MANUAL FOR GENERAL DESIGN STANDARDS

FOR

PAVEMENT, DRAINAGE SYSTEMS

AND

WATER & SANITARY SEWER SYSTEMS

CITY OF CEDAR HILL, TEXAS
DEPARTMENT OF PUBLIC WORKS

CEDAR HILL

ORDINANCE NO. 2012-473
Adopted May 8, 2012

CITY OF CEDAR HILL VISION STATEMENT:

WE ENVISION CEDAR HILL AS A PREMIER CITY THAT RETAINS ITS DISTINCTIVE CHARACTER, WHERE FAMILIES AND BUSINESSES FLOURISH IN A SAFE AND CLEAN ENVIRONMENT.

CEDAR HILL

MAYOR

ROB FRANKE

COUNCIL MEMBERS

DANIEL HAYDIN JR, MAYOR PRO TEM
CORY SPILLMAN
CHRIS PARVIN
CLIFFORD SHAW
STEPHEN MASON
WALLACE SWAYZE

CITY MANAGER

ALAN E. SIMS

DEPUTY CITY MANAGER

GREG PORTER

PUBLIC WORKS DIRECTOR

ELIAS K. SASSOON, P.E.

*THE **MISSION** OF THE PUBLIC WORKS DEPARTMENT IS TO PROVIDE THE HIGHEST QUALITY WATER, SEWER, TRAFFIC AND DRAINAGE INFRASTRUCTURE SYSTEMS IN A MANNER CONSISTENT WITH PROFESSIONAL ENGINEERING PRINCIPLES.*

CITY OF CEDAR HILL, TEXAS

DEPARTMENT OF PUBLIC WORKS

MANUAL FOR GENERAL DESIGN STANDARDS

(The City of Cedar Hill adopts the latest addition of the NCTCOG's Public Works Construction Standards. Content in this manual are special condition to NCTCOG specifications)

TABLE OF CONTENTS

DIVISION 100 GENERAL PROVISIONS AND DESIGN APPROACH

- 100.01 Introduction
- 100.02 Submittals
- 100.03 Mandatory Pre-construction Meeting
- 100.04 Permits, Insurance, Bonding and Fees
- 100.05 Construction Standards
- 100.06 Marking Underground Utilities
- 100.07 Water Main Backflow Prevention
- 100.08 Visibility Triangle Requirements
- 100.09 Storm Drain Inlet lids
- 100.10 Televise All Gravity Lines
- 100.11 Storm Drain Inlet Environmental Markers

DIVISION 200 SITE PROTECTION AND PREPERATION

- 200.01 Purpose
- 200.02 Eagle Ford Geology
- 200.03 Embankment and Side Slope Designs
- 200.04 High Plasticity Soils
- 200.05 Escarpment
- 200.06 Grading Plans
- 200.07 Erosion Protection
- 200.08 Tree Protection and Mitigation

DIVISION 300 ROADWAY DESIGN

- 300.01 Purpose and Scope

300.02 Street and Thoroughfare Classifications
300.03 Street and Thoroughfare Geometrics
300.04 Design Vehicles
300.05 Design Speed
300.06 Horizontal Geometrics
300.07 Vertical Alignment
300.08 Sight Distance at Intersections
300.09 Median Openings
300.10 Driveway Access and Curb Openings
300.11 Parking Lot Pavement Design
300.12 Driveway Grades
300.13 Pavement Structure
300.14 Standard Street and Thoroughfare Pavement Design
300.15 Pavers and Stamped Concrete
300.16 Alternate Pavement Design
300.17 Sustainable Public Rights-of Way Design
300.18 Complete Streets
300.19 Special Roadway Sections
300.20 Traffic Impact Analysis
300.21 Procedure for Traffic Impact Analysis Process
300.22 Waiver of Traffic Impact Analysis
300.23 List of Figures

DIVISION 400 ROADWAY MAINTENANCE & REHABILITATION (REFER TO NCTCOG SPECIFICATIONS)

DIVISION 500 WATER AND SANITARY SEWER SYSTEMS DESIGN
500.01 Purpose and Scope
500.02 Water Lines
500.03 Fire Hydrants
500.04 Sanitary Sewers
500.05 Sanitary Sewer Lift Stations

500.06 Control and Monitoring for Sanitary Sewer Lift Stations
500.07 Figure A

DIVISION 600 CONDUIT & APPURTENANCE REHABILITATION (REFER TO NCTCOG SPECIFICATIONS)

DIVISION 700 STRUCTURES (REFER TO NCTCOG SPECIFICATIONS)

DIVISION 800 MISCELLANEOUS CONSTRUCTION AND MATERIALS (REFER TO NCTCOG SPECIFICATIONS)
800.01 Street Lighting

DIVISION 900 DRAINAGE
901.01 Introduction
901.02 Application
901.03 Platting / Dedication of Water Course and Basins
902.01 Floodplain Designation
902.02 Floodplain Alterations
902.03 Floodplain Alteration Permit or Fill Permit
902.04 Floodplain Fill Permit Process
902.05 Engineering Requirements for Filling in a Floodplain
902.06 Letter of Map Revision (LOMR)
902.07 Procedure for Filling in a Floodplain
902.08 Filling in a 100 Year Floodplain Fringe
902.09 Filling Operation
902.10 Parking Areas in the Floodplain
902.11 Parking Lot Discharge
902.12 Parking Lot Drainage
902.13 Minimum Lot and Floor Elevations
903.01 Lot-to-lot Drainage
904.01 Detention / Retention
904.02 Detention Ponds

904.03	Regional Detention
904.04	Erosion Control / Downstream Assessment
905.01	Drainage Design Criteria and Procedures
905.02	Rainfall
905.03	Design Storm Frequency
905.04	Determination of Design Discharge
905.05	Runoff Coefficients and Time of Concentration
905.06	Gutter Flow and Inlet Location
905.07	Inlet Design
905.08	Street Intersection Drainage
905.09	Alley Capacities
905.10	Manhole Placement
905.11	Energy Dissipaters
905.12	Hydraulic Gradient of Conduits
905.13	Velocity in Closed Conduits
905.14	Roughness Coefficients for Conduits
905.15	Minor Head Losses
905.16	Procedure for Hydraulic Design of Closed Conduits
906.01	Criteria for Channels, Bridges and Culverts
906.02	Open Channels
906.03	Types of Channels
906.04	Quantity of Flow
906.05	Channel Alignment and Grade
906.06	Roughness Coefficients for Open Channels
906.07	Procedure for Water Surface Profile Calculation for Unimproved Channels
906.08	Procedure for Hydraulic Design of Open Channels
906.09	Hydraulic Design of Culverts
906.10	Culvert Hydraulics
906.11	Quantity of Flow
906.12	Headwalls and Entrance Conditions
906.13	Culvert Discharge Velocities
906.14	Procedure for Hydraulic Design of Culverts

906.15	Hydraulic Design of Bridges
906.16	Quantity of Flow
906.17	Procedure for Hydraulic Design of Bridges
906.18	Roadway Ditch Requirements
907.01	Sustainable Public Rights-Of-Way Design
908.01	Definition of Terms
908.02	Detention System Definitions
908.03	Abbreviation of Terms and Symbols
909.01	List of Tables
910.01	List of Figures
911.01	List of Forms

DIVISIONS 1000 – 6000 STANDARD DETAILS (Separate Document)

APPENDIX A Pre-Construction Packet

Which Includes:

- Permit Application for Public Improvements
- Contractor Contact List
- Right-of-way Permit Checklist
- Right-of-way Permit
- Pre-Construction Checklist
- Final Acceptance Checklist

APPENDIX B CHECKLISTS

- Paving and Drainage CIP Plan Review Checklist
- Plan Review Checklist for Development Projects
- Site Plan Checklist

APPENDIX C ADDITIONAL FORMS, PERMITS AND APPLICATIONS

- Traffic Impact Analysis Worksheet
- Waiver of Traffic Impact Analysis
- Floodplain - Grading Permit Application

DIVISION 100 - GENERAL PROVISIONS AND DESIGN APPROACH

100.01 INTRODUCTION

The purpose of this General Design Section is to provide a set of design criteria for general design standards and the preparing of construction plans in the City of Cedar Hill, Texas. Design of the improvements shall focus towards the goal of the City of Cedar Hill's Vision Statement. This manual will be used by the Department of Public Works, other City departments, consulting engineers employed by the City for all community development projects, and engineers for private developments within the City in conjunction with the appropriate sections of this manual. The Director of Public Works may approve unusual circumstances or special designs requiring variance from the standards in this manual. Other City of Cedar Hill standards and requirements related to the overall development, layout and function of new facilities are found in the City's Subdivision Ordinance, Zoning Ordinance, Utility & Drainage Master Plans, Comprehensive Plan (Thoroughfare plan), Trail and Bikeway Master Plan and Building Codes. Information in this manual is intended to support other City ordinances, state and federal regulations.

100.02 SUBMITTALS

The private development of commercial, industrial and/or residential properties shall follow the review process per City of Cedar Hill ordinance. Contact the City's Planning Department for requirements, procedures and application processes. For Capital Improvements Projects, please refer to the check list for CIP improvements. All plan and plat sets shall be legible and printed on bond paper as part of required documents including at the time of the Final Acceptance Letter.

This manual is intended to aid and assist engineers in the design and layout of storm drains, streets, sanitary sewers and water lines to definite standards and to obtain uniformity in the plans. It is recognized that some projects may have special circumstances; therefore, final approval of all or any part of any plans rests with the Public Works Director. The time period for each submittal with any comments are returned within 10 business days.

1. Conceptual Submittal (Optional): On the initial conception of the plans and engineering of a proposed subdivision or commercial site, it will be to the designer's or developer's advantage to provide two sets of drawings with 2-foot contours and the layouts of preliminary water and sewer systems to the Public Works office, whereby verification can be made as to the general layout and availability of water and sewer. Based on availability of traffic access, water supply and sanitary sewer access, the City is open to explore possible solutions and discuss any available options for development of the property.
2. Preliminary Plans: The preliminary engineering plans shall be submitted with the Preliminary Plat per the Preliminary Plat Application and Sub-division Ordinance requirements. The plans and plat shall be complete with eight (8) sets of clear, legible full sized (24"x36") prints and one (1) half sized (11"x17") prints to the City. The minimum drawings to be provided to the City shall contain a preliminary plat site layout, drainage plans and utility plans. Drawing scale shall not be smaller than 1 in / 200 ft. The Preliminary Drawings shall have enough pertinent data to determine the impacts of the proposed developments will have on the City's existing infrastructure and master planning for the future development of the City.
3. Final Plans and Final Plat: After approval of the Preliminary Plans and Plat, and if the corrections were few, the plans may be re-submitted as final. Red-line markups of the submittal are available upon request and must be returned with the next submittal. Before you request approval of the construction plans, the following must be checked:

    A. The final plans must be complete and correct. An engineer and city staff can review the plans and easily determine that they comply with these standards and all pertinent city ordinances. The construction contractor, who is not familiar with the plans or the City of

Cedar Hill, can construct the project from the plans. Plans shall be clear, legible, and neatly drawn on bordered sheets.

