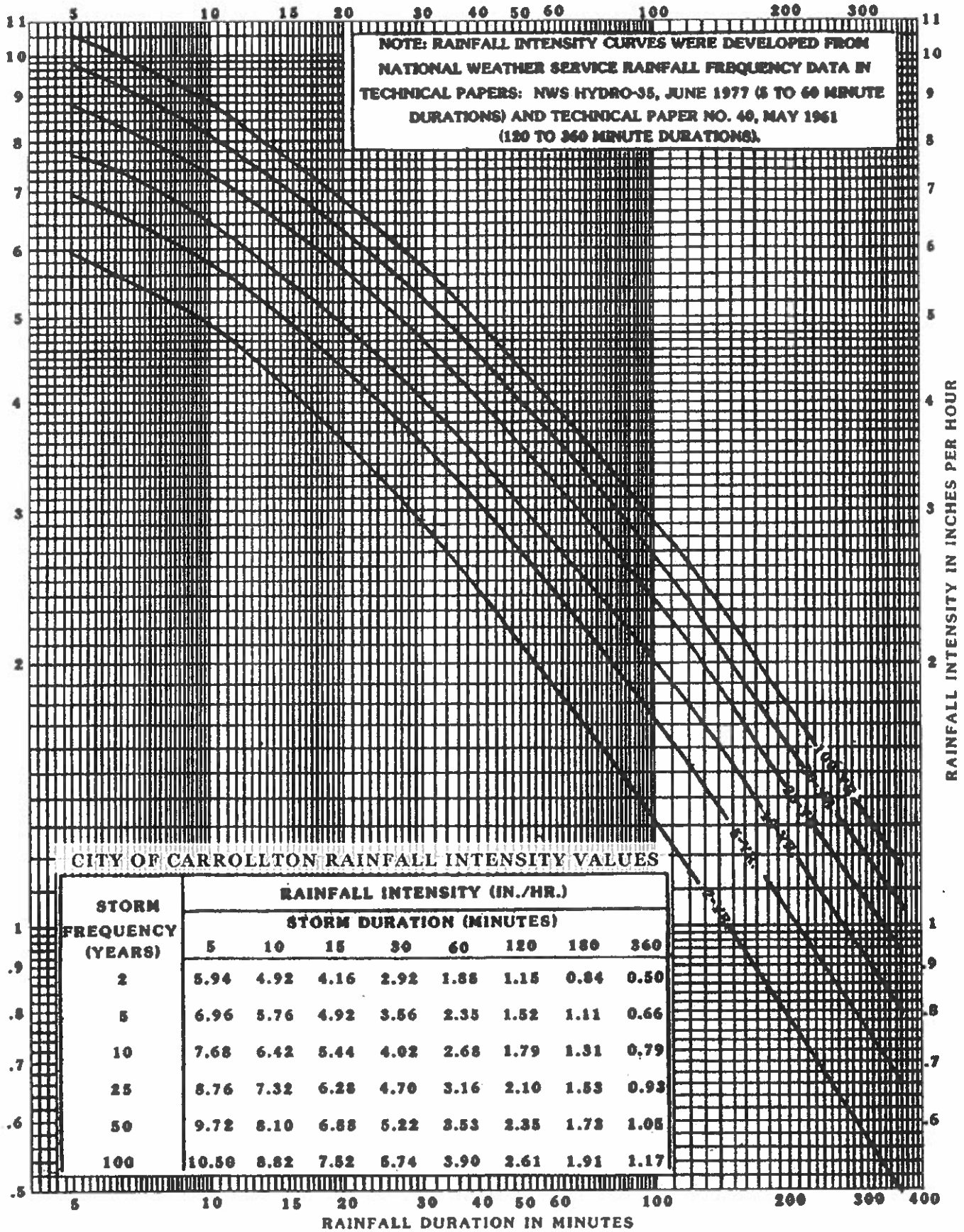
8. O&M Revisions

Any proposed revisions or modifications made to an approved O&M Form requires a new O&M Form to be completed. The revised O&M Form must be submitted to the City for review and approval.

9. Enforcement Actions

In addition to the reimbursement of costs incurred by the City, the developer may also be subject to fines under the City's Code of Ordinances for violations of this ordinance, on a per day basis.

FIGURE 1



CITY OF CARROLLTON RAINFALL INTENSITY VALUES

STORM FREQUENCY (YEARS)	RAINFALL INTENSITY (IN./HR.) STORM DURATION (MINUTES)							
	5	10	15	30	60	120	180	360
2	5.94	4.92	4.16	2.92	1.88	1.15	0.84	0.50
5	6.96	5.76	4.92	3.56	2.35	1.52	1.11	0.66
10	7.68	6.42	5.44	4.02	2.68	1.79	1.31	0.79
25	8.76	7.32	6.28	4.70	3.16	2.10	1.53	0.93
50	9.72	8.10	6.88	5.22	3.53	2.35	1.72	1.05
100	10.50	8.82	7.52	5.74	3.90	2.61	1.91	1.17

CAPACITY OF TRIANGULAR GUTTERS

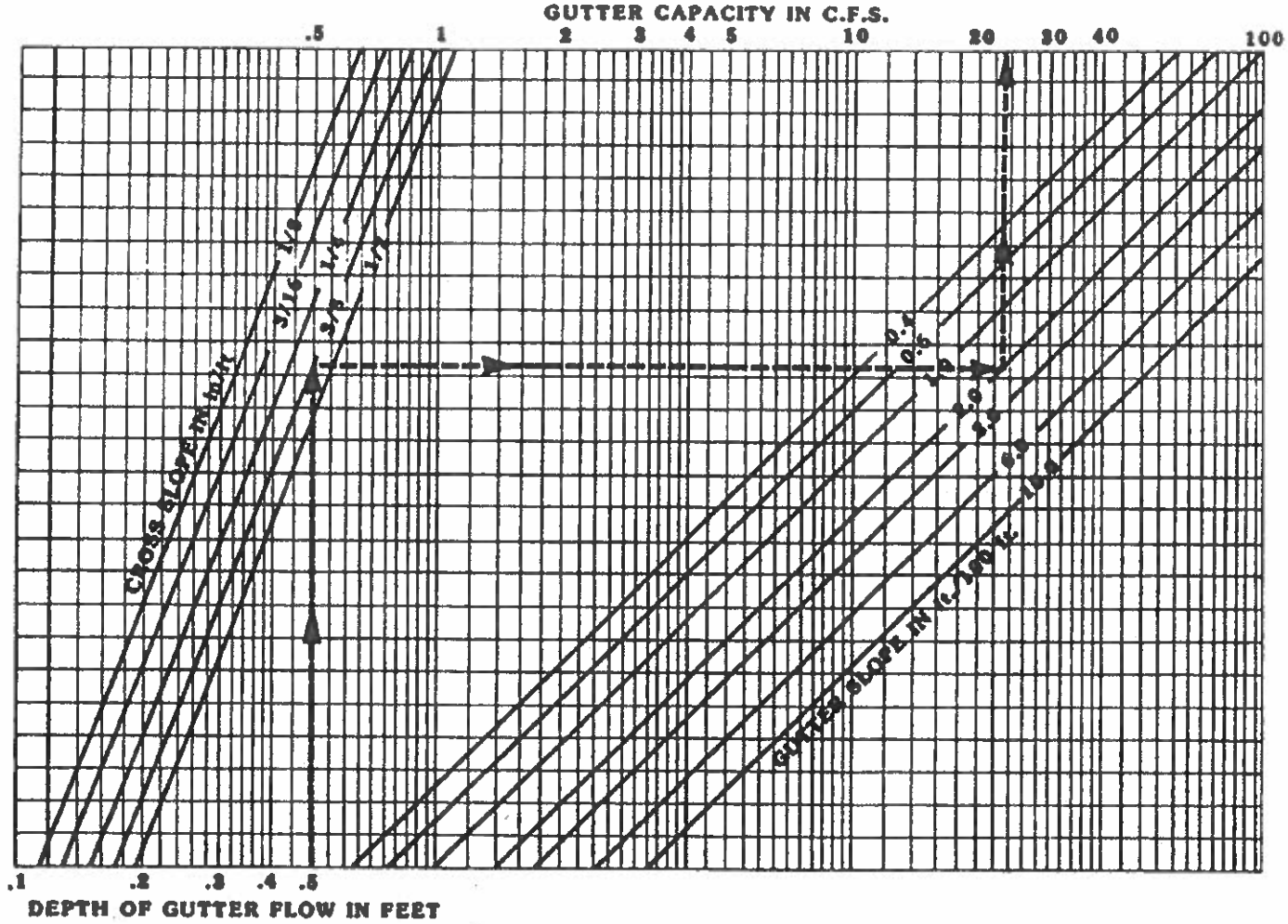
FIGURE 2

EXAMPLE

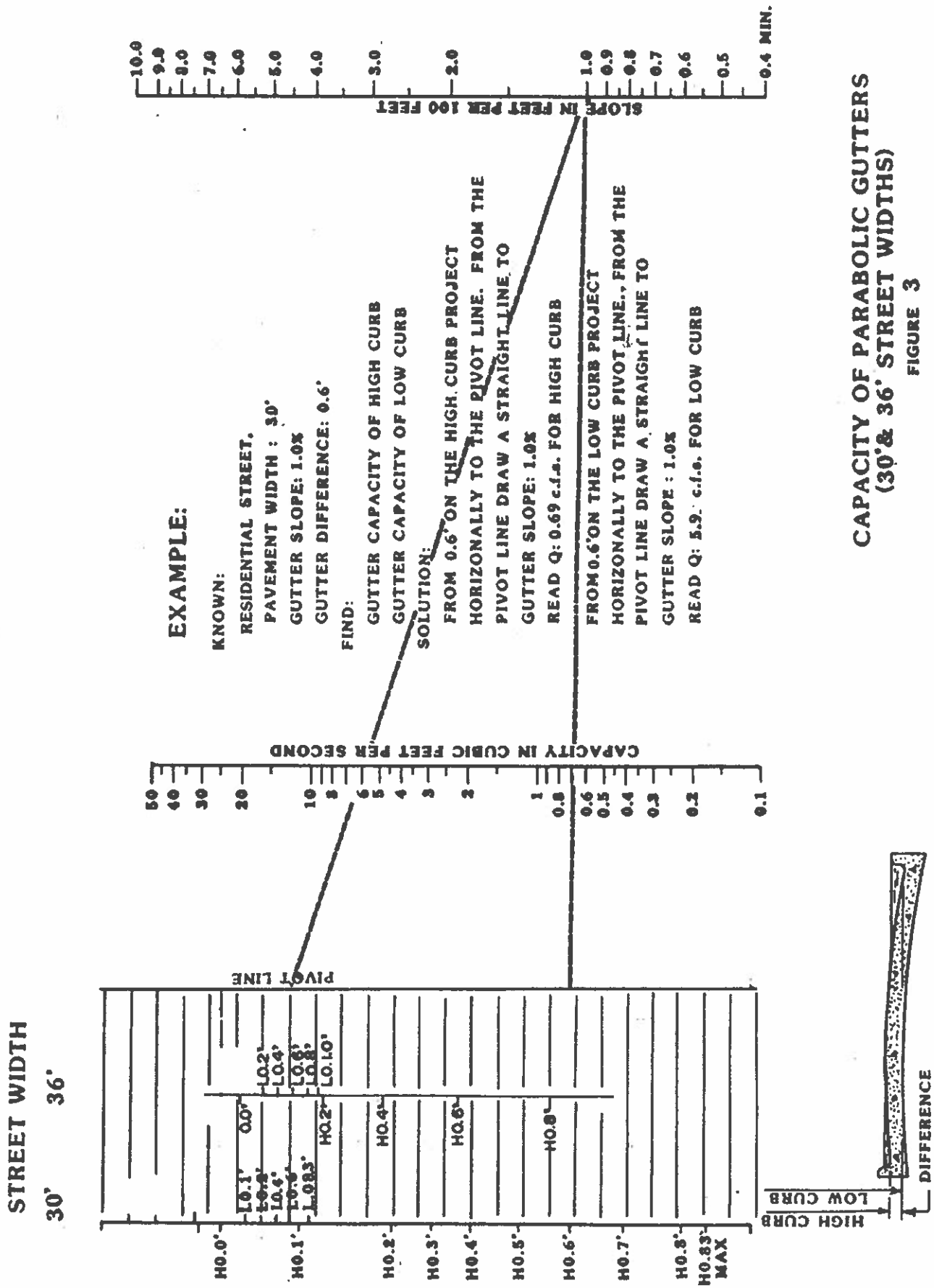
KNOWN :
MAJOR THOROUGHFARE, TYPE M6D
PAVEMENT WIDTH : 33'
GUTTER SLOPE : 2.0%
PAVEMENT CROSS SLOPE : 3/8"/1'
DEPTH OF GUTTER FLOW : .5'

FIND:
GUTTER CAPACITY

SOLUTION:
ENTER GRAPH AT .5'
INTERSECT CROSS SLOPE : 3/8"/1'
INTERSECT GUTTER SLOPE : 2.0%
READ GUTTER CAPACITY : 23.5 c.f.s.