B. The plans and profiles shall be drawn on 24" x 36" (full sized) sheets. 11" x 17" (half sized) sheets shall be reduced from the full sized sheets such that the scale is a true ½ scale and can be measured with an engineer's scale all drawings shall be in AutoCAD® release 2004.

C. The horizontal scale shall normally be 40 feet per inch and the vertical scale shall normally be 4 feet per inch. If the plan is in an extremely congested area, a scale of 1" = 20' may be necessary and will be permitted. All profiles shall be drawn on a vertical scale as required for clarity, and the horizontal scale shall be the same as for the plan unless otherwise directed by the Public Works Department.

D. Data to be included:
Provide the following and sufficient information for the submittal:

1. The City's Cover Sheet shall be used for all proposed public facilities engineering plans. The Cover Sheet shall include the project name, appropriate City project numbers, correct vicinity map, City signature block, and sheet index. The City of Cedar Hill standard details and general notes shall be included in the construction plan sets.
2. The plans shall show surrounding streets, lots, property lines, creeks, benchmarks and other landmarks to orientate the plans with the site. A scale bar and north arrow shall be shown on all plan views. The symbols and methods of illustration shall be consistent with typical construction plans used in this region. A legend may be provided instead of labeling all lines and points. However, all lines and points shall be described in the plans A title block in the lower right-hand corner or along the right hand edge and shall be filled in to include: project name, date, scale, sheet number, the engineer's name, address and telephone number.
3. A surveyor can provide construction staking without obtaining additional information. A minimum of two benchmarks located outside the limits of construction shall be shown and described on the plans. If the project is within 1000' of an existing City benchmark, the plans for the project shall include and describe the City's benchmark.
4. Existing and proposed underground utility crossings shall be shown in all profiles of a proposed alignment. If an existing utility parallels a proposed alignment within three (3) feet, the existing utility shall also be shown in the profile.

E. A copy of the approved final plat shall be attached with the final signed and released for construction plan set.

F. The plans must be signed and sealed (not executed) by the Licensed Professional Engineer (licensed with the state of Texas) who is responsible for the design. After all comments are addressed, the City's signature block for acceptance of this project is added to all sheets for one full sized set of plans (original set) on bond paper and provided to the City. This original set will be signed by the Public Works Director or person designated by the Public Works Director.

G. Three (3) sets of complete and signed full size (24"x 36") and five (5) half sized (11"x17") copies of the original signed set are required for City use. Additional accepted plans are typically obtained from the engineering consultant for use during construction of the project. The City Construction Inspector will only recognize those plans with the signed "City" stamp

A comprehensive checklist for both CIP and private development construction plans is found in Appendix B. The design engineer is required to sign the appropriate checklist acknowledging the submitted plans are complete.

.

4. Site Plan: A site plan is required for all new non-residential developments and re-developments. Civil drawings must be included as part of the submittal. A site plan checklist is included in Appendix B (*Note: the site plan checklist is part of the Planning Department's application process)*; which further elaborates on the Site Plan requirements. The Site Plan must be approved prior to issuance of a building permit. Signed plans by the design engineer and the City are the only authorized plan set to be used at the construction site.

   Proposed changes in the construction plan sets during construction shall be initiated by the contractor and then the proposed changes are submitted by the engineer of record to City Staff to review for compliance to these standards. Only the construction plan set bearing the City's signed and dated acceptance stamp are authorized for use at the project site.

   One set of As-Built construction plans on bond paper set shall be submitted to the Public Works Department before the subdivision will be accepted. The As-Built construction plans shall have all seals, record/as-built stamps and engineer of record signatures and should be scanned into a single TIFF or PDF format file. The City's signature block for authorizing construction shall be removed from all sheets. The scanned PDF of the file and the base file in state plane coordinates and in AutoCAD® r2004 (or most current version) drawings shall be submitted on compact disc or e-mailed to the public works department including the layout view of lot lines, water, sewer and storm drain lines for insertion into the city GIS system.

100.03 MANDATORY PRE-CONSTRUCTION MEETING

After all the above requirements are completed a mandatory pre-construction meeting is required and scheduled prior to work commencing at the project site. A list of required items and corresponding schedules for the pre-construction meeting shall be obtained from the Public Works Department or downloaded at the City's Web site. Samples of these items are available in Appendix A. Insurance, bonding, permits and related documents shall be executed and in place at the time of the pre-construction meeting. Other submittals or shop drawings for materials not listed in the approved material list shall be submitted prior to the meeting for review and approval. The Owner, General Contractor, and Engineer of Record are expected to attend this meeting. All fees and other monies due must be paid in full.

100.04 PERMITS, INSURANCE, BONDING AND FEES

Preliminary / Final Plat applications and related fees are available at the City's Planning Department. In addition, other City fees are required for buildings and applicable structures. Inspection fees for the public improvements portion of the project are 3.5% of the total cost for the public improvements; including storm water improvements. Contractor's insurance and bonding documents must be in the City's correct format, contain the correct dates and be executed prior to the pre-construction meeting.

Any work proposed to be performed within an existing right of way or public easement shall be permitted by the City of Cedar Hill. Application for the R.O.W. permit shall be obtained from the Public Works Department (also available in Appendix A). The City R.O.W. permit begins the process to have the City mark the water and sewer lines within 48 hours after the application is filed. Existing utilities above and below grade shall be shown and labeled on the plan set. The design engineer shall make reasonable effort to identify the existing utilities.

Evidence of all necessary submittals to State and Federal agencies for permitting / review of accessibility, TxDOT Rights-of-Ways, funding requirements and environmental regulations are required. TxDOT *and Trinity River Authority (TRA)* permits for public improvements shall first be submitted to the City with the City listed as the owner and the contractor as the applicant. In addition to the R.O.W. permit, all work performed within public R.O.W. and easements or the proposed work and materials shall be insured and bonded. If the work within the R.O.W. or easement is less than $25,000, bonds are not required. Construction plans, permits and approved submittals are considered part of the contract documents. The documents shall be signed and

dated by the appropriate parties for the project and only these authorized documents are used for the duration of the construction. Examples of the required documents are included in the Pre-construction packet mentioned above. The Owner identified in the contract documents is responsible for the administration of their contract with the contractor. The contractor shall ensure the required insurance is current and not expired. If the liability insurance is found to be expired, work shall not proceed until the insurance is made current.

100.05 CONSTRUCTION STANDARDS

The objective for this section is to provide direction and the required supporting documents to protect and prepare for construction activities for the public facilities and to provide a safe working environment. Standard construction practices are expected to be consistent with the requirements of the contract documents, federal and state regulations and City of Cedar Hill construction standards.

The North Central Texas Council of Governments (NCTCOG) most recent updated Standard Specifications and Details for Public Works Construction, Cedar Hill's Special Provisions to the NCTCOG Standards, City specific general construction notes and City details shall be used for all construction of community facilities in the City of Cedar Hill. If any conflicts are discovered between the details shown or listed in the plan set and other documents the priority of interpretation shall be in the following order: City Design Standards, the City of Cedar Hill details / general notes, NCTCOG Standards and then the construction plan set; unless directed otherwise by the Public Works Director.

Applicable City Standard Details shall be referenced and included in the final accepted construction drawings. The City of Cedar Hill Construction Notes (Sheet SD-001) shall always be included in the construction plans.

All construction within the escarpment area shall conform to the Escarpment Ordinance #94-198. See Division 200.02 for "Eagle Ford Geology".

100.06 MARKING UNDERGROUND UTILITIES

Underground utilities placed in right-of-way or easements shall be marked with plastic tape for all lines which carry water, sewer, electric, gas or any hazardous material. The tape shall be placed a minimum of one-foot (1') directly above the utility and a maximum of two-feet (2') below the surface.

Plastic mark tape shall be acid and alkali resistant polyethylene film, three inches (3") wide with a minimum thickness of 0.004 inch. Tape shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise. The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to three-feet (3') deep. The tape shall be of a type specifically manufactured for marking and locating underground utilities. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion. Tape color shall be as specified in the table on the next page and shall bear a continuous printed inscription describing the specific utility.

TAPE COLOR	UTILITY
Red	Electric
Yellow	Gas, oil, hazardous materials
Orange	Telephone, telegraph, television, police, and fire communications
Blue	Water System
Green	Sewer System

100.07 WATER MAIN BACKFLOW PREVENTION

All water service connections shall comply with the Backflow Prevention Ordinance # 98-399. See Figure A in Division 500 for typical locations for backflow devices.

100.08 VISIBILITY TRIANGLE REQUIREMENTS

No walls, buildings, fences or other obstructions to view in excess of thirty inches (30") in height shall be placed within the visibility triangle areas at the intersections of streets and alleys, except trees pruned high enough to permit unobstructed vision to automobile drivers:

1. At an intersection including an arterial street or a collector street, the triangular area formed by the street curb lines and a line connecting them at points a minimum of thirty feet (30') from the intersection of the street curb lines. Depending on the curvature and grade of intersecting roads, the City Engineer may require a larger triangular area.
2. At all other street intersections, the triangular area formed by the street curb lines and a line connecting them at points twenty-five feet (25') from the intersection of the street curb lines.
3. At all intersections of streets with alleys, the triangular area formed by the street right-of-way line and the alley right-of-way line and a line connecting them at points ten feet (10') from the intersection.
4. Site distances at intersections shall also be addressed and shown on the engineering plans and shown on final plats. See Section 300.08.

100.09 STORM DRAIN INLET LIDS

All new or replaced storm drain inlet manhole lids shall be accordance with the standard details shown on Sheet SD-400.

100.10 TELEVISE ALL GRAVITY LINES

All new public storm drain and sanitary sewer lines utilized by the development shall be televised with a camera in DVD format prior to final acceptance of the public improvements. A copy of the video shall be submitted to the Public Works Department Inspector for review. Any deficiencies noted on the video shall be repaired or replaced prior to final acceptance of the public improvements.