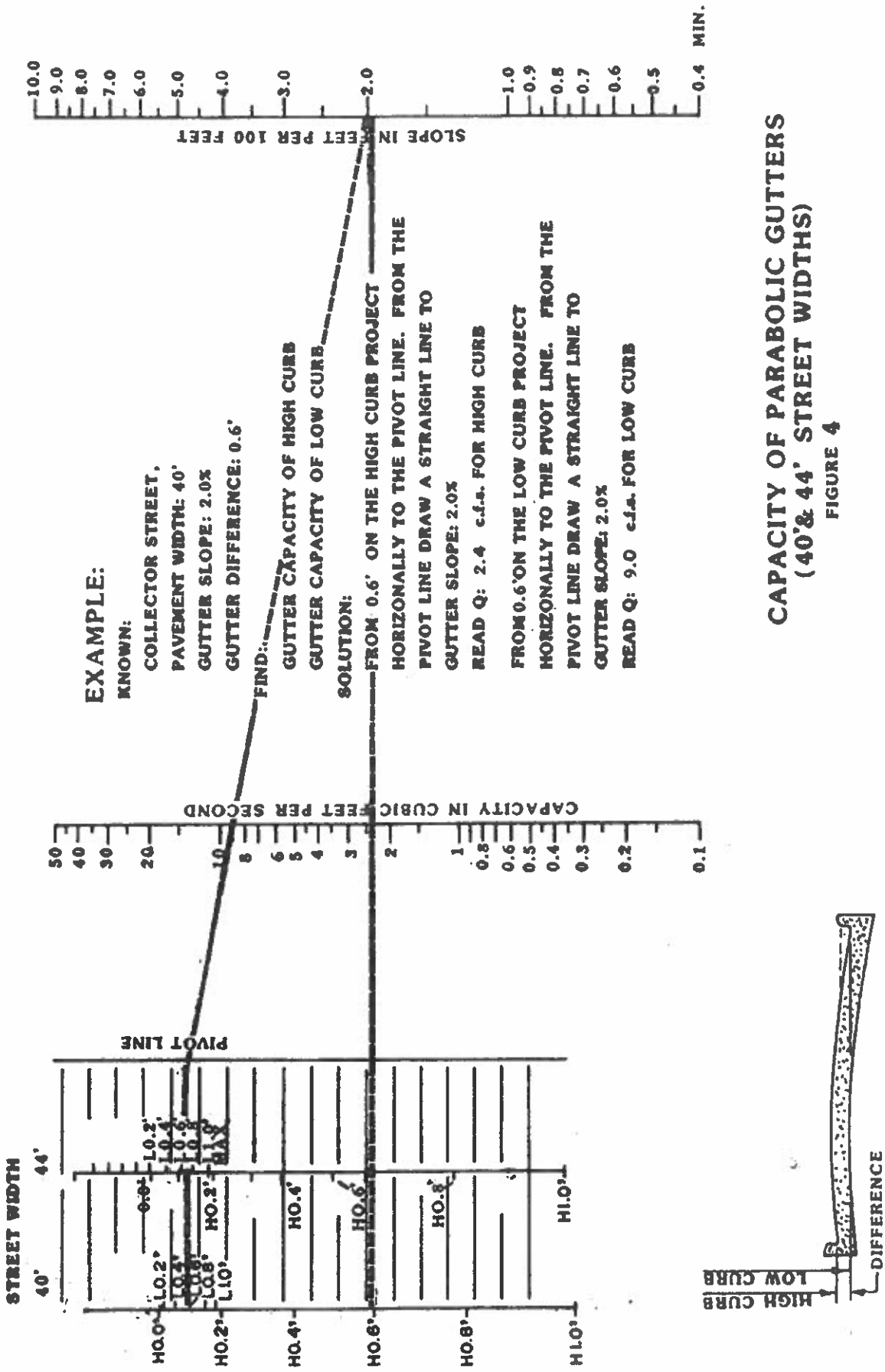


(ROUGHNESS COEFFICIENT n : .0175)



CAPACITY OF PARABOLIC GUTTERS
(30' & 36' STREET WIDTHS)

FIGURE 3



CAPACITY OF PARABOLIC GUTTERS
(40'& 44' STREET WIDTHS)
FIGURE 4

CAPACITY OF ALLEY SECTIONS

n:0.0175

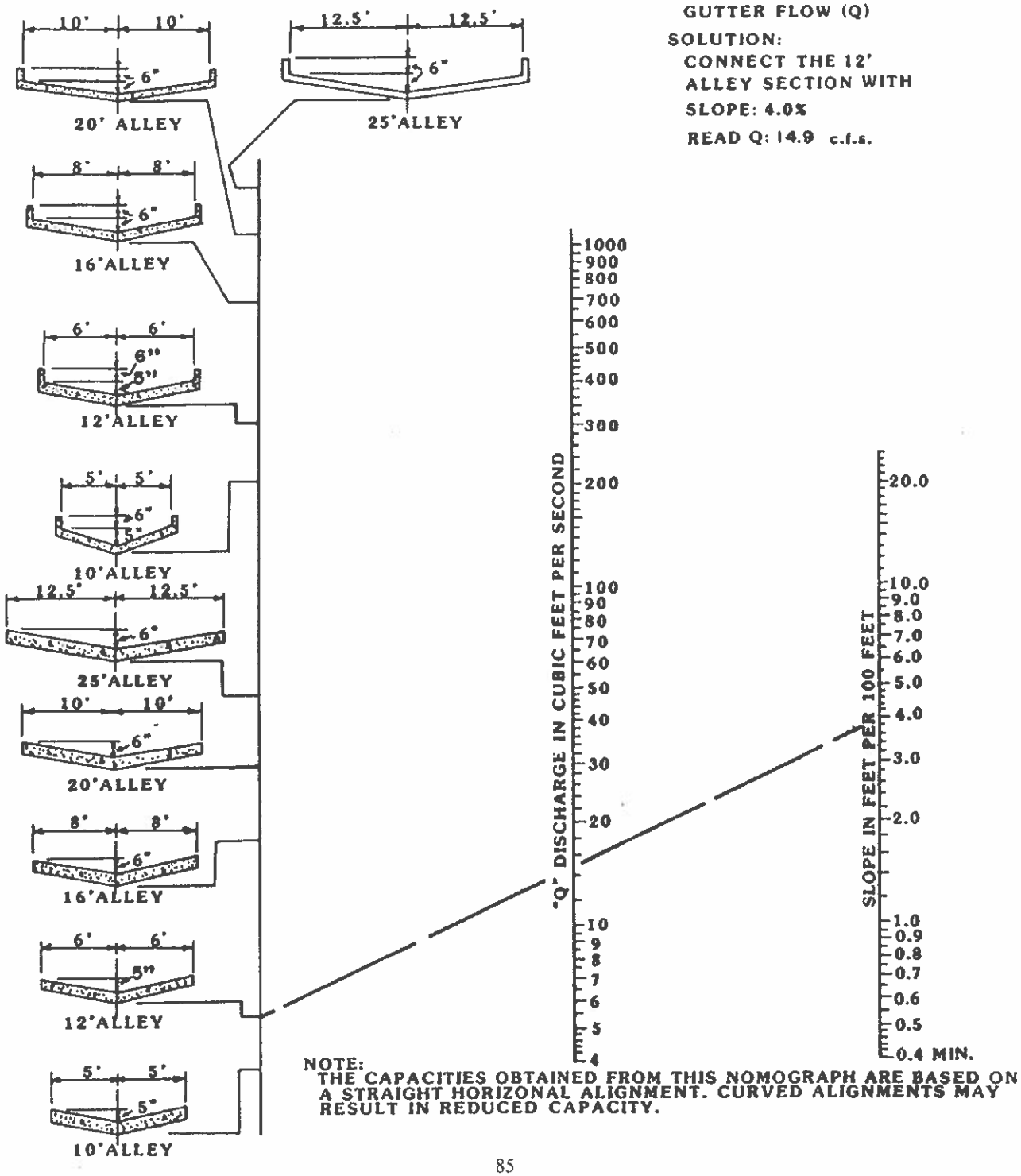
FIGURE 5

EXAMPLE :

KNOWN:
- ALLEY WIDTH: 12'
- ALLEY DEPRESSION: 5"
- GUTTER SLOPE: 4.0%

FIND:
- GUTTER FLOW (Q)

SOLUTION:
- CONNECT THE 12' ALLEY SECTION WITH SLOPE: 4.0%
- READ Q: 14.9 c.f.s.



NOTE:
THE CAPACITIES OBTAINED FROM THIS NOMOGRAPH ARE BASED ON A STRAIGHT HORIZONAL ALIGNMENT. CURVED ALIGNMENTS MAY RESULT IN REDUCED CAPACITY.

FIGURE 6

STORM DRAIN INLETS

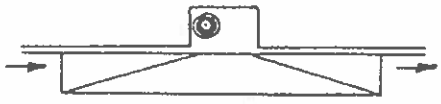
INLET DESCRIPTION	AVAIL. INLET SIZES	WHERE USED	DESIGN CURVES
 STANDARD CURB OPENING INLET ON GRADE	8' 10' 12' 14'	Residential Street, Collector Street - Types C2UA and C2UB; Alley	Figures 7 Through 11
 STANDARD CURB OPENING INLET AT LOW POINT	8' 10' 12' 14'	Residential Street, Collector Street - Types C2UA and C2UB; Alley	Figure 12
 RECESSED CURB OPENING INLET ON GRADE	8' 10' 12' 14'	Collector Street, Type C4U Major Streets - Types M4U, M4D, M6D, Principal Streets (P6D)	Figures 7 Through 11
 RECESSED CURB OPENING INLET AT LOW POINT	8' 10' 12' 14'	Collector Street, Type C4U Major Streets - Types M4U, M4D, M6D, Principal Streets (P6D)	Figure 12

FIGURE 6 CONTINUED

INLET DESCRIPTION	AVAIL. INLET SIZES	WHERE USED	DESIGN CURVES
 COMBINATION INLET ON GRADE	8'	Combination Inlets to be Used Where Space Behind Curb Prohibits Other Inlet Types	Figures 13 Through 15
 COMBINATION INLET AT LOW POINT	8'	Combination Inlets to be Used Where Space Behind Curb Prohibits Other Inlet Types	Figure 16
 GRATE INLETS	2 GRATE 3 GRATE 4 GRATE 6 GRATE	Grate Inlets to be Used Where Space Restrictions Prohibit Other Inlet Types or At Locations with No Curb.	Figures 17 THROUGH 20
 DROP INLET	2' x 2' 3' x 3' 4' x 4'	Open Channels	Figure 21

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 7

EXAMPLE

KNOWN:

PAVEMENT WIDTH : 30'

GUTTER SLOPE: 2.0 %

5" PARABOLIC CROWN

GUTTER FLOW: 5.2 c.f.s.

FIND:

LENGTH OF INLET REQUIRED

SOLUTION:

ENTER GRAPH AT 5.2 c.f.s.

INTERSECT SLOPE: 2.0 %

READ L_i : 8.7'

DECISION:

1. USE 10' INLET

NO FLOW REMAINS IN GUTTER

2. USE 8' INLET

INTERCEPT ONLY PART OF FLOW

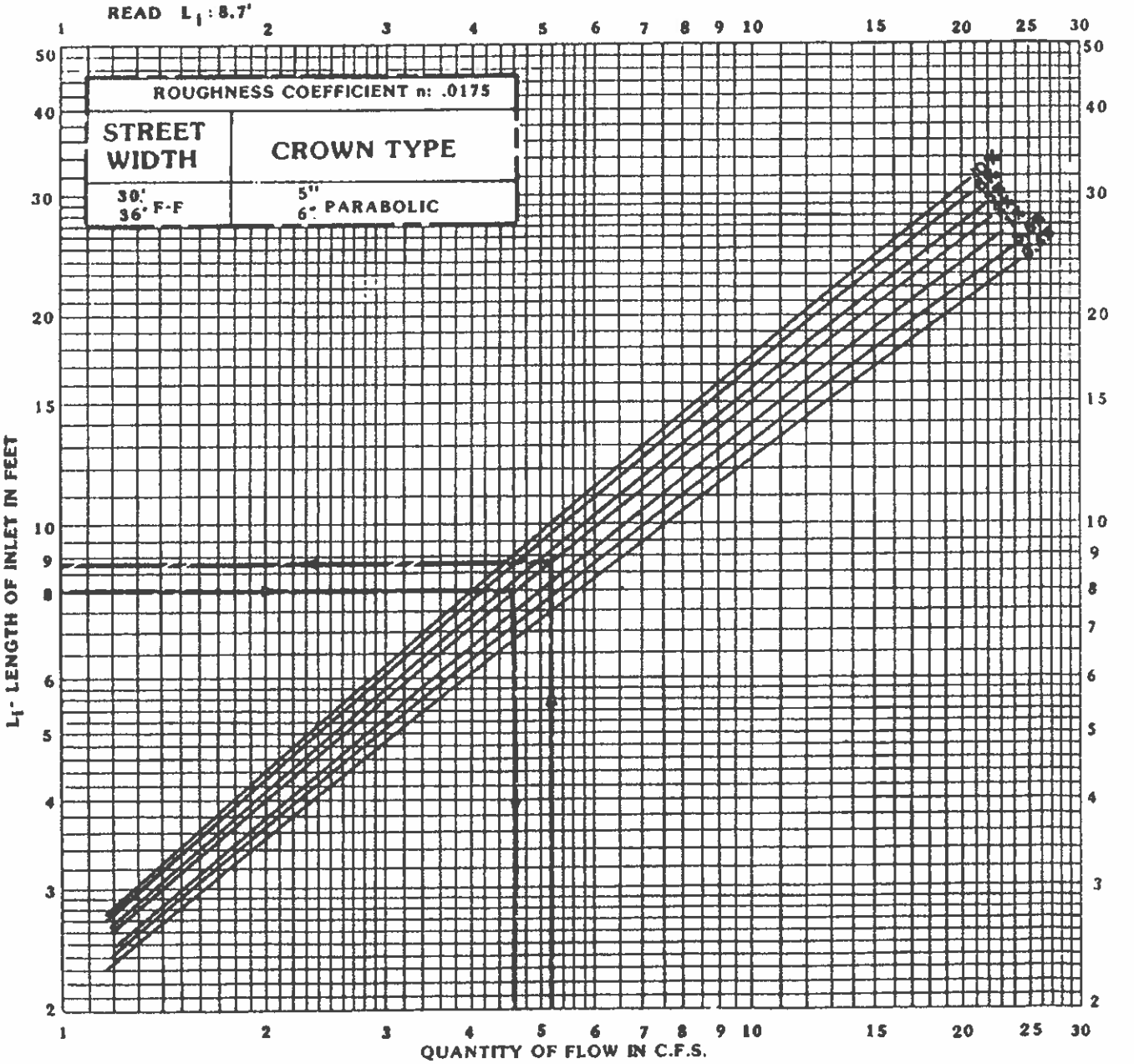
USE 8' INLET

ENTER GRAPH AT L_i : 8'

INTERSECT SLOPE: 2.0 %

READ Q: 4.6 c.f.s.

REMAINING GUTTER FLOW: 5.2 c.f.s. - 4.6 c.f.s. : .6 c.f.s.



RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 8

EXAMPLE

KNOWN:

PAVEMENT WIDTH : 36'

GUTTER SLOPE: 3.0%

1/2"/ft CROSS SLOPE

GUTTER FLOW: 5.2 c.f.s.

FIND:

LENGTH OF INLET REQUIRED

SOLUTION:

ENTER GRAPH AT 5.2 c.f.s.

INTERSECT SLOPE: 3.0%

READ L_i: 8.8'

DECISION:

1. USE 10' INLET

NO FLOW REMAINS IN GUTTER

2. USE 8' INLET

INTERCEPT ONLY PART OF FLOW

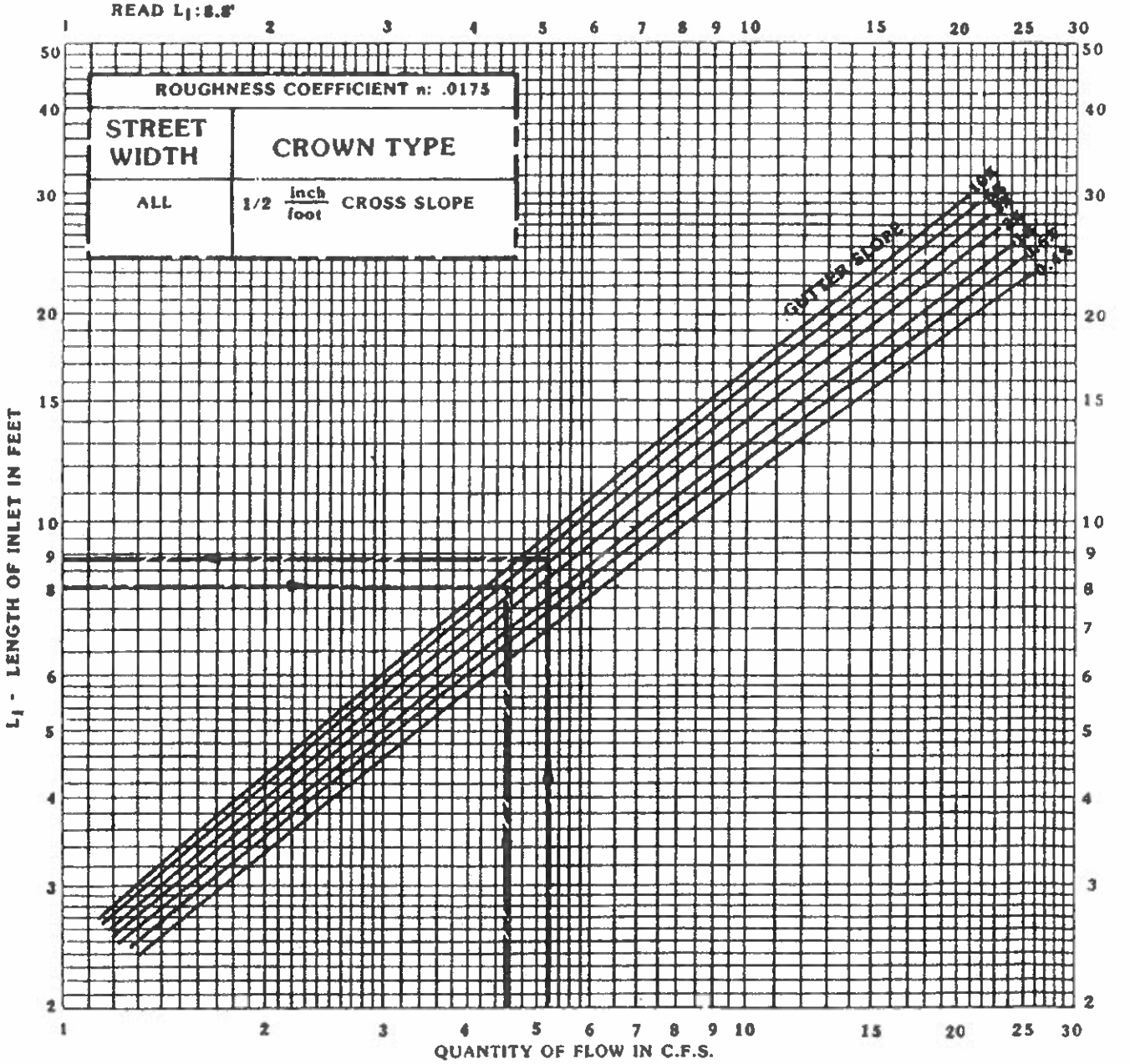
USE 8' INLET

ENTER GRAPH AT L_i: 8'

INTERSECT SLOPE: 3.0%

READ Q: 4.6 c.f.s.

REMAINING GUTTER FLOW: 5.2 c.f.s. - 4.6 c.f.s. : 0.6 c.f.s



RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 9

EXAMPLE

KNOWN:

PAVEMENT WIDTH : 30'

GUTTER SLOPE: 3.0%

PAVEMENT CROSS SLOPE: 1/4"/1'

GUTTER FLOW: 4.8 c.f.s.

FIND:

LENGTH OF INLET REQUIRED

SOLUTION:

ENTER GRAPH AT 4.8 c.f.s.

INTERSECT SLOPE: 3.0 %

READ L_I : 9.5'

DECISION:

1. USE 10' INLET

NO FLOW REMAINS IN GUTTER

2. USE 8' INLET

INTERCEPT ONLY PART OF FLOW

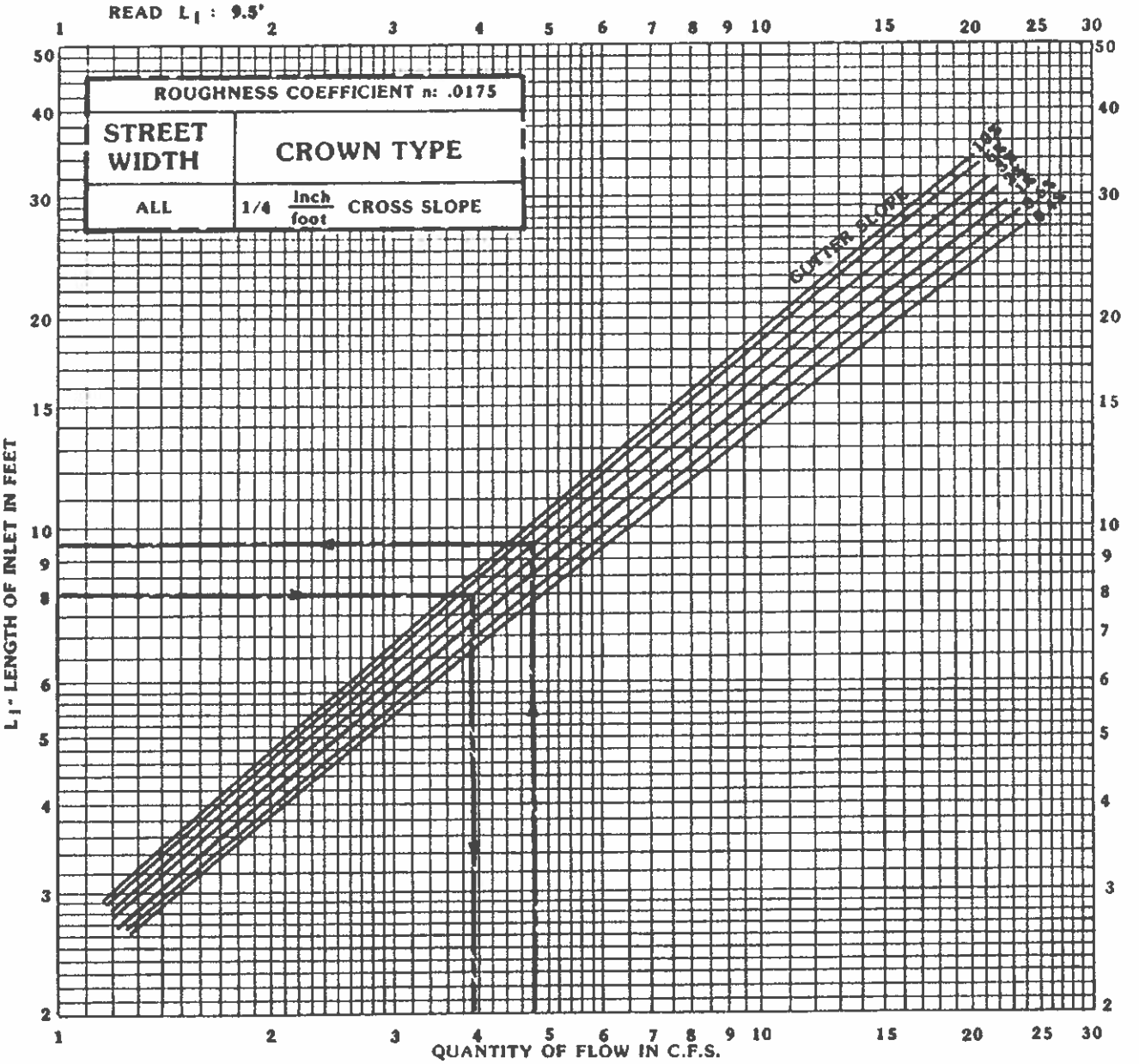
USE 8' INLET

ENTER GRAPH AT L_I : 8'

INTERSECT SLOPE: 3.0%

READ Q: 3.9 c.f.s.

REMAINING GUTTER FLOW: 4.8 c.f.s.-3.9 c.f.s.=0.9 c.f.s



RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 10

EXAMPLE

KNOWN:

PAVEMENT WIDTH : 40'

GUTTER SLOPE: 1.0%

6" PARABOLIC CROWN

GUTTER FLOW: 6.5 c.f.s.

FIND:

LENGTH OF INLET REQUIRED

SOLUTION:

ENTER GRAPH AT 6.5 c.f.s.

INTERSECT SLOPE: 1.0 %

READ L_i : 10'

DECISION:

1. USE 10' INLET

NO FLOW REMAINS IN GUTTER

2. USE 8' INLET

INTERCEPT ONLY PART OF FLOW

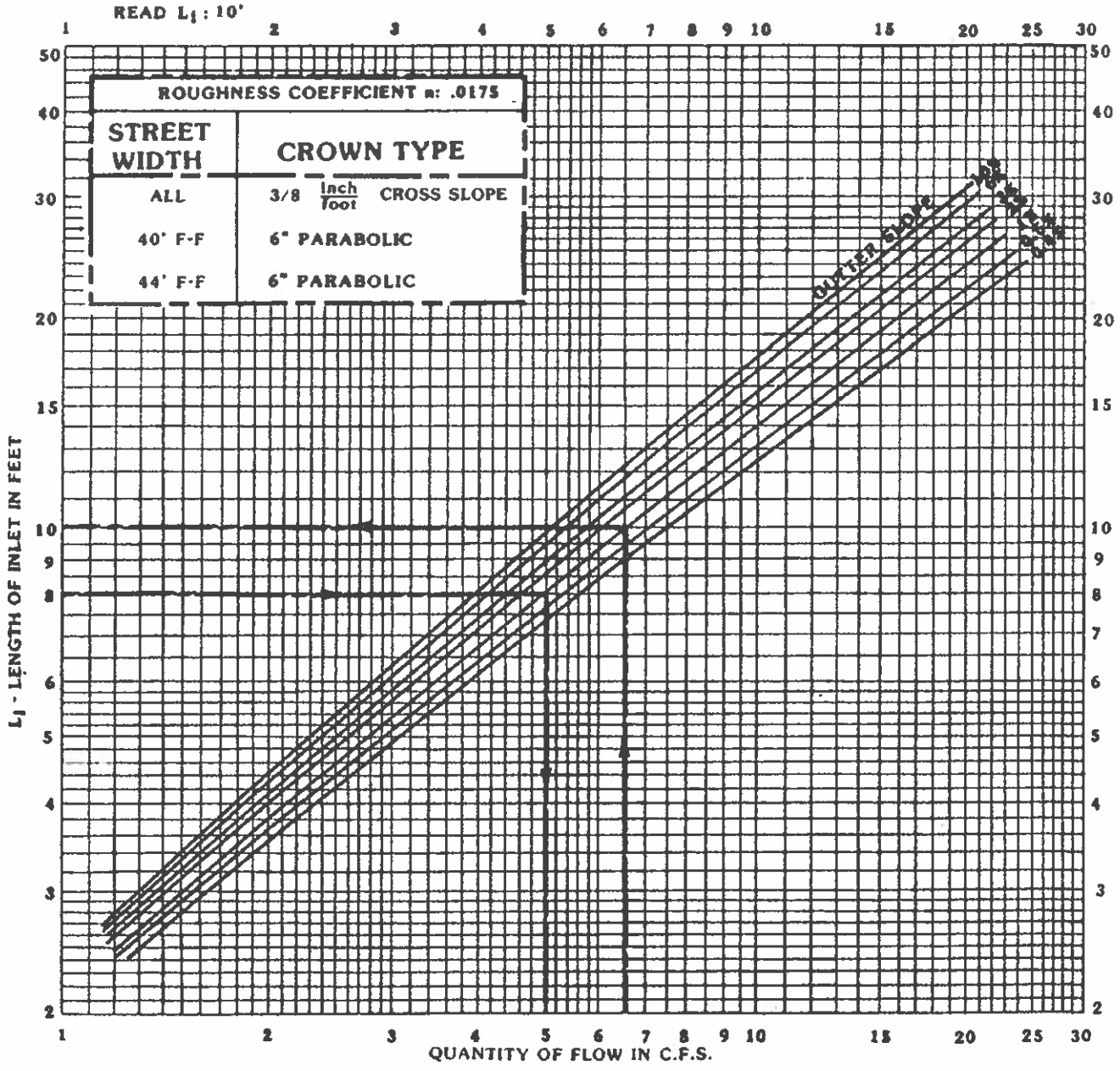
USE 8' INLET

ENTER GRAPH AT L_i : 8'

INTERSECT SLOPE: 1.0%

READ Q: 5.0 c.f.s.

REMAINING GUTTER FLOW: 6.5 c.f.s. - 5.0 cfs :1.5 c.f



RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 11

EXAMPLE

KNOWN:

PAVEMENT WIDTH : 12'

ALLEY SLOPE: 0.4%

QUANTITY OF FLOW: 10.5 c.f.s.

FIND:

LENGTH OF INLET REQUIRED

SOLUTION:

ENTER GRAPH AT 10.5 c.f.s.

INTERSECT SLOPE: 0.4%

READ L_i : 13.0 ft.

DECISION:

1. USE 14' INLET

NO FLOW REMAINS IN GUTTER

2. USE 10' INLET

INTERCEPT ONLY PART OF FLOW

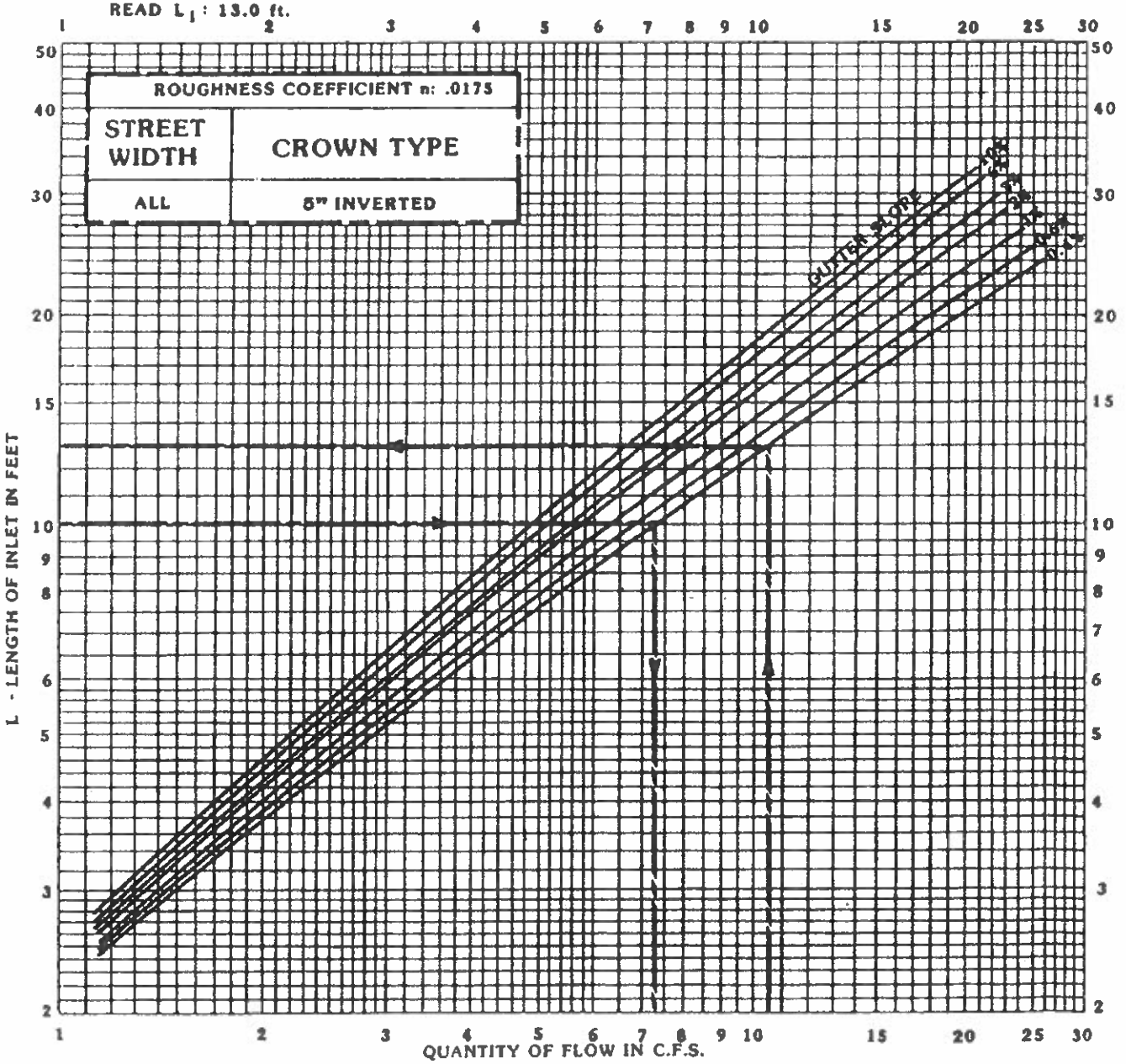
USE 10' INLET

ENTER GRAPH AT L_i : 10'

INTERSECT SLOPE: 0.4%

READ Q: 7.3 c.f.s.

REMAINING FLOW IN ALLEY : 10.5 c.f.s. - 7.3 c.f.s. : 3.2 c.f.s.



RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES AT LOW POINT

FIGURE 12

EXAMPLE

KNOWN:

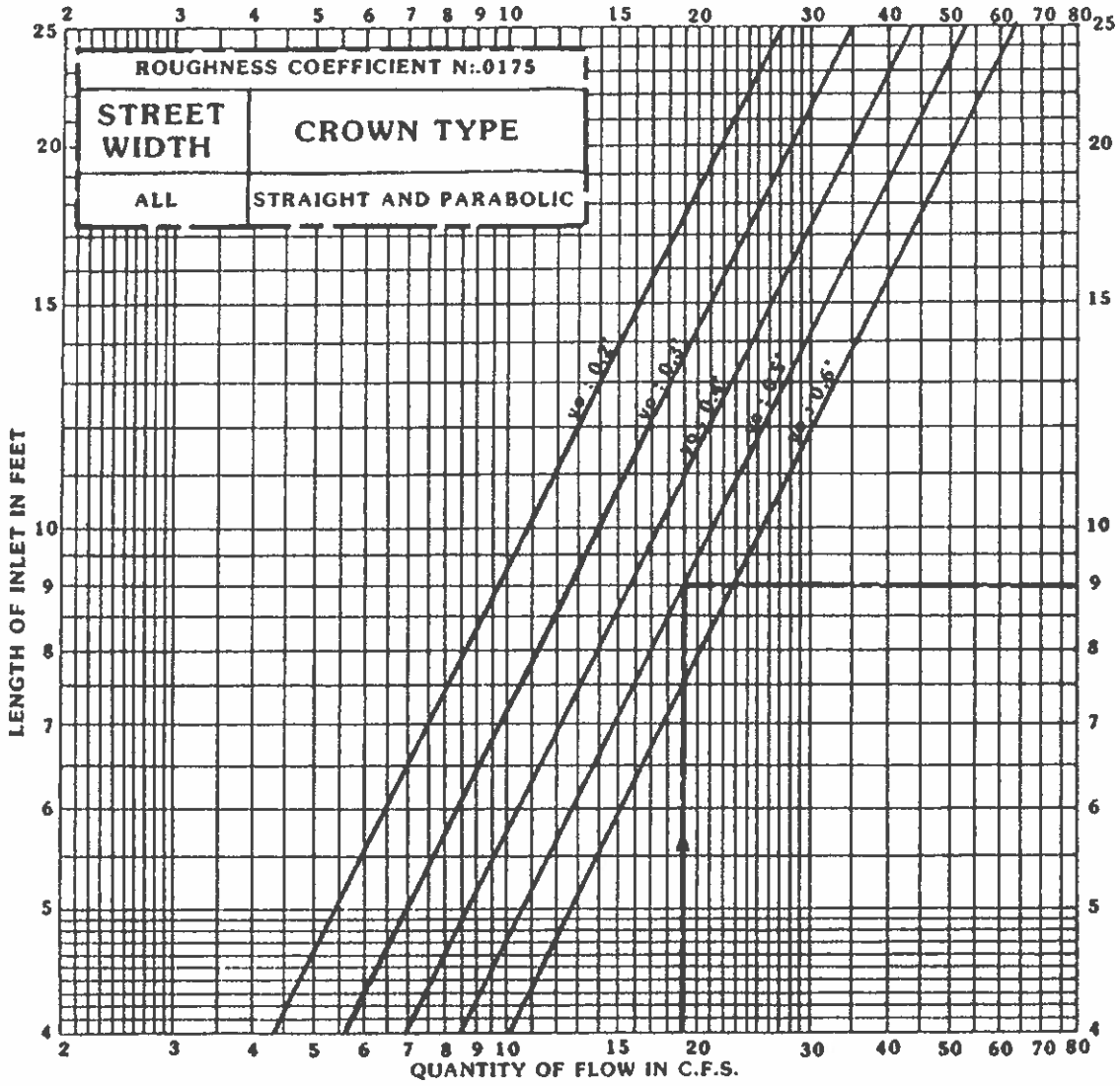
QUANITY OF FLOW: 19.0 c.f.s.
MAXIMUM DEPTH OF FLOW DESIRED IN GUTTER AT LOW POINT (yo): 0.5'

FIND:

LENGTH OF INLET REQUIRED (L_i)

SOLUTION:

ENTER GRAPH AT 19 c.f.s.
INTERSECT yo: 0.5'
READ L_i : 9.0'
USE 10' INLET



TWO GRATE COMBINATION INLET CAPACITY CURVES ON GRADE

FIGURE 13

EXAMPLE

KNOWN:

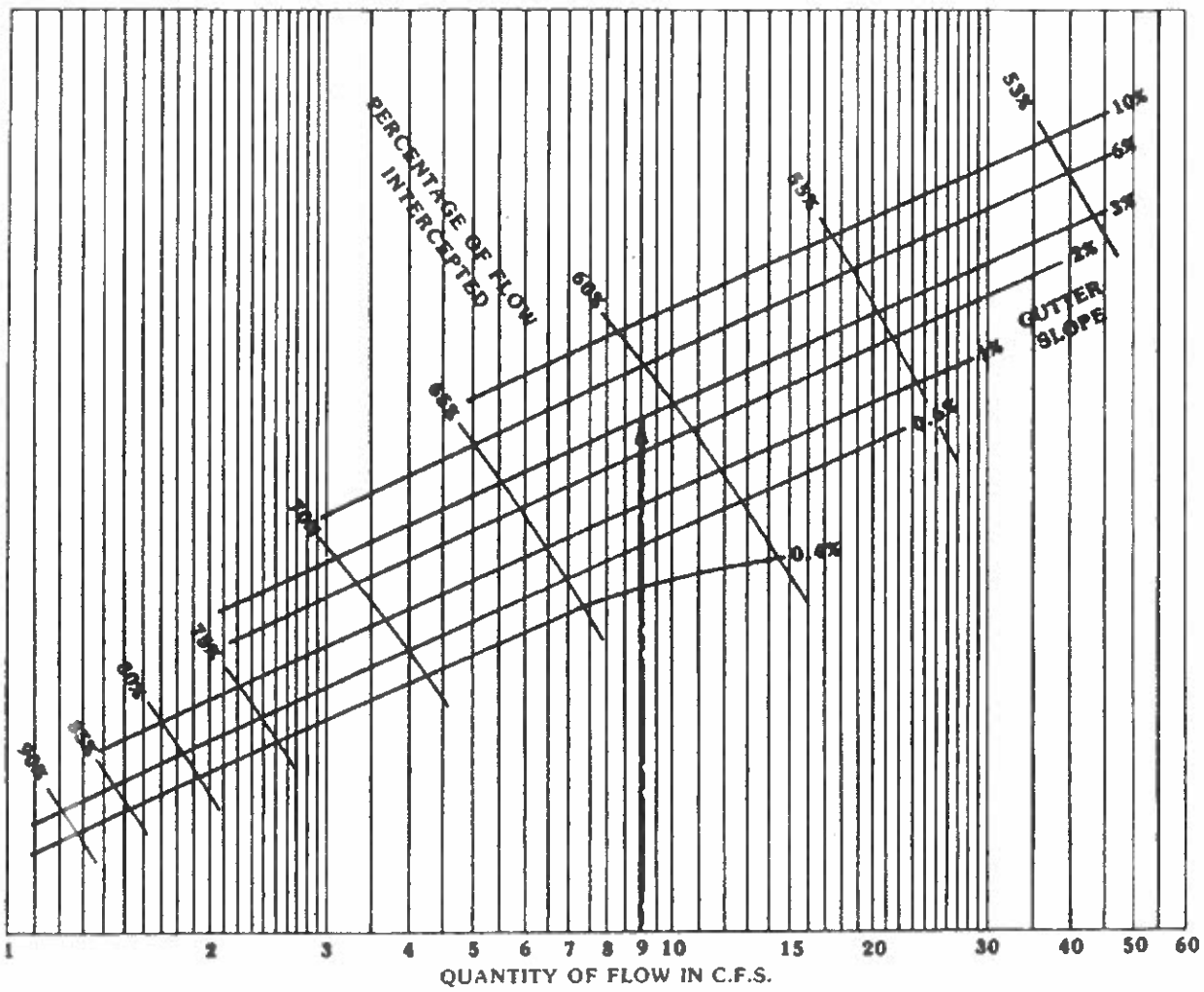
QUANITY OF FLOW: 9 c.f.s.
GUTTER SLOPE: 3.0%

FIND:

CAPACITY OF TWO GRATE COMBINATION INLET

SOLUTION:

ENTER GRAPH AT 9.0 c.f.s.
INTERSECT SLOPE: 3.0 %
READ PERCENT OF FLOW INTERCEPTED: 61%
61% OF 9.0 c.f.s. : 5.5 c.f.s.
AS CAPACITY OF TWO GRATE COMBINATION INLET
REMAINING GUTTER FLOW:
9.0 c.f.s. - 5.2 c.f.s. : 3.8 c.f.s.



THREE GRATE COMBINATION INLET
CAPACITY CURVES ON GRADE

FIGURE 14

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 15 c.f.s.

GUTTER SLOPE: 2.0 %

FIND:

CAPACITY OF THREE GRATE INLET

SOLUTION:

ENTER GRAPH AT 15 c.f.s.

INTERSECT SLOPE: 2.0 %

READ PERCENT OF FLOW

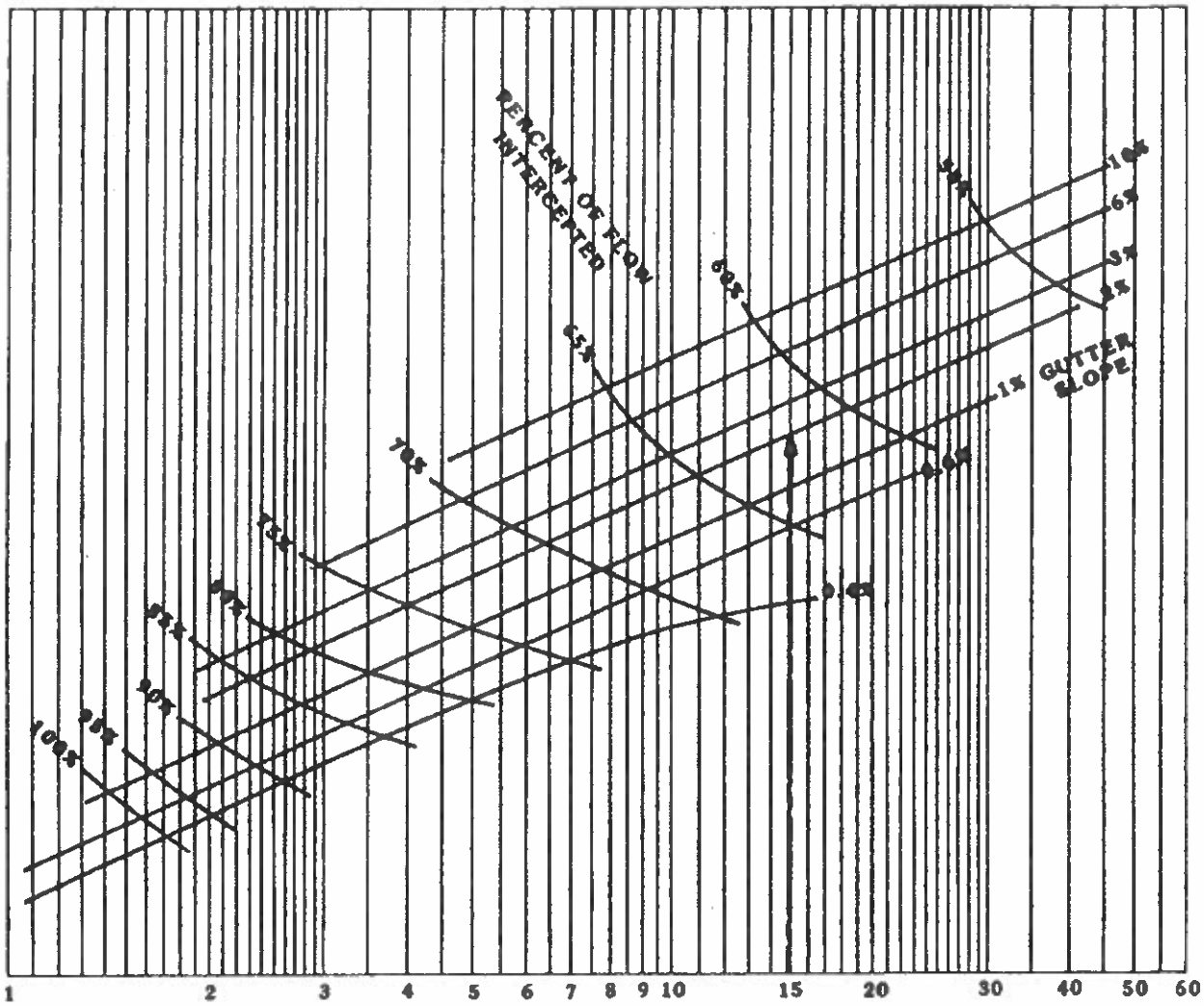
INTERCEPTED: 62%

62 % OF 15 c.f.s.: 9.3 c.f.s.

AS CAPACITY OF THREE GRATE INLET

REMAINING GUTTER FLOW:

15 c.f.s.-9.3 c.f.s. : 5.7 c.f.s.



FOUR GRATE COMBINATION INLET CAPACITY CURVES ON GRADE

FIGURE 15

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 12 c.f.s.

GUTTER SLOPE: 2.0 %

FIND:

CAPACITY OF FOUR GRATE COMBINATION INLET

SOLUTION:

ENTER GRAPH AT 12 c.f.s.

INTERSECT SLOPE: 2.0 %

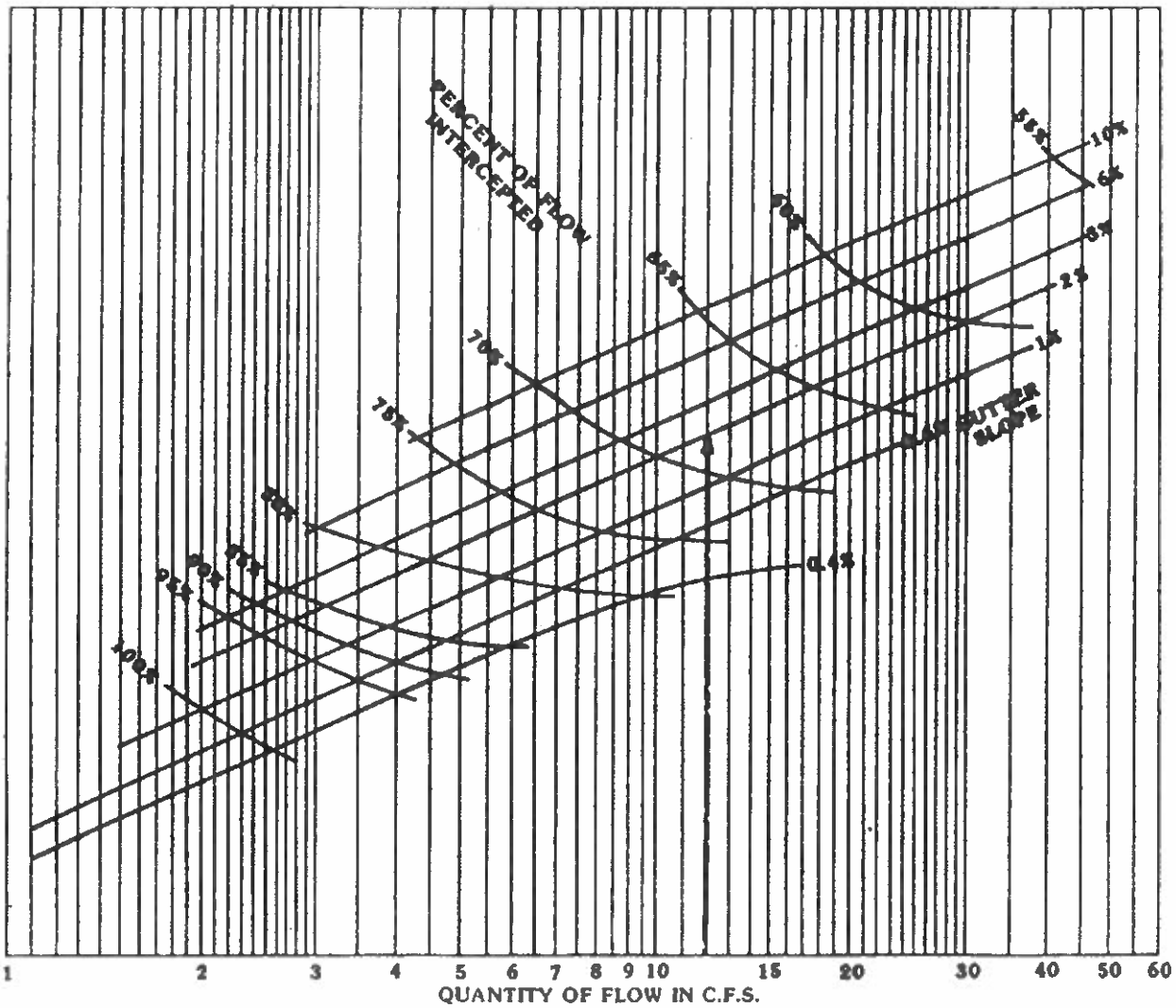
READ PERCENT OF FLOW INTERCEPTED: 68 %

68 % OF 12 c.f.s.: 8.2 c.f.s.

AS CAPACITY OF 4 GRATE COMBINATION INLET

REMAINING GUTTER FLOW:

12 c.f.s.-8.2 c.f.s. : 3.8 c.f.s.



COMBINATION INLET CAPACITY CURVES AT LOW POINT

FIGURE 16

EXAMPLE

KNOWN :

QUANTITY OF FLOW : 20.0 c.f.s.