100.11 STORM DRAIN INLET ENVIRONMENTAL MARKERS

All new or replaced storm drain inlets in Cedar Hill shall have the official City Environmental Marker permanently attached to the top and near the throat of the inlet.

DIVISION 200 SITE PROTECTION AND PREPARATION

200.01 PURPOSE

The construction site involves the cooperation of the contractor, their employees and other citizens that may come in contact within the project site. The contractor is responsible for the daily operations within the limits and perimeter of the project. The plans shall clearly identify access, special conditions, limits of construction and site protection and preparation. Special conditions unique to the City of Cedar Hill are described in this section.

200.02 EAGLE FORD GEOLOGY

Most of western Cedar Hill is comprised of very unstable soil conditions generally found in the Eagle Ford Shale Formation. These soil conditions are unique and require special considerations for the design of erosion control, streets, drainage and utilities. The characteristics of this soil include a high Plasticity Index (up to 60), severe erosion/sedimentary potential, poor slope stability and a high sulfate content which can make conventional lime stabilization methods ineffective.

The Eagle Ford Shale Formation is found in an area adjacent to and below the Escarpment. This area is shown on the Geologic Map of Dallas County, Texas published by the Dallas Geological Society, Inc. A copy of the map may be obtained via their website: http://www.nhnct.org/geology/dallascomap.html. The unstable soil area is also is shown on the United States Department of Agriculture Soil Conservation Service publication "Soil Survey of Dallas County" which identifies it as the Heiden series, Houston Black series, Lewisville series, Ovan series, Trinity series, Vertel series, and Eddy-Brackett complex.

Where soil conditions with a Plasticity Index (PI) of 15 or greater and a sulfate concentration greater than 3,000 ppm are present on a project site the following is required:

1. A copy of a geotechnical report with laboratory results shall accompany the construction plans. The report shall show the sulfate concentration and the P.I. of the soil at every 200 linear feet of right of way or utility easement. If the sulfates are greater than 2,000 ppm, the project engineer shall provide to the city a procedure for stabilization in high sulfate soils using the current best engineering practice and recommended procedures from the geotechnical report. The procedures should take advantage of the latest research in stabilizing high sulfate soils from the College of Engineering at the University of Texas at Arlington.
2. Underground utilities will not be placed under pavement where practical. If the utility is placed in the street the backfill shall be treated in the manner described above and compacted to 95% of the standard proctor in six-inch lifts. No underground utility except service connections shall be placed under streets unless select backfill is used or the native material is treated so that the PI is less than 18
3. Utility cuts and embankments shall not exceed 12 feet in depth, unless approved by the Public Works Director. Avoid excessive roadway cut and fill sections.
4. Roadway cuts and embankments shall not be cut nor filled more than 12 feet, without a geotechnical recommendation and shall be approved by the Public Works Director.
5. Service connections that cross the roadway and the trench size shall be minimized.

200.03 EMBANKMENT AND SIDE SLOPE DESIGNS

All embankments and the cut sections four feet and less in height shall be at slope of no more than one vertical foot per four horizontal feet (4:1). All embankments and the cut sections greater than four feet in height the slope grade shall be designed so that the factor of safety is greater than 1.5

200.04 HIGH PLASTICITY SOILS

Area soils with a Plasticity Index (PI) of 18 or greater shall conform to the following:

1. No underground utility except service connections shall be placed under streets unless select backfill is used or the native material is treated so that the PI is less than 18.
2. Avoid utility cuts deeper than twelve feet (12').
3. Avoid excessive roadway cut and fill sections.

200.05 ESCARPMENT

The Escarpment zone is an environmentally fragile bluff having a slope of 4:1 or slopes located immediately above and below the exposed contact line between the Austin chalk and the Eagle Ford shale. The zone is a linear corridor, whose width is described as the distance:

1. The greater of one hundred twenty-five (125) horizontal feet above chalk and shale contact, or thirty-five (35) horizontal feet beyond the crest (that point above the escarpment line where the slope becomes flatter than 4:1); and
2. The greater of eighty-five (85) horizontal feet below the chalk and shale contact, or ten (10) horizontal feet beyond the toe (that point below the escarpment line where the slope becomes flatter than 4:1).

The escarpment zone is for the most part generally located in hilly sections west of US Highway 67. Subdivision Regulations, Section 20, Article III, in the City of Cedar Hill's Code of Ordinances describes the purpose, definitions, conditions and criteria for development within contact of the escarpment zone. These special conditions shall be addressed in the construction plans and site. The escarpment zone shall be identified, labeled and shown on the Final Plat and construction plans.

200.06 GRADING PLANS

Final grading plans for all development projects shall be submitted with contour information of at least 1-foot intervals. Spot elevations shall be described and elevations provided. Difficult soil conditions and some steep slopes are common in the western side of the City of Cedar Hill. Regardless of size, cross lot draining shall not be permitted. Furthermore, obstruction of the existing natural drainage pattern of adjacent public or private property is not allowed.

If a property is not being developed but the existing topography is being modified by means of fill, excavation and/or re-graded, the proposed grading plans must be submitted for review and a grading permit must be obtained. As part of the grading permit, a tree survey plan and a Storm Water Pollution Prevention Plan (SWP3) must also be submitted.

For these types of situations the following is not allowed without provisions which must be provided and approved:

- Lot-to-lot drainage (For more information, refer to Section 903.01)
- Obstruction of the existing natural drainage pattern of adjacent properties
- Redirecting or increasing the existing quantity or velocity of water draining onto adjacent properties
- Altering the natural drainage configuration onto adjacent properties and/or collecting the drainage and draining onto adjacent properties in a concentrated manner

200.07 EROSION PROTECTION

All construction projects shall comply with TCEQ regulations, the NCTCOG Storm Water Quality Best Management Practices for Construction Activities and complies with City Standard Construction Details for storm water erosion and sedimentation control. The project shall have a staging plan for erosion control activities for the entire length of construction. All topsoil removed for construction shall be stock piled and used to cover bare soil when the project is complete.

200.08 TREE PROTECTION AND MITIGATION

City Ordinance Number 2007-320 requires the preservation of most trees, including large cedar trees. The ordinance defines a protected tree being typically 8 inches or larger in diameter and describes the criteria for removal or preservation of trees in the City of Cedar Hill. Contact the City's Planning Department for more information. Existing trees shall be clearly marked in the field as per plans as to which ones will remain and which ones will be removed. Remaining protected trees shall be fenced off to restrict construction activity within the drip line of he protected trees. Silt fences and other grading work shall be addressed as to not adversely impact protected trees.

DIVISION 300 ROADWAY DESIGN

300.01 PURPOSE AND SCOPE

The scope of this Pavement Design Section includes the various design elements, criteria, standards and instructions required to prepare paving plans. Classification for the various roadways as described in the City of Cedar Hill's Comprehensive Plan are given, along with geometric standards and criteria for these pavement structures. The goal of these guidelines is to construct safe thoroughfares that can carry acceptable traffic volumes while providing for pedestrian traffic as well. Private streets shall adhere to the City's design standards and construction requirements for public streets.

300.02 STREET AND THOROUGHFARE CLASSIFICATIONS

The Street Classifications are established by the Thoroughfare Plan and can be seen in Table 1 below:

TABLE 1
STREET AND THOROUGHFARE
GEOMETRIC STANDARDS

Street	Classification	Back to Back Street Width (Ft.)	Median Width (Ft.)	Normal Right-of-Way Width (Ft.)
Residential		27	NA	50
Major Collector	Class III	39	NA	64
Minor Collector	Class IV	39	NA	60
Minor Arterial	Class II	25 in each direction	16	90
Principal Arterial	Class I	37 in each direction	16	112

300.03 STREET AND THOROUGHFARE GEOMETRICS

Geometrics of city streets and thoroughfares may be defined as the geometry of the curbs or pavement areas which governs the movement of traffic and the path that vehicular traffic should follow within the confines of the rights-of-way. Included in the geometrics are the pavement, width, degree of curvature, width of traffic lanes, parking lanes, turning lanes, median width separating opposing traffic lanes, median nose radii, curb radii at street intersections, crown height, crossfall, geometric shapes of islands separating traffic movements and other features. City streets and thoroughfares are differentiated by their functions and location. The City Standard Details for paving contain specific information for the cross sections of a roadway. Remaining sections cover particular criteria for designing the alignment and placement of pavement structures.

300.04 DESIGN VEHICLES

The geometrics of city street and thoroughfare intersections vary with the different dimensions of the intersecting facilities. Criteria for the geometric design of intersections must be based on certain vehicle operating characteristics and vehicle dimensions. The American Association of State Highway and Transportation Officials (AASHTO) have standardized vehicle criteria into three general designs. In the

design of street and thoroughfare intersections for the City of Cedar Hill, these vehicle designs are adopted for use (refer to Table 2 below) and a sketch of each design vehicle is shown in Figures 1, 2 and 3. Unless otherwise determined by the Director of Public Works, Table 2, DESIGN VEHICLE CRITERIA, shall serve as a guide in the selection of the design vehicle to be used in the design of intersections.

TABLE 2
DESIGN VEHICLE CRITERIA
Design Vehicle Used in Intersection Design

Intersecting Streets	Passenger (P)	Single Unit Truck (SU)	Tractor Semi-Trailer Combination (WB-50)
Collector with Collector	X		
Collector with Minor Arterial		X	
Collector with Principal Arterial		X	
Minor Arterial with Minor Arterial			X
Principal Arterial with Minor Arterial			X
Principal Arterial with Principal Arterial			X

300.05 DESIGN SPEED

The design speed is a primary factor in the horizontal and vertical alignment on city streets and thoroughfares. Design features such as curvature, super elevation, radii for turning movements and sight distance are directly related to the design speed. The design speed also affects features such as lane widths, pavement width, pavement crossfall, pavement crown, and clearances.

The design speed is defined as the approximate maximum speed that can be maintained safely by a vehicle over a given section of road when conditions are so favorable that the design features of the roadway govern. The design speed should never be less than the likely legal speed limit for Minor and Principal Arterial.

The various street and thoroughfare classifications, which make up the system within the city, require different design speeds according to their use and location. Presented in Table 3 are the allowable design speeds for the various classifications within the City of Cedar Hill. Lower design speeds will be permitted for all classifications for unusual conditions of terrain or alignment.

300.06 HORIZONTAL GEOMETRICS

The horizontal geometrics of city streets and thoroughfares include the segment of geometric design associated with the alignment, intersections, pavement widths, and related geometric elements. The various classifications, utilizing the design speed as a control, must have certain horizontal and vertical geometrics to provide a safe economical facility for use by the public. Visibility triangles (refer to Section 100.08) shall be included in the design of intersections and driveways. Per Zoning Code Article 5, traffic shall not be required to backup in the public ROW in order to access or exit the development. Loading areas shall be separate from parking areas. All turning movements for trucks are made within the development. Parking lot layouts shall be per City of Cedar Hill Zoning ordinance or otherwise

approved by the Director of Public Works. A traffic plan or traffic impact analysis may be required for traffic patterns from the new development.

Horizontal Curves and Super Elevation - The alignment of city streets and thoroughfares is usually determined by the alignment of the existing right-of-way or structures that cannot be relocated. Constructing a simple curve having a radius that is compatible with the speed of vehicular traffic minimizes changes in the direction of a street or thoroughfare. To increase the safety and reduce discomfort to drivers traversing a curved portion of a thoroughfare, the pavement may be super elevated.

Curvature in the alignment of principal and minor arterials is allowed under certain conditions, but greater traffic volume and higher vehicle speeds which accompany these facilities tend to increase accidents on curving roadways.

A recommended minimum radius of curvature for vehicle design speed and pavement cross-slopes is shown in Table 3. These are based on traffic consisting of typical present day automobiles operating under optimum weather conditions. There are other important considerations in the design of curves on city streets and thoroughfares including the location of intersecting streets, drives, bridges and other topographic features. When super elevation is required on principal and minor arterials, the following basic formula shall be used:

$$e = \frac{v^2}{15R} - f$$

where

e = rate of roadway super elevation, foot per foot
f = side friction factor (See Table 4)
V = vehicle design speed, mph
R = radius of curve in feet

TABLE 3
MINIMUM CENTERLINE RADIUS (FT)
FOR THOROUGHFARES

Rate of Super Elevation (Inches Per Foot)	Minor Collector Design Speed 30 mph	Major Collector Class III Design Speed 35 mph	Minor Arterial Class II Design Speed 40 mph	Arterial - Class I Design Speed 45 mph
-1/2	590	790	1010	1270
-3/8	540	720	930	1170
-1/4	500	670	860	1080
-1/8	470	630	800	1010
0	440	590	750	940
+1/8	420	550	710	890
+1/4	390	502	670	840
+3/8	370	490	630	790

TABLE 4
SIDE FRICTION FACTORS

Street Classification	Side Friction Factor (f)
Class III	0.160
Class II	0.155
Class I	0.145

For local residential streets minimum centerline radius shall be 150 feet.

Turning Lanes - Turning lanes are provided at intersections to accommodate left-turning and right-turning vehicles. The primary purpose of these turning lanes is to provide storage for the turning vehicles. The secondary purpose is to provide space to decelerate from normal speed to a stopped position in advance of the intersection or to a safe speed for the turn in case a stop is unnecessary. Left turn lanes at intersections are usually 10 feet in width. When turning traffic is too heavy for a single lane and the cross street is wide enough to receive the traffic, two turning lanes may be provided. Availability of right-of-way may limit locations where this is feasible. The geometrics for most intersections involving left turn lanes are shown in Figures 8, 9, and 10..

The location of the median nose at the end of the left turn lane should be so located that left turning traffic will clear the median nose while making a left turn. Other considerations include adequate clearance between the median nose and through traffic on the intersecting thoroughfare and location of the median nose to properly clear the pedestrian crosswalks.

Depending on traffic demands at major intersections, right turn lanes are provided to increase the capacity of an intersection by providing an extra lane exclusively for right turn movements. These lanes are usually 10-11 feet in width and should include a tapered section and sufficient length for the storage of several vehicles. Right turn lane shall have 200' feet of storage.

Street Intersections - The standard intersection at grade for principal arterials, and minor arterials and collectors shall be at 90 degrees. The three basic standard intersection types include the Type I intersection, street without median intersecting street without median, Type II intersection, street with median intersecting street with median and Type III intersection, street with median intersecting street without median. Figures 8, 9, and 10 show these intersection types including tables of dimensions. Residential and minor collector street centerline shall not be less than 150' offset to the closest intersecting street. Street intersections at arterial streets shall generally follow the spacing requirement for median cuts unless otherwise approved by the Public Works Director.

Special Intersections - Street and thoroughfare types in the city often intersect at angles less than 90 degrees. The radii required to fit the minimum paths of the design vehicles are longer than those for standard or 90 degree intersections. Presented in the manual are sketches showing design data for the P Design Vehicles, SU and WB-50 (Figures 1, 2 and 3). Special intersections shall be approved by the City and designed using this data.

Sidewalks - The purpose of the public sidewalk is to provide a safe area for pedestrians and bicyclists. Sidewalks shall be constructed when building construction occurs in all residential areas and wherever pedestrian traffic may be generated. The design and construction of all sidewalks and ramps shall conform to the Texas Accessibility Standards (TAS) and the American Disability Act (ADA).

pedestrian traffic may be generated. The design and construction of all sidewalks and ramps shall conform to the Texas Accessibility Standards (TAS) and the American Disability Act (ADA).

The standard City of Cedar Hill concrete sidewalk is a minimum of four (4) feet in width and the edge of the sidewalk located nearest the street right-of-way is normally two feet from the right-of-way line. Special sidewalk designs include a minimum 5-foot wide sidewalk adjacent to and directly behind the street curb, a sidewalk within the entire parkway width in commercial areas and a sidewalk as the footing for a concrete retaining wall. Sidewalk alignments may be varied to avoid the removal of trees or the creation of excessive slopes.

300.07 VERTICAL ALIGNMENT

Street Grades - The vertical alignment of city streets and thoroughfares shall be designed to insure the safe operation of vehicles by the traveling public, provide positive drainage to the street and allow for easy access to adjacent property. A travel way which is safe for vehicles is dependent on criteria which consider operating speeds, maximum grades, vertical curves and sight distance. In addition to these considerations, other factors related to vertical alignment include storm drainage, crown or crossfall and the grade and right-of-way elevation relationship. The grade of the street or thoroughfare, particularly at its intersection with another grade, is of prime importance in providing a safe, comfortable riding surface to the motoring public. The intersection design of two major arterials shall include grades that will result in a plane surface or at least a surface that approximates a plane surface. A vehicle traveling on either thoroughfare should be able to traverse the intersection at the design speed without discomfort. To accomplish a smooth transition, crossfall toward the median of one lane of each thoroughfare may be required. A storm drainage inlet may also be required in the median.

In presenting the grades of intersecting thoroughfares in the paving plans, profiles of all four curbs of a thoroughfare should be shown as a continuous grade through the intersection of the other thoroughfare.

Minimum Grades - Minimum longitudinal grades for streets and thoroughfares are required to insure proper flow of surface drainage toward inlets. Minimum grades shall be five tenths (0.5) percent. Where valley gutters are used for intersecting drainage, the minimum grades for valley gutters shall be five tenths (0.5) percent.

Maximum Grades - Maximum longitudinal grades shall be compatible with the type of facility and the accompanying characteristics including the design speed, traffic conditions and sight distance.

TABLE 5
MAXIMUM STREET GRADES

Street Type	Normal Maximum Grade in Percent
Residential,	10% *
Collector	8%
Minor and Principal Arterial	6%

* A 12% Grade may be used if the area has another access and is available at a grade of 10% or less.

Vertical Curves - When two longitudinal street grades intersect at a point of vertical intersection (PVI) and the algebraic difference in the grades is 1.0% or greater, a vertical curve is required. Vertical curves are utilized in roadway design to effect a gradual change between tangent grades and should result in a

design which is safe, comfortable in operation, pleasing in appearance and adequate for drainage. The vertical curve shall be formed by a simple parabola and may be a crest vertical curve or a sag vertical curve. The six possible conditions for crest and sag vertical curves are shown in Figure 4. The geometric elements of the parabolic vertical curve required in the design of pavement profiles are shown in Figure 5.

Stopping Sight Distance - Crest Vertical Curve
When a vertical curve is required, it must not interfere with the ability of the driver to see a length of street ahead, should he be required to suddenly stop. This length of street, called the stopping sight distance, should be of sufficient length to enable a person in a vehicle having a height of eye of 3.75 feet above the pavement and traveling at or near design speed to stop, before reaching an object in his path 0.5 foot in height.

The minimum stopping sight distance is the sum of two distances: one, the distance traversed by a vehicle from the instant the driver sights an object for which a stop is necessary, to the instant the brakes are applied; and the other, the distance required to stop the vehicle after the brake application begins.

The minimum safe stopping sight distances for the City of Cedar Hill street types and design speeds are shown in Table 6. These sight distances are based on each design speed shown and a wet pavement. The minimum length of a vertical curve required for the safe stopping sight distance (crest curve) or to provide a comfortable ride (sag curve) of each street type may be calculated using the formula L = KA. The values of K for a crest vertical curve shown in Table 6 where L equals the minimum length required, K is the horizontal distance in feet required to effect 1% change in gradient and A is the algebraic difference in grade.

TABLE 6
MINIMUM LENGTH OF VERTICAL CURVE

Street Type	Design Speed (1)*	Design Speed (2)**	Safe Stopping Sight Distance (1)*	Safe Stopping Sight Distance (2)**	Normal Crest Vertical Curve K (1)*	Normal Crest Vertical Curve K (2)**	Normal Sag Vertical Curve K (1)*	Normal Sag Vertical Curve K (2)**
Residential	35	20	150	110	20	15	20	20
Class III	40		240		38		27	
Class I	50		310		69		44	

*Use Column (1) for ordinary terrain having average grades from 0% to 8%.
**Use Column (2) for rolling terrain having average grades greater than 8

Intersection Grades - The grade of an intersecting street with the principal street gutter should not be generally more than four (4) percent either up or down within-the first twenty (20) feet beyond the curb line of the principal street except that in rolling terrain a maximum intersecting grade of six (6) percent can be considered. Grade changes of one (1) percent or more require vertical curves.

300.08 SIGHT DISTANCE AT INTERSECTIONS

An important consideration in the design of city streets and thoroughfares is the vehicle attempting to cross the street or thoroughfare from the side street or drive. The operator of the vehicle attempting to

cross should have an unobstructed view of the whole intersection and a length of the thoroughfare to be crossed sufficient to permit control of the vehicle to avoid collisions. The minimum sight distance considered safe under various assumptions of physical conditions and driver behavior is related directly to vehicle speeds and to the resultant distance traversed during perception and reaction time and during braking. This sight distance, which is termed intersection sight distance, can be calculated for different street or thoroughfare widths and for various grades upwards and downwards. Recommended intersection sight distances are shown in Table 7 and Table 8. Figure 6 shows the method for measuring the intersection sight distance.