MAXIMUM DEPTH OF FLOW DESIRED AT LOW POINT (yo) : 0.5'

FIND :

LENGTH OF INLET REQUIRED (Li)

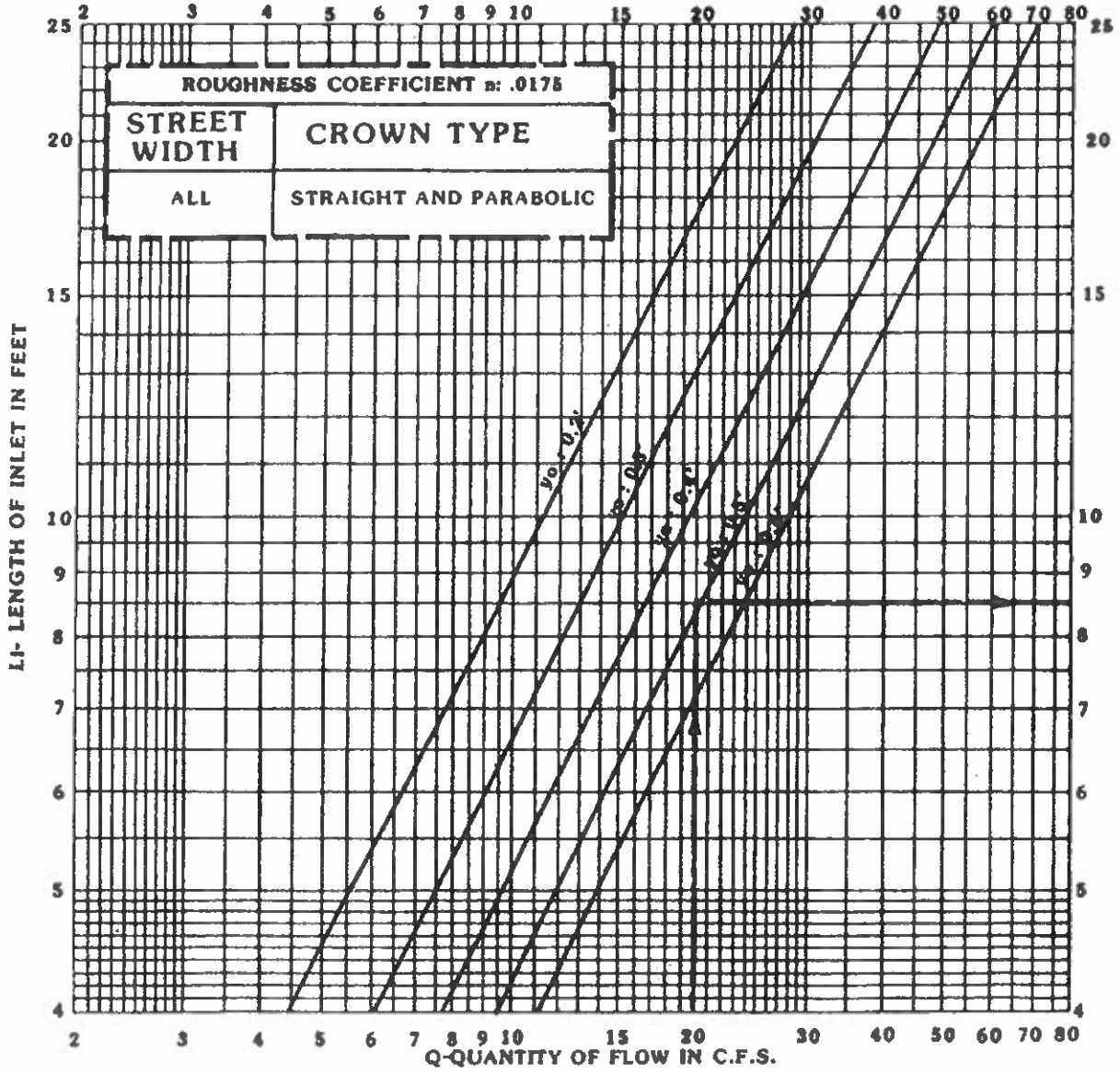
SOLUTION :

ENTER GRAPH AT 20.0 c.f.s.

INTERSECT yo : 0.5'

READ Li : 8.4

USE 10' INLET



TWO GRATE INLET CAPACITY CURVES ON GRADE

FIGURE 17

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 5.0 c.f.s.

GUTTER SLOPE: 0.6 %

FIND:

CAPACITY OF TWO GRATE INLET

SOLUTION:

ENTER GRAPH AT 5.0 c.f.s.

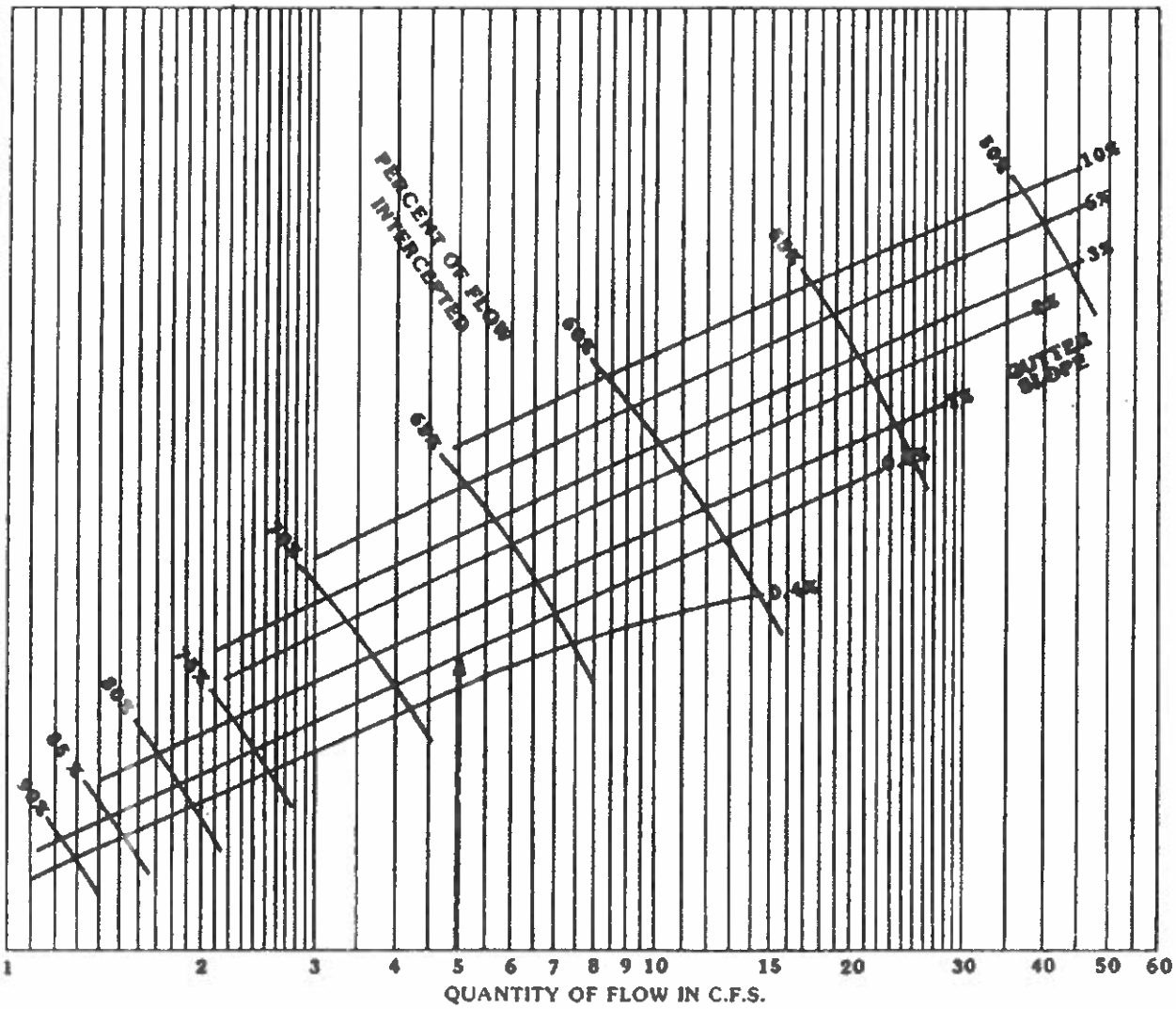
INTERSECT SLOPE: 0.6 %

READ PERCENT OF FLOW INTERCEPTED: 63%

63 % OF 5.0 c.f.s. : 3.2 c.f.s. AS CAPACITY OF TWO GRATE INLET

REMAINING GUTTER FLOW:

5.0 c.f.s. -3.2 c.f.s. : 1.8 c.f.s.



FOUR GRATE INLET CAPACITY
CURVES ON GRADE

FIGURE 18

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 20 c.f.s.

GUTTER SLOPE: 1.0 %

FIND:

CAPACITY OF FOUR GRATE INLET

SOLUTION:

ENTER GRAPH AT 20 c.f.s.

INTERSECT SLOPE: 1.0 %

READ PERCENT OF FLOW

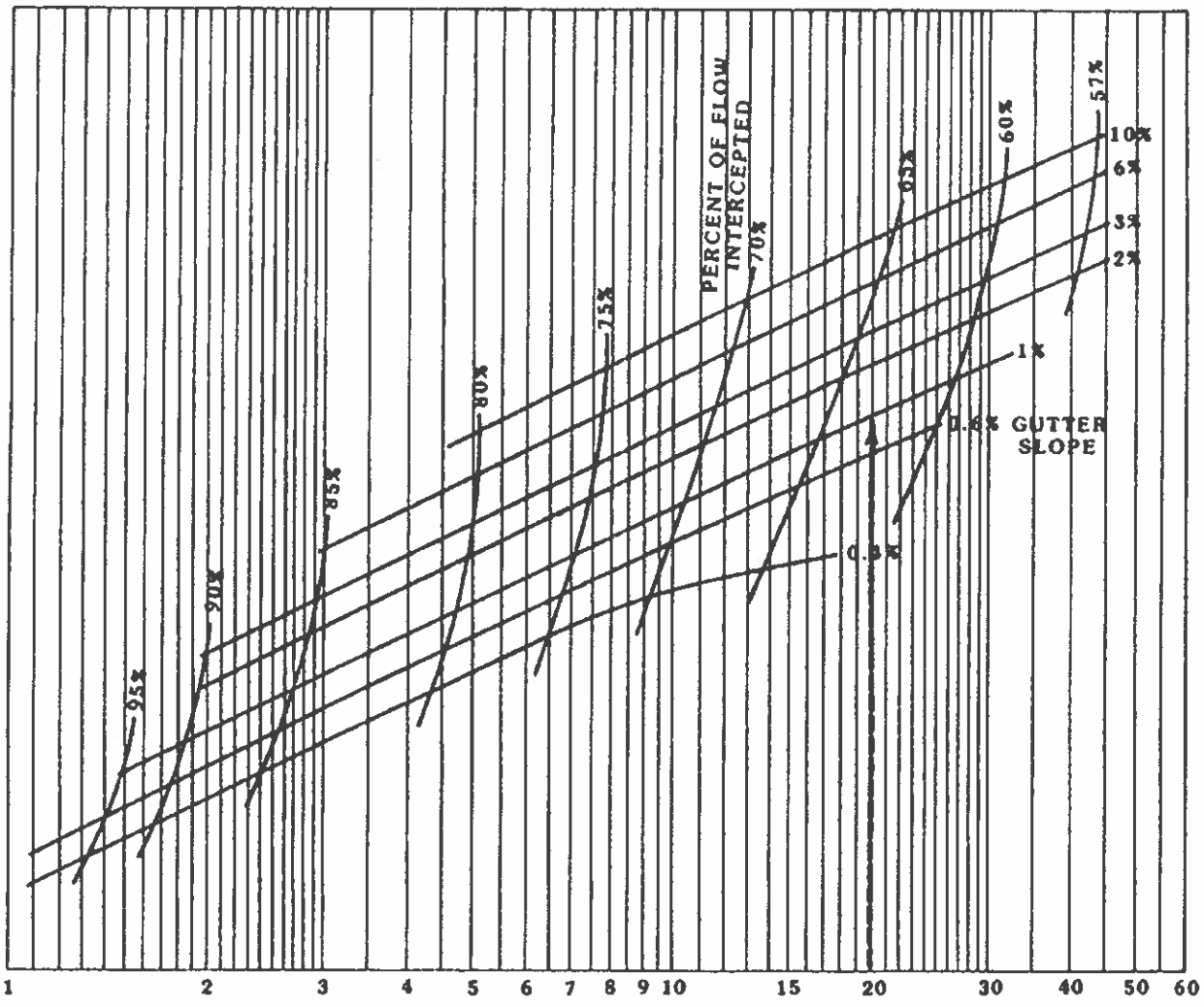
INTERCEPTED: 63 %

63 % OF 20 c.f.s.: 12.6 c.f.s.

AS CAPACITY OF FOUR GRATE INLET

REMAINING GUTTER FLOW:

20.0 c.f.s. – 12.6 c.f.s. = 7.4 c.f.s.



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SIX GRATE INLET CAPACITY CURVES ON GRADE

FIGURE 19

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 4.0 c.f.s.