TABLE 7
SIGHT DISTANCES
(SEE FIGURE 6)

	DESIGN SPEED (mph)	STOPPING SIGHT DISTANCE (FEET)		PAVEMENT WIDTH (B.O.C)	INTERSECTION SIGHT DISTANCE – (FEET)			
		MINIMUM	DESIRABLE		NEAR SIDE		FAR SIDE	
					MINIMUM	DESIRABLE	MINIMUM	DESIRABLE
Res.	25	150	200	27'	150	220	150	260
IV	30	200	200	27'	200	260	200	300
				39'	200	275	220	310
III	35	240	250	40'	240	325	270	370
				44'	240	330	275	375
				2 – 24.5'	240	330	305	410
				33'	275	350	280	400
II	40	275	300	49'	275	350	305	425
				2 – 33'	280	400	400	520
I	45	315	375	2 – 36'	320	450	450	580

TABLE 8
SIGHT DISTANCE ADJUSTMENTS DUE TO GRADE

DESIGN SPEED	UPGRADES (DECREASE)			DOWNGRADES (INCREASE)		
	3%	6%	10%	3%	6%	10%
(mph)	(measured in feet)			(measured in feet)		
25	5	10	15	5	15	25
30	10	15	20	10	20	30
35	15	20		15	25	
40	20	25		20	35	
45	25	30		25	50	

300.09 MEDIAN OPENINGS

The following standards for median openings are established to facilitate traffic movement and promote traffic safety.

Principal Arterials - Median openings may be permitted at all intersections with dedicated city streets. Exceptions would be at certain minor streets where, due to unusual conditions, a hazardous situation would result.

Midblock median openings or other openings with turns permitted into an adjacent property will normally be permitted if all the following conditions exist:

a. The property to be served is a significant traffic generator with demonstrated or projected trip generation of more than two hundred and fifty (250) vehicles in a twelve hour period.

b. The median opening is not less than 400 feet from an intersection with principal and minor arterials.

c. The median opening is not less than 260 feet from an intersection with a minor street.

d. The median opening is not less than 300 feet from any other existing or proposed midblock median opening.

e. The median width is sufficient to permit the construction of a left turn storage lane.

Minor Arterials- Median openings may normally be permitted at all intersections with dedicated city streets. Normally the spacing between median openings should be no more than 1,200 feet.

300.10 DRIVEWAY ACCESS AND CURB OPENINGS

A large percentage of the local retail commercial tracts are accessed by TxDOT ROW. For those projects, an approved TxDOT permit is a prerequisite for a site plan approval. Individual access to public roadways for each parcel is required for development of the project. The City's goal is to provide safe roadways to the general public and emergency vehicle access. The intent of this section is to provide direction for the engineer to design consistently safe accessible routes to the development. Any new curb cuts or driveway connections to a public roadway require a City ROW permit. The ROW permit is available for download at http://www.cedarhilltx.com/index.aspx?nid=658. The Director of Public Works makes the final determination for how the driveway accesses the City's ROW.

Unless a driveway is shared *and* is dedicated by a public access easement, in no case shall the new driveway radius for the curb return extend past the adjacent shared property line, either projected to the curb line or at right angle to the existing curb line; whatever is the most restrictive and feasible. Access driveways shall be located at existing or planned median openings if possible. In general, the spacing for non-residential driveways is no less than 200 feet between the throats of the proposed driveway to the next adjacent driveway. If a non-residential platted parcel has less than 200 feet of arterial/collector roadway frontage, a single driveway approach is permitted as either a shared access or at the farthest distance possible from the closest driveway or intersection. Any proposed non-residential subdivision to be platted shall maintain the 200 foot spacing requirement. New residential driveways, excluding zoning for rural areas, are not allowed on major collector and arterial roadways. Driveway width, curb return radius and minimum spacing specifications are found in the City's Standard Details.

Access driveways and parking areas shall allow for adequate room for maneuvering and to safely enter and exit the driveway and parking area. This is including fire lanes if required by the Fire Department. Gated or controlled access shall provide for the ability to safely exit the property with the

gate remaining closed. Traffic flow shall clearly be defined by signage and paint markings if multiple drive lanes are intersecting at the same point. All traffic is expected to yield to traffic entering from the public ROW. Storage length shall be provided for the vehicles entering the non-residential driveway and is measured from ROW line. The length varies based on the number of parking spaces listed below.

- Less than 50 parking spaces — 18 feet of storage length
- 50 to 200 parking spaces — 50 feet of storage length
- Over 200 parking spaces — 78 feet of storage length

One-way driveways are allowed due to the limited frontage available for parking area configuration, for maneuvering room and for available driveway widths, being at least one drive lane (at least 12') typically. Angled driveways shall be no less than 45 degrees. Adequate line of sight dedication shall be provided for these driveways. Illustrations for parking areas and related driveways are found in the back of the City's Zoning Code. Residential circular driveways are approved by the City's ROW permit process provided it meets the width, spacing and other specified conditions. The layout for the approach shall have the driveways perpendicular to the curb line.

300.11 PARKING LOT PAVEMENT DESIGN

The developer shall provide a geotechnical report sealed by a Texas licensed professional engineer with recommendations for pavement thickness and subgrade requirements. The minimum pavement thickness for a parking lot driveway or aisle shall be the same as a residential street in Table 9. Fire lanes adjacent to a multi-story building and dumpster loading areas shall have the same pavement thickness as a collector or arterial class street. Parking spaces shall have a minimum pavement thickness of 5-inches and 3500psi strength concrete. Rebar and concrete strength shall reflect the same specifications as indicated in the City Standard Details per use, driveway or fire lanes, and their corresponding classification of street.

300.12 DRIVEWAY GRADES

The normal driveway grade within the street right-of-way is set at one-quarter inch per foot rise above the top of curb at the property line. The minimum elevation of a driveway at the right-of-way line is two inches above the top of curb. Barrier free sidewalk construction requires a maximum driveway grade as measured from the gutter of eight (8) percent.

Where driveway construction or reconstruction must occur off the street right-of-way, the usual maximum grade is fourteen (14) percent for residential and ten (10) percent for non-residential with fire lanes. The maximum change in grade without vertical curve is twelve (12) percent for any ten feet in distance. Driveways should be profiled for a distance of at least twenty-five feet outside the right-of-way to insure adequate design for replacement of existing driveways or adequate access to the parcel.

300.13 PAVEMENT STRUCTURE

Factors which influence the performance of street and thoroughfare pavement include the subgrade upon which the pavement structure rests, the quality of materials used to construct the pavement and the type and amount of traffic using the facility. In designing a pavement that will provide a reasonable degree of performance during an expected life, a certain number of these factors can be predetermined. The load bearing capacity of the subgrade can be determined by making a soils-engineering investigation of the site for the proposed pavement. Specifications and quality control during construction can also establish the strength of the pavement. A reasonable estimate can also be made of the traffic including the number of equivalent 18-Kip axial loads anticipated during the expected life of the pavement.

Although the subgrade and traffic vary for different locations, the plasticity index (P.I.) of the subgrade and the street or thoroughfare type (residential, and minor arterial, etc.) reflect to a degree these factors. Therefore, standard pavement sections are established for certain subgrade conditions and street types and are included in the manual in Table 9, "Standard Street and Thoroughfare Pavement Design". Unusual design conditions may be encountered which will preclude the use of Table 9. Also, alternate designs accompanied by calculations and data based on accepted pavement design procedures will be reviewed, studied and considered by the Director of Public Works.

300.14 STANDARD STREET AND THOROUGHFARE PAVEMENT DESIGN

The developer shall provide a geotechnical report sealed by a licensed professional engineer with recommendations for thickness and lime content. Table 9 shows the minimum pavement thickness and the minimum subgrade requirements for certain soil conditions and for various street types. The procedure for using this table requires that a soils-investigation be made including obtaining soil auger borings, classifying the soils encountered and determining the strength and physical properties of the underlying and supporting soils system in the laboratory by means of Atterburg Limits, optimum moisture content, and unit dry weight. For each soil classification encountered, the plasticity index (P.I.) shall be calculated and depending on whether the P.I. is less or more than the critical percentage shown, the subgrade design shall typically consist of a minimum 6-inch compacted subgrade or a lime treated compacted subgrade as shown in Table 9 or otherwise stated by the geotechnical report or approved by the Director of Public Works.

TABLE 9
STANDARD STREET AND THOROUGHFARE PAVEMENT DESIGN

Facility Type	Classification	Usual Crown	Subgrade P.I. < 15	Subgrade P.I. > 15*	Pvmt. Thickness **
	Alley	3" Inverted	6" Compacted	6" Lime Treated	6"
	Residential	4" Parabolic	6" Compacted	6" Lime Treated	6"
Class III/IV	Collector	6" Parabolic	6" Compacted	6" Lime Treated	8"
Class II	Minor Arterial	1/4" per Ft.	6" Compacted	6" Lime Treated	8"
Class I	Principal Arterial	1/4" per Ft.	6" Compacted	6" Lime Treated	8" min.

NOTE: * Refer to Section 200.02 Eagle Ford Geology for soils with sulfate concentration greater than 3,000 ppm.

** Twenty-eight day concrete strength of rigid pavement to be not less than 4000 p.s.i. if machine-poured or 4500 p.s.i. if hand-poured, unless specified otherwise. Determined by AASHTO pavement design criteria.

300.15 PAVERS AND STAMPED CONCRETE

For selected street crosswalks and special areas approved by the Director of Public Works, stamped concrete finishes are allowed in those designated sections used by vehicular traffic. The pattern shall be symmetrical throughout and limited to rectangular segments in the street pavement. Segments are to be at a right angle to the centerline. Coloring shall be an integral part of the concrete mix and therefore a concrete mix submittal including color is required for approval. Brick pavers are not to be installed in the driveways or traffic lanes. However, pavers can be used as an alternative material in

medians, pedestrian walkways, emergency access only and other non-vehicular traffic areas, such as sidewalks, walkways, or bicycle lanes.