GUTTER SLOPE: 3.0 %

FIND:

CAPACITY OF SIX GRATE INLET

SOLUTION:

ENTER GRAPH AT 4.0 c.f.s.

INTERSECT SLOPE: 3.0 %

READ PERCENT OF FLOW

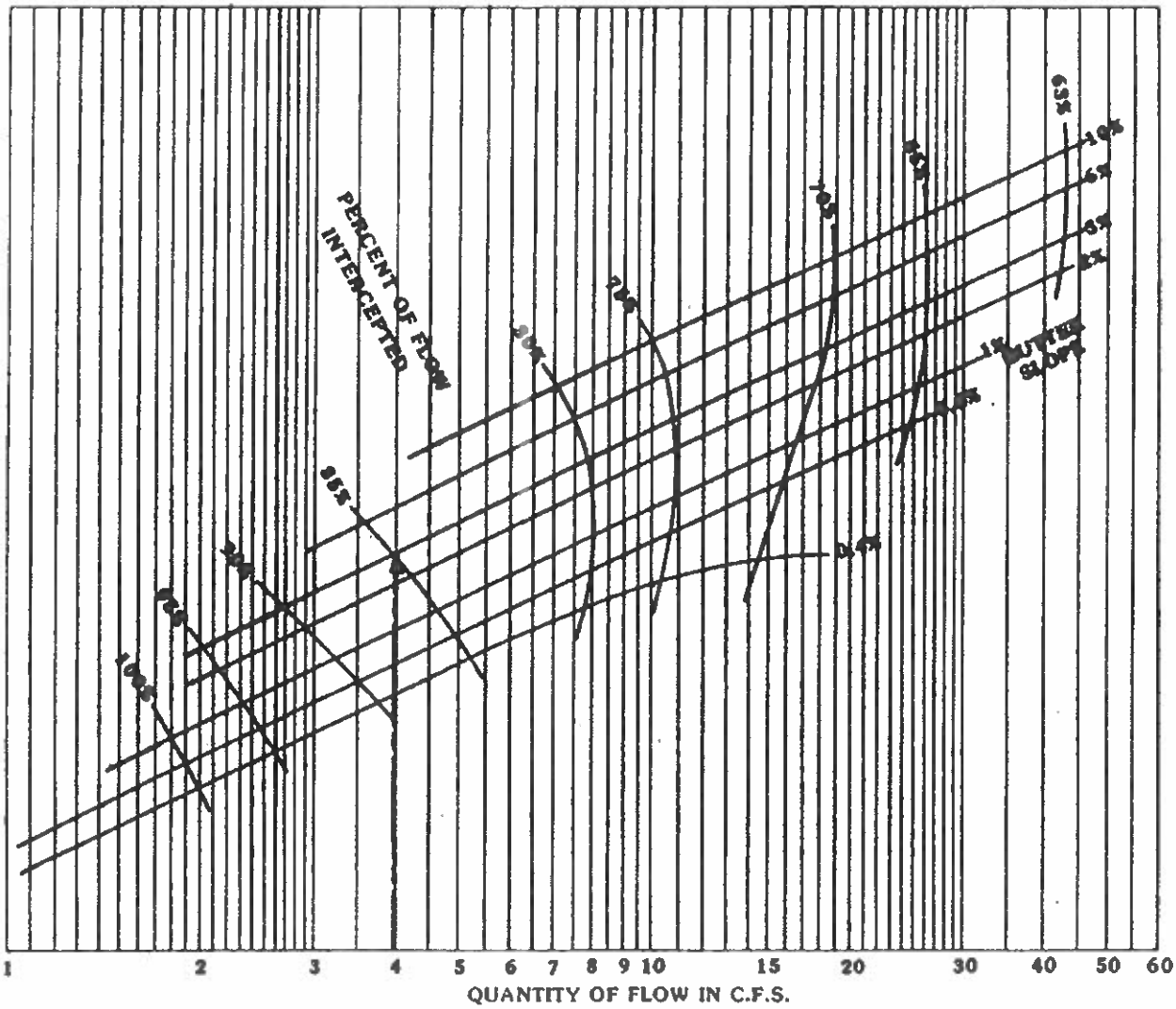
INTERCEPTED: 85%

85% OF 4.0 c.f.s.: 3.4 c.f.s.

AS CAPACITY OF SIX GRATE INLET

REMAINING GUTTER FLOW:

4.0 c.f.s. - 3.4 c.f.s. : 0.6 c.f.s.



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GRATE INLET
CAPACITY CURVES AT LOW POINT

FIGURE 20

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 4.8 c.f.s.

MAXIMUM DEPTH OF FLOW DESIRED AT LOW POINT: 0.4'

FIND:

INLET REQUIRED

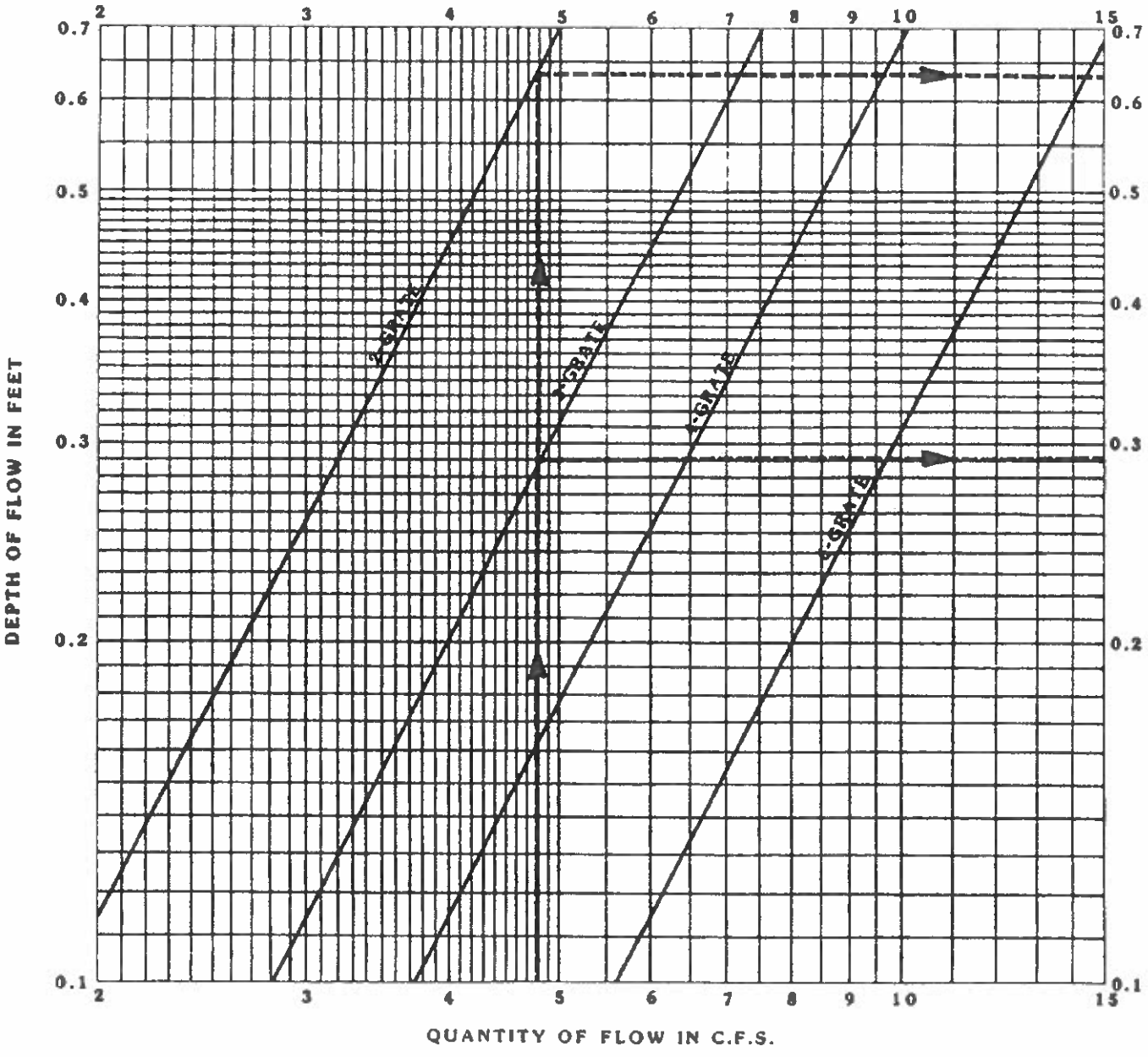
SOLUTION:

ENTER GRAPH AT 4.8 c.f.s.

INTERSECT 3 - GRATE AT 0.28'

INTERSECT 2 - GRATE AT 0.65'

USE 3 - GRATE



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DROP INLET
CAPACITY CURVES AT LOW POINT

FIGURE 21

EXAMPLE

KNOWN:

QUANTITY OF FLOW: 12 c.f.s.

MAXIMUM DEPTH OF FLOW DESIRED (yo): 0.5'

FIND:

LENGTH OF INLET OPENING REQUIRED (L_i)

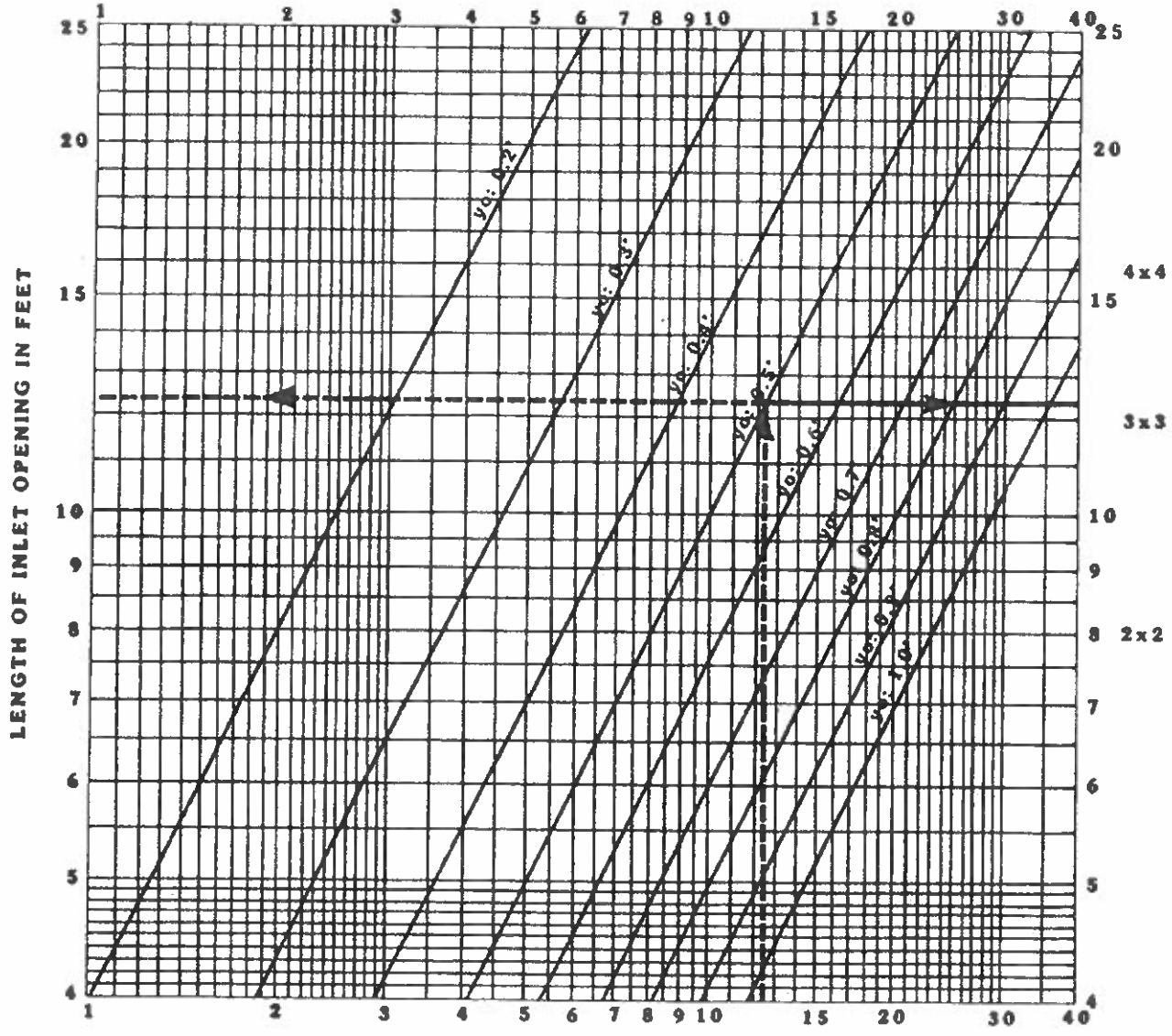
SOLUTION:

ENTER GRAPH AT 12 c.f.s.