300.16 ALTERNATE PAVEMENT DESIGN

The Director of Public Works will consider an alternate pavement design in lieu of selecting a design from Table 9, particularly when there are circumstances that warrant an individual design. Certain recognized factors that affect the design of street and thoroughfare pavement are as follows:

a. *Traffic* - One of the important factors influencing the design of pavement structure is the magnitude and number of load applications expected during the life of the pavement. Streets of similar type have essentially the same magnitude and number of load applications during the life of the facility. The minor street, for example, carries some bus traffic and practically no truck traffic and its primary function is to provide access to adjacent properties. The number of load applications expected during the life of the minor street pavement is considerably less than that of the principal and minor arterials.
b. *Wheel Loads* - Alternate pavement designs submitted to the Department of Public Works shall be based on axle loads as shown in Figure 7. These include the Passenger Vehicle (P); the Single Unit Truck (SU); and the Semi-Trailer Combination (WB- 50).
c. *Soils and Subgrade* - The subgrade is the top of the usual grading operation in the construction of a street pavement, including the subgrade treatment, upon which the sub-base, or pavement is placed. The subgrade should be compacted to at least 95 percent of Standard Density at or slightly above optimum moisture to a depth of 6-inches. Subgrades having a plasticity index of 15 or greater are treated with lime and compacted to ninety-five (95) percent of Standard Density. To predict the performance of the subgrade when subjected to traffic loads samples and tests of the natural soil shall be made. Soil engineering investigations for the design of street pavement shall include auger borings, classification of the materials encountered and determining the strength and physical properties of the underlying and supporting soils system.

The type of pavement shall be the rigid type pavement. The support that the underlying soil layers gives to a portland cement concrete pavement measured at the top of the subgrade or sub-base is expressed as the Modulus of Subgrade Reaction K. This value for a particular soil shall be obtained by means of a plate bearing test or an approximation of the K-value and can often be accurately approximated by correlation of soils data. The K-values for various soil types are approximated as follows in Table 10.

TABLE 10
APPROXIMATE K-VALUES

Approximate Modulus of Subgrade Reaction K	Type of Soils
100	Silts and Clays
200	Sandy Soils
300	Sand - Gravel

Another method of measuring the ability of the subgrade to support the traffic load is the Texas Triaxial Compression Classification.

To develop additional strength in the pavement subgrade, the existing soil may be treated with hydrated lime. In addition to adding strength to the subgrade, lime treatment also reduces the tendency of the soil to volumetric change by forming a moisture barrier and reducing moisture

fluctuations in the underlying soils. Subgrade treatment is also an aid in speeding up construction by providing a "working table" for the contractor.

All laboratory tests and field procedures in the use of lime to treat the subgrade under streets and thoroughfares should be performed under the supervision of a registered engineer.

300.17 SUSTAINABLE PUBLIC RIGHTS-OF-WAY DESIGN

Goal: Cedar Hill supports the design and development of public rights-of-way that not only meet the needs of today but do not compromise the ability of future generations to meet tomorrow's needs. Sustainable public rights-of-way shall include the following:

1. Improve air and water quality
2. Create pedestrian and bicycle friendly community
3. Provide safer, healthier neighborhoods
4. Improve performance and reduce costs
5. Promote economic development
6. Provide safe pedestrian and bike routes to schools, neighborhoods, government buildings and retail areas.

Policy: Design and development of public rights-of way that balance multiple uses, multiple modes of transportation, environmentally friendly, and cost effective to construct and maintain are encouraged and shall be given strong consideration. The City of Cedar Hill will consider and support appropriate modifications or variances to the City's adopted subdivision and design standards in support of the development of sustainable public rights-of way.

By way of example in certain instances/locations a roadway may be designed with rain gardens and bioswales along the side. Further, the median can also be utilized to treat storm water runoff by accommodating vegetated medians, and/or creating bioswales and/or rain gardens. These types of medians, with appropriate maintenance arrangements can add considerably to the appearance and aesthetics of the roadway, as well as allow a greater amount of pervious surface, filter water runoff and create green space allowing improved air quality.

Procedures: Sustainable rights-of-way shall be designed and constructed in accordance with "Sustainable Rights-of-Way" guidelines which are prepared by the North Central Texas Council of Governments (NCTCOG). These guidelines can be found at: http://www.nctcog.org/envir/SEEDevEx/pubworks/ROW/index.asp. All proposals for sustainable public right-of-way that do not comply with the City's adopted subdivision regulations or design manual shall be submitted along with plans and written request and supporting justification to the Director of Public Works. Subsequently, The Director of Public Works, upon careful review and evaluation of the proposal, based on appropriateness and cost effectiveness, shall submit the application and a report along with a recommendation to the City Council for consideration. The City Council will have final approval on any modification to the adopted Subdivision Regulations or Design Manual.

300.18 COMPLETE STREETS

Complete streets are roadways designed and operated to enable safe, attractive and comfortable access and travel for all users, including pedestrians, bicyclists, motorists, and public transport users of all ages and abilities. Further, complete streets improve safety, lower transportation costs, provide alternatives to private motorized cars, encourage health through walking and biking, create a sense of place, advocate social interaction and generally increase adjacent property values.

Bicycle and pedestrian modes of travel are recognized by the City of Cedar Hill as cost-efficient ways to address mobility and air quality concerns while improving physical health and quality of life.

The City of Cedar Hill Master Plan for Trails and Bikeways details the goals, responsibilities, and activities of the Bicycle and Pedestrian Program by setting strategies for providing a network of trails and bikeways in an effective, cost efficient, safe intermodal access for bicyclist and pedestrians. The design of any roadway within the City of Cedar Hill shall comply with this Trail and Bikeways Master Plan and shall meet all the design requirements set by the North Central Texas Council of Governments (NCTCOG). Any deviation or variation from the established City guidelines and/or NCTCOG guidelines and design requirements must be approved by the Director of Public Works.

300.19 SPECIAL ROADWAY SECTIONS

The special roadway sections are defined on a case-by-case basis when a unique design is needed that does not fit within either the standard or minimum categories. Circumstances warranting a special roadway section might include a five-lane roadway, one way streets, narrower roadways and a paving design different from the standards. Further, When a roadway is dimensionally classified as "existing" then the pavement does not have to be widened. The Public Works Director has the authority to approve Special Roadway Sections.

300.20 TRAFFIC IMPACT ANALYSIS

Understanding the demands placed on the community's transportation network by development is an important part of assessing the overall impacts of any development project. All development projects generate traffic, and in larger and/or denser development projects the generated traffic may cause or create congestion. In order to mitigate this congestion more capital may need to be invested into the transportation network whether it is in the form of widening an existing road or adding traffic signal lights or designing and constructing additional turn lanes. Traffic congestions result in a number of problems, including economic costs due to delayed travel times, air pollution and accidents.

A Traffic Impact Analysis (TIA) is a study which assesses the effects that a particular development's generated traffic will have on the transportation network of the City.

A TIA must accompany developments which have the potential to adversely impact the transportation network. The analysis is used to identify what type of transportation improvement may be necessary to mitigate these adverse impacts.

300.21 PROCEDURE FOR TRAFFIC IMPACT ANALYSIS PROCESS

In an attempt to simplify the process in the City of Cedar Hill, a "Traffic Impact Worksheet" form has been prepared (see Appendix C) which indicates the trip rates for various uses and includes the directions for completing the form.

For medium and large development projects this form must be filled out. If the calculated total trips generated as a result of the development project exceeds certain trips per day as reflected on the form, then a Traffic Impact Analysis (TIA) is required. The TIA must be prepared by a traffic engineer who is licensed to practice in the State of Texas. The study must be approved by the Public Works Department and upon approval the developer must comply with the recommended mitigations as part of the development.

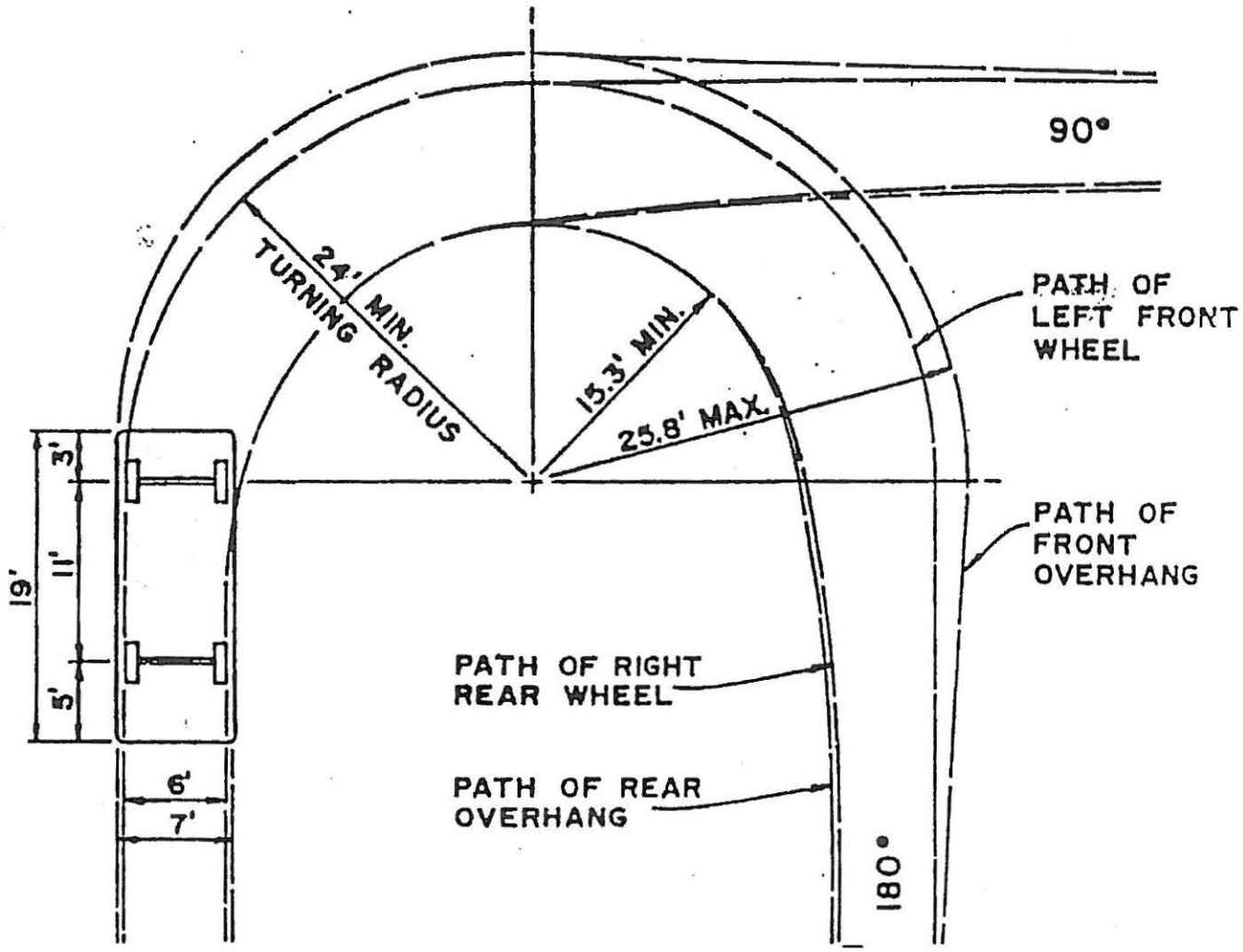
300.22 WAIVER OF TRAFFIC IMPACT ANALYSIS

If the Traffic Impact Worksheet shows that total trips generated as a result of a development exceeds the threshold but in the opinion of the traffic engineer has no significant impact on the street design system then the "Waiver of Traffic Impact Analysis" form needs to be filled out by the traffic engineer and submitted to the Public Works Department for review and approval. If the waiver is approved the preparation of the TIA is waived for the development.