INTERSECT yo: 0.5'

READ L_i: 12.3

USE 12.3 OF INLET 4x4



STANDARD DROP INLET SIZES: 2'x 2', Li:8' 3'x 3', Li:12' 4'x 4', Li:16'

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SLOPE OF PIPE IN FEET PER 100 FEET CAPACITY OF CIRCULAR PIPES FLOWING FULL

FIGURE 22

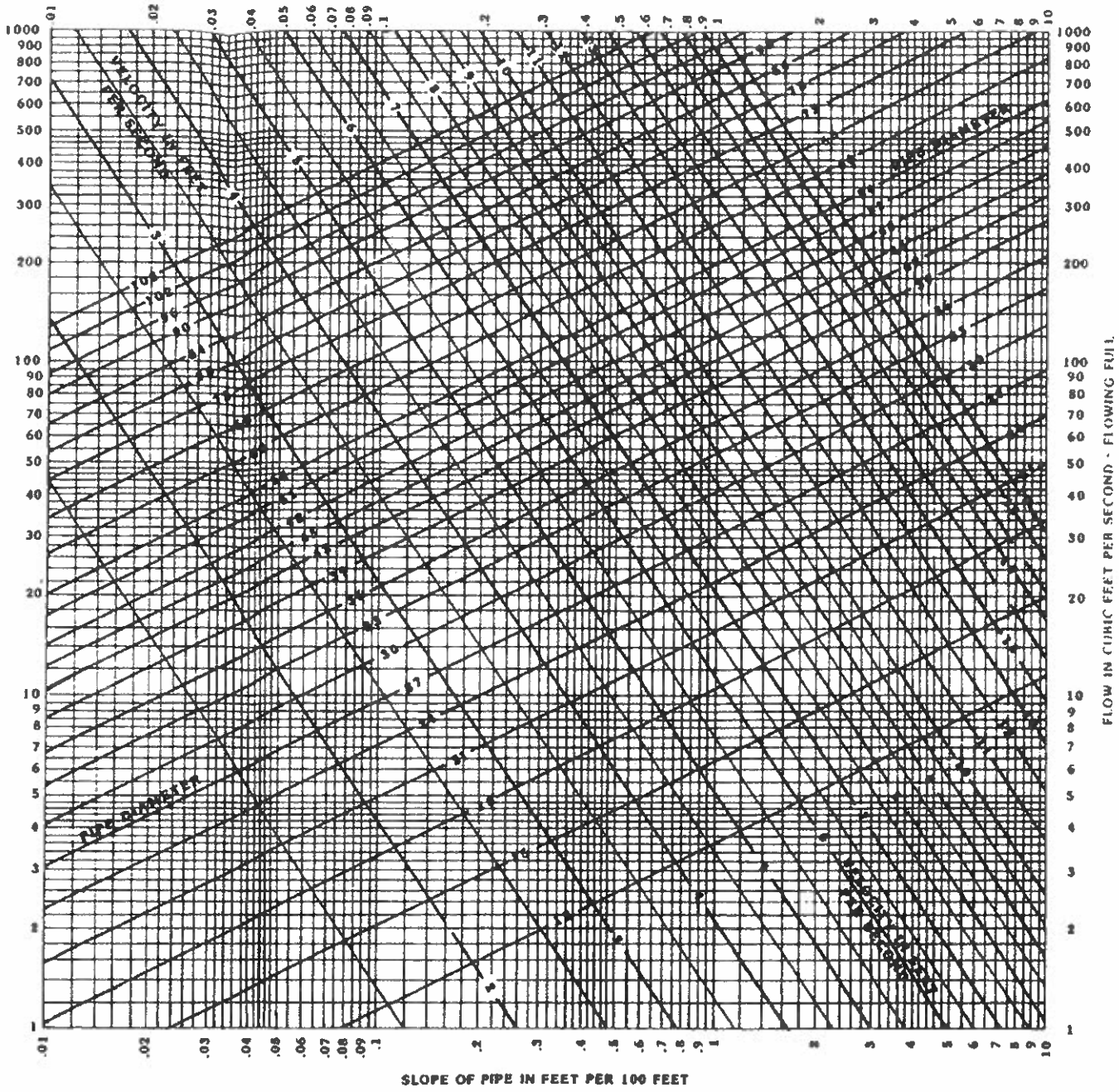
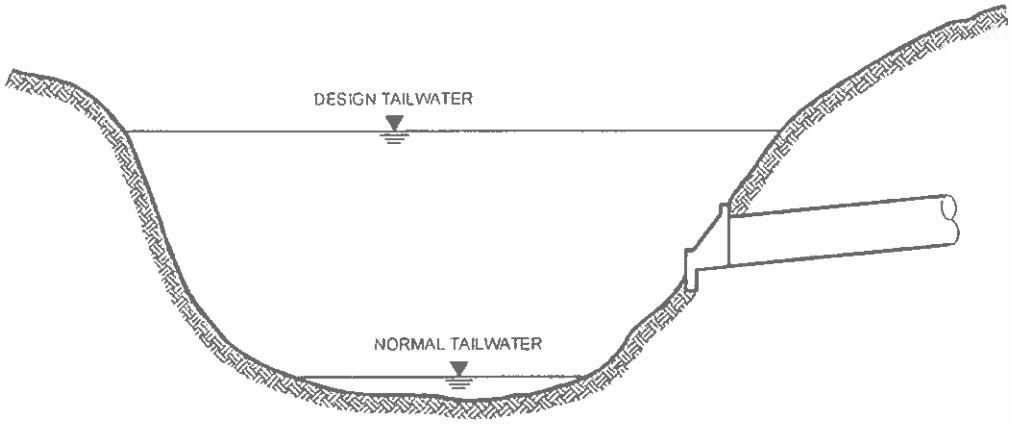
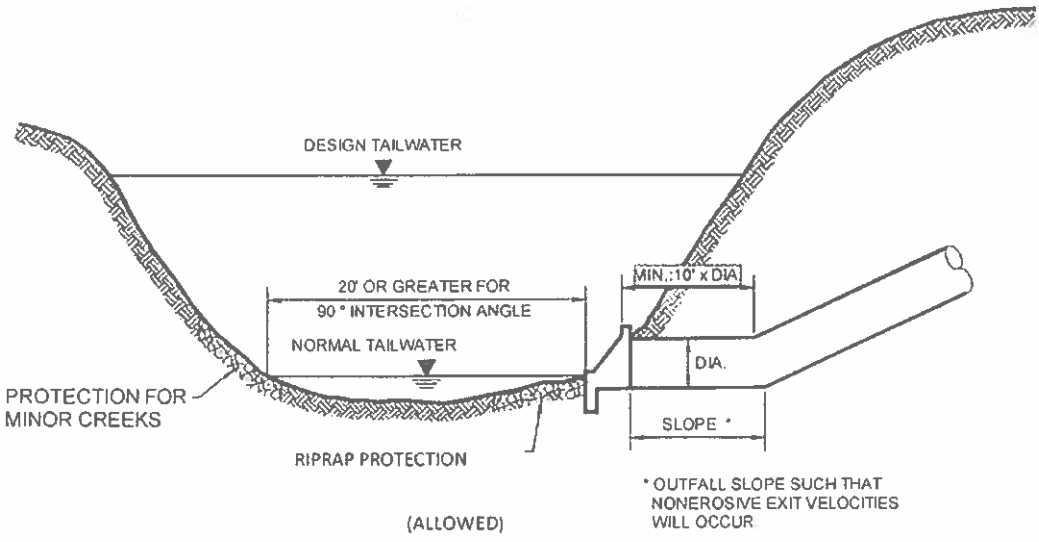


FIGURE 23

OUTFALL OF A STORM SEWER
INTO A CHANNEL



(NOT ALLOWED)



(ALLOWED)

FIGURE 23

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FIGURE 24

PROCEDURE FOR SPACING GRADE CONTROL STRUCTURES.

1. Establish the design channel velocity and channel bottom slope.

2. Determine the stable channel bottom slope that will decrease the channel velocity to less than 6.0 fps.

3. Space grade control structures such that no more than 1 foot of vertical distance occurs between the design channel bottom slope and the projected stable channel bottom slope that would reduce velocities to 6 fps or less.

Use:

s = grade control spacing
ds = design channel bottom slope
ss = stable channel bottom slope

then:

$$s = \frac{1}{ds - ss}$$

example:

ds = 0.0055 ft/ft
ss = 0.004 ft/ft

$$s = \frac{1}{.0055 - .004} = 667 \text{ feet (maximum spacing between grade control structures)}$$

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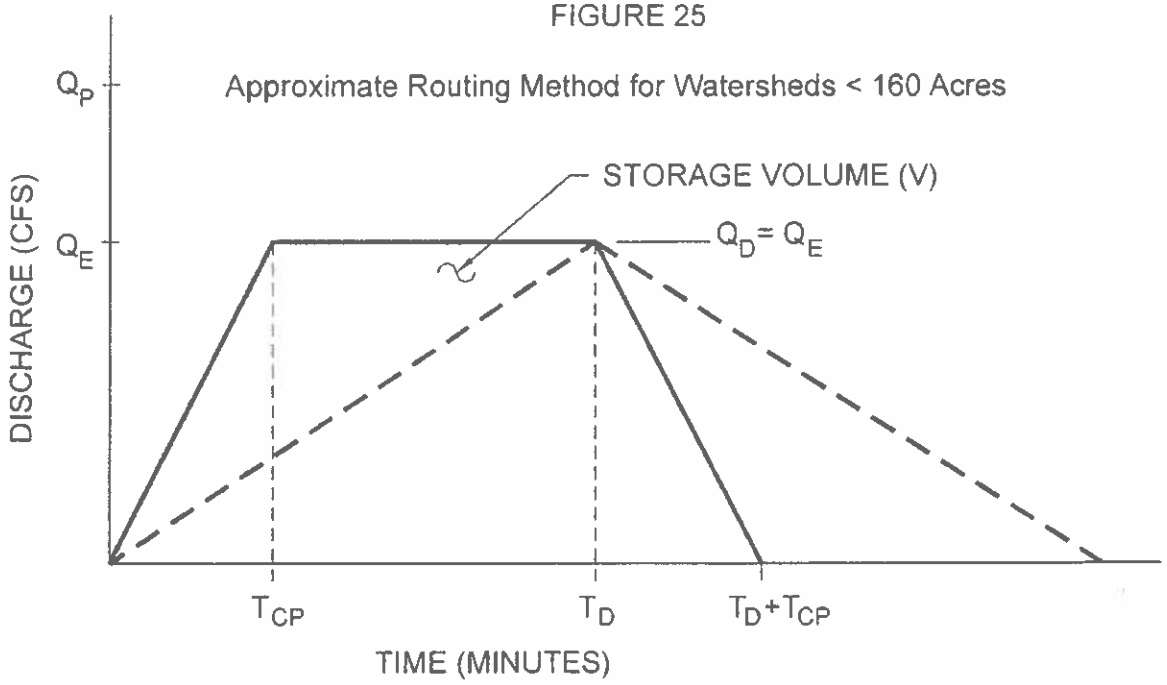
FIGURE 25

Approximate Routing Method for Watersheds < 160 Acres



$$V = \left(\frac{60}{43{,}560}\right) \left[\left(Q_D \left[\left(T_D - T_{CP} \right) + \left(T_D + T_{CP} \right) \right] /2 \right) - \left(Q_E \left[T_{CP} + T_D \right] /2 \right) \right]$$

in acre-feet.

or

$$V = \frac{60}{43{,}560} \left(Q_{E/2}\right) \left(T_D - T_{CP}\right)$$

Q_E = Peak discharge in cfs for existing watershed, assuming an undeveloped site condition and corresponding Tc.

Q_D = Peak discharge in cfs for developed watershed, based on a storm duration that yields the existing discharge for C_P and A.

T_{CP} = Time of concentration in minutes for proposed development.

T_D = Storm duration in minutes corresponding to I_D.

I_D = Rainfall intensity (inches/hour) for a storm duration that produces Q_D and is calculated using the following formula:

$$I_D = \frac{Q_D}{\left(C_P A\right) C_f}$$

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FIGURE 25, continued

Where:

C_P = Rational "C" for developed condition.

A = Drainage area in acres.

C_f = Frequency factor coefficient of 1.25

Detention Basin Example:

Development Data:

Drainage Area = 160 acres
Undeveloped C = 0.3
Undeveloped T_{CR} = 20 minutes
Developed C_P = 0.70
Developed T_{CP} = 10 minutes
C_f = 1.25

For the 100-year storm:

I_{EX} = 6.8 in/hour (from Figure 1)
I_P = 8.82 in/hour.

$Q_E = Q_D = (1.25)\ (0.30)\ (6.8)\ (160) = 408$ cfs

$Q_P = (1.25)\ (0.70)\ (8.82)\ (160) = 1235$ cfs

$$I_D = \frac{Q_D}{(C_P A)\ C_f} = \frac{408}{(.7)(160)(1.25)} = 2.91 \text{ in/hour}$$

From Figure 1, for $I_D = 2.91$ in/hour,

T_D = 100 minutes

$$V = 60 \left(\frac{408}{2}\right) (100-10)$$

= 12,240 (90) = 1,101,600 cubic feet = 25.3 acre-feet

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FIGURE 26

NATURAL FLOODWAY EXAMPLE