300.23 LIST OF FIGURES

Figure No.	Title
1	Passenger Car (P Design Vehicle) Turning Radius
2	Single Unit Truck (SU Design Vehicle) Turning Radius
3	Semitrailer Combination (WB-50 Design Vehicle) Turning Radius
4	Vertical Curve Types
5	Geometric Elements of Vertical Curves
6	Sight Distance at Intersections
7	Loading and Dimensions for Design Vehicles
8	Type I Intersections
9	Type II Intersections
10	Type III Intersections

FIGURE 1

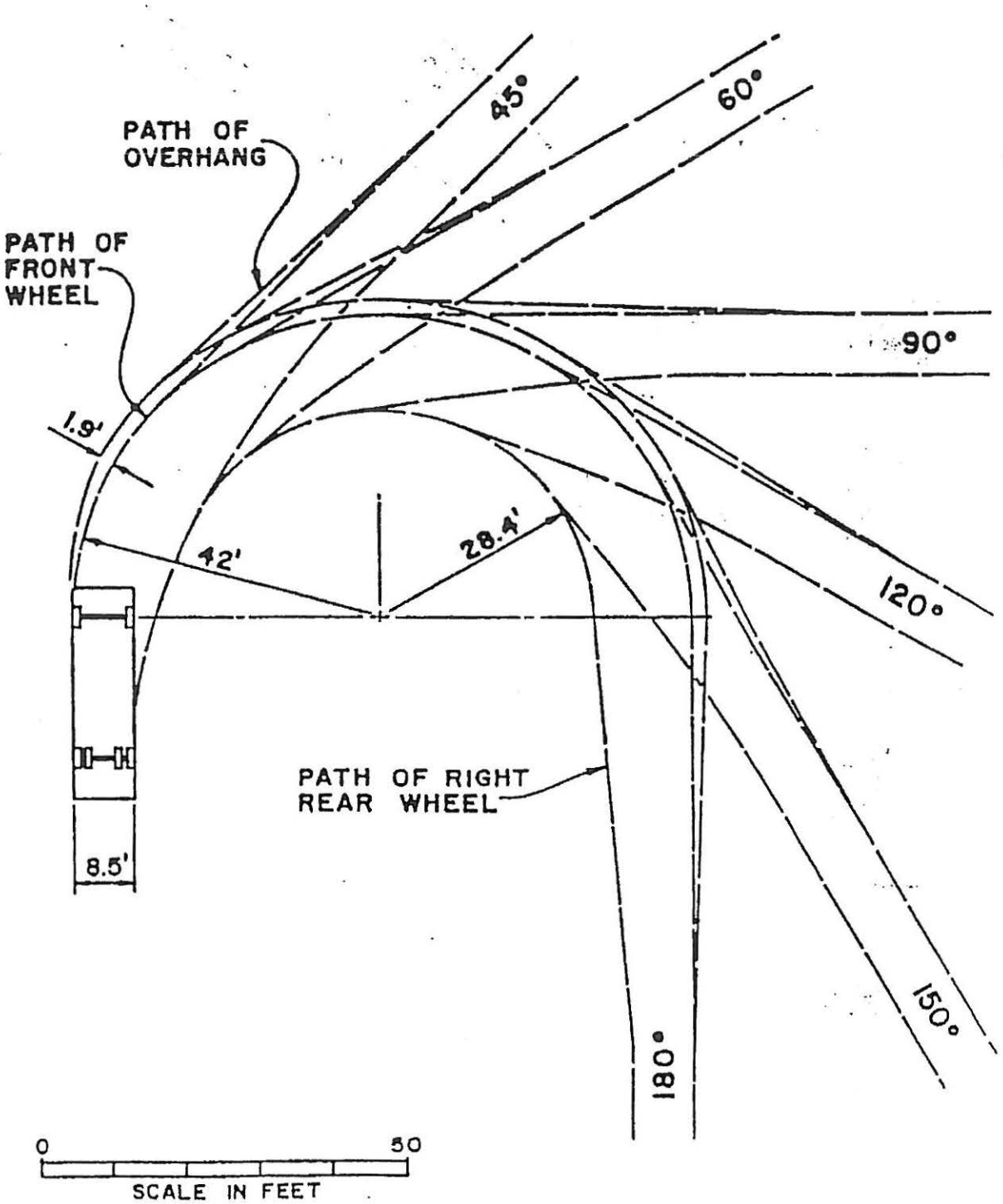


PASSENGER CAR

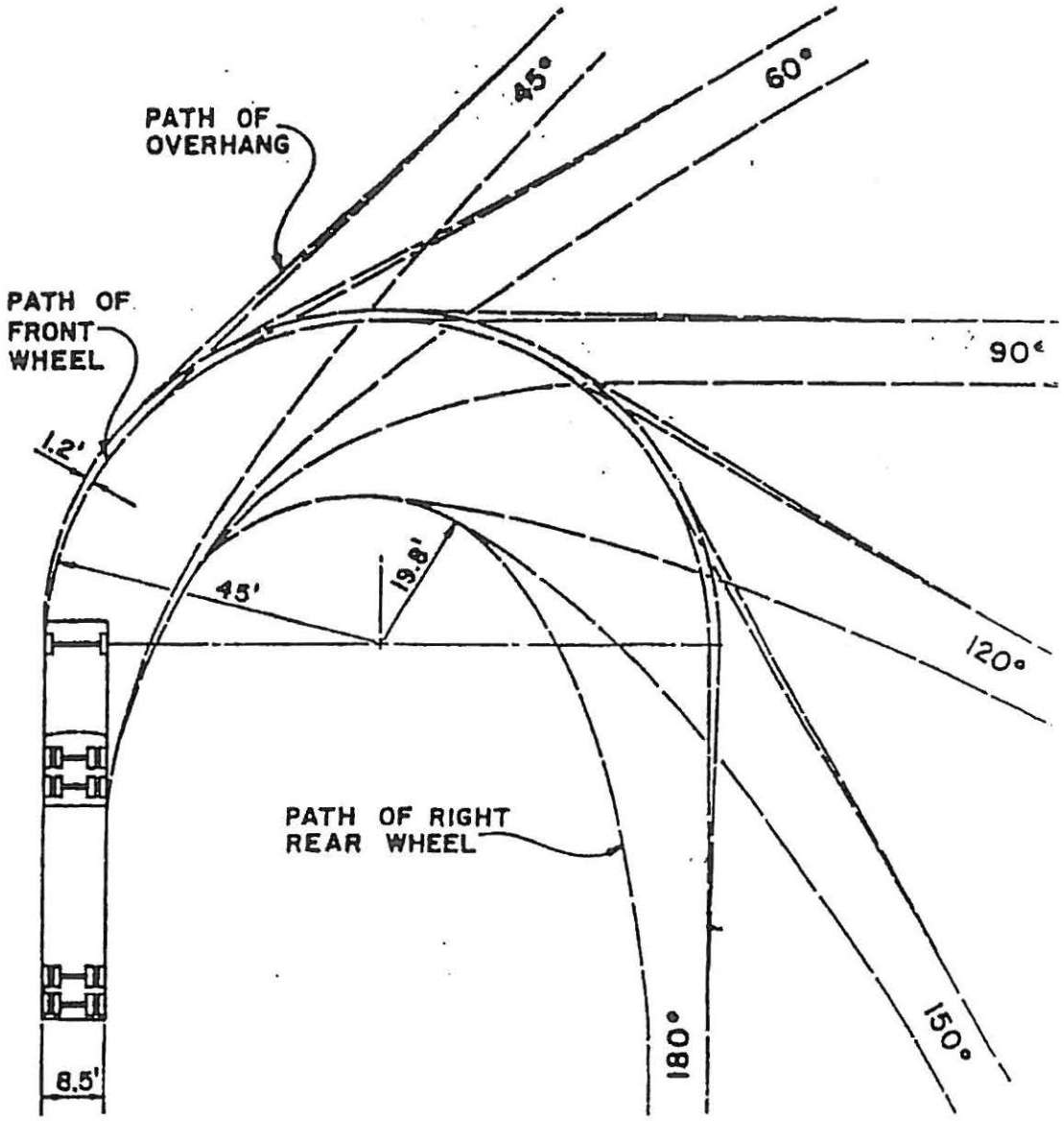
P DESIGN VEHICLE

MINIMUM TURNING RADIUS = 24'

FIGURE 2

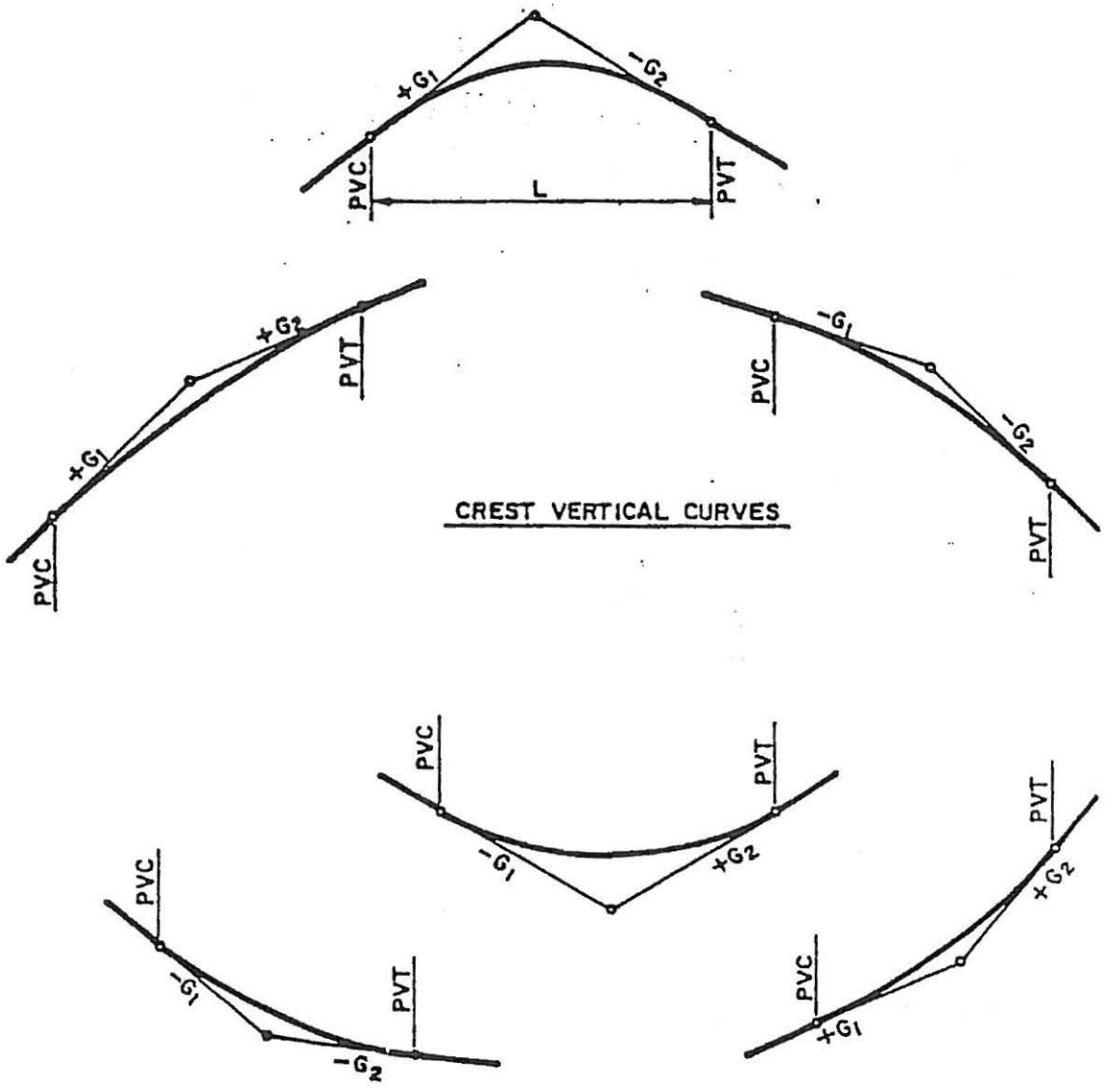


SINGLE UNIT TRUCK
SU DESIGN VEHICLE
MINIMUM TURNING RADIUS = 42'



SEMITRAILER COMBINATION
WB-50 DESIGN VEHICLE
MINIMUM TURNING RADIUS = 45'

FIGURE 4



LEGEND

G_1 & G_2 = TANGENT GRADES IN PERCENT

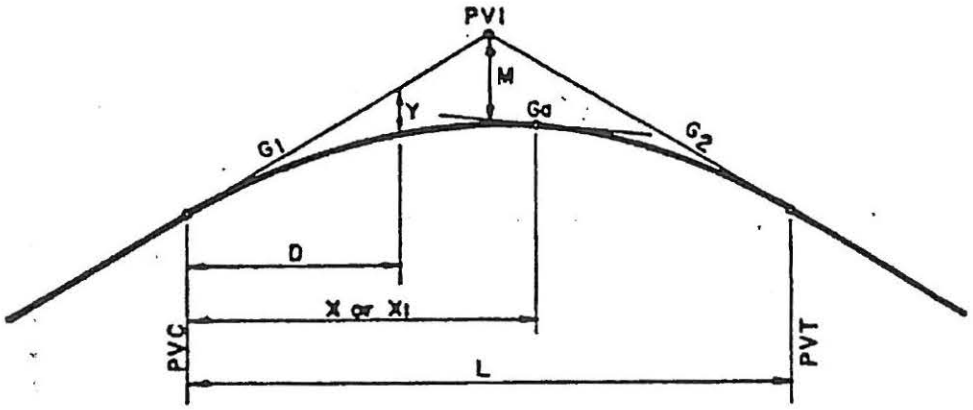
L = LENGTH OF VERTICAL CURVE

PVC = POINT OF VERTICAL CURVATURE

PVT = POINT OF VERTICAL TANGENCY

VERTICAL CURVE TYPES

FIGURE 5



IN A VERTICAL CURVE

$$M = \frac{AL}{8} \qquad X_1 = \frac{LG_1}{A}$$

$$Y = D^2 \times \frac{M}{(L/2)^2} \qquad Ga = G_1 - \frac{AX}{L}$$

WHERE:

G_1 & G_2 = TANGENT GRADES IN PERCENT

PVI = POINT OF VERTICAL INTERSECTION

PVC = POINT OF VERTICAL CURVATURE

PVT = POINT OF VERTICAL TANGENCY

M = ORDINATE FROM PVI TO CURVE IN FEET

A = $G_1 - G_2$ THE ALGEBRAIC DIFFERENCE IN GRADE

L = LENGTH OF CURVE IN STATIONS

Y = ORDINATE FROM TANGENT TO CURVE IN FEET

D = DISTANCE FROM NEAREST PVC OR PVT TO ANY POINT ON CURVE

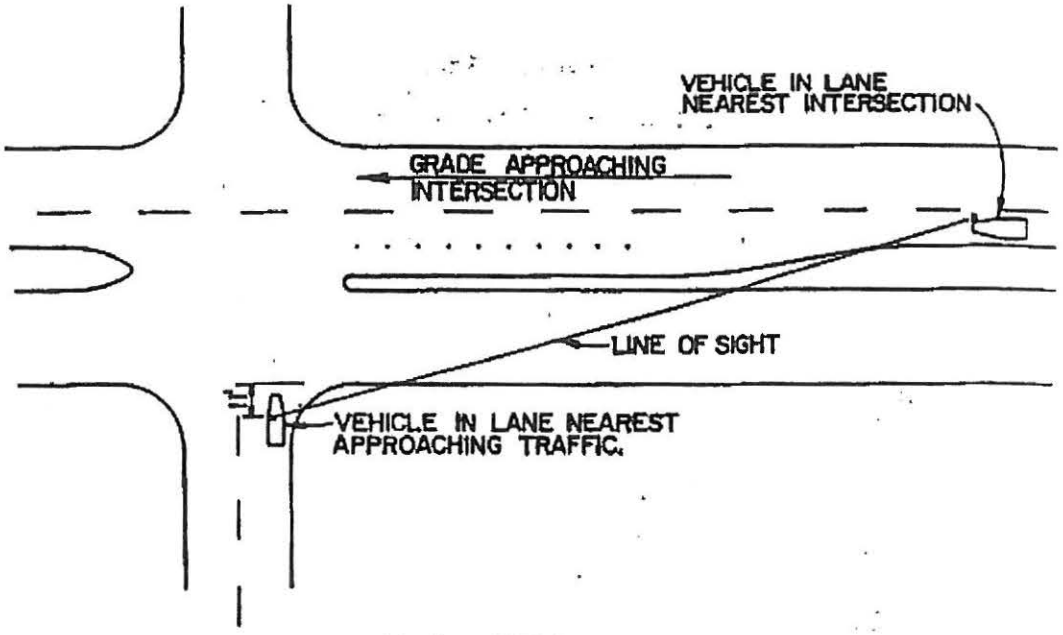
X = ANY DISTANCE FROM PVC OR PVT IN STATIONS

X_1 = DISTANCE FROM PVC TO LOWEST OR HIGHEST POINT ON VERTICAL CURVE

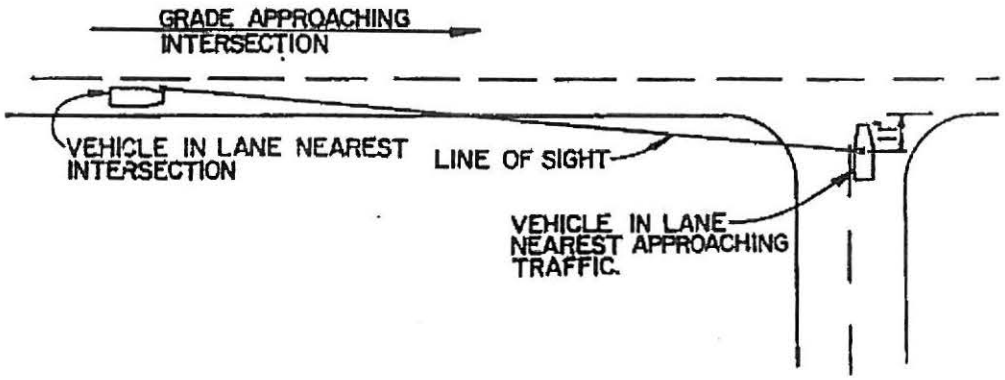
Ga = TANGENT GRADE AT ANY POINT IN PERCENT

GEOMETRIC ELEMENTS OF VERTICAL CURVES

FIGURE 6



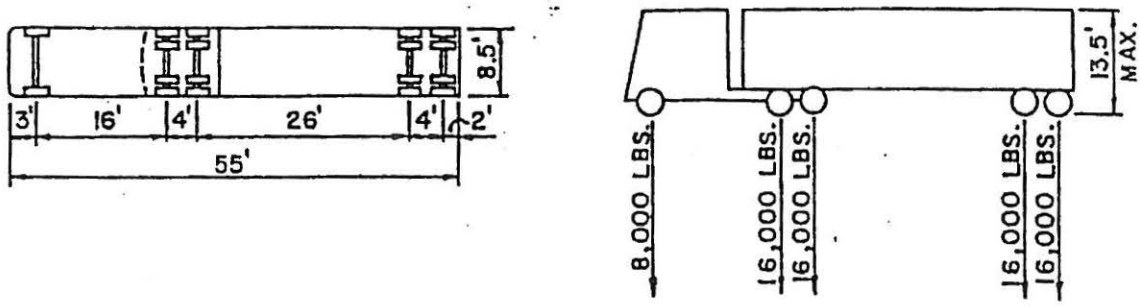
FAR SIDE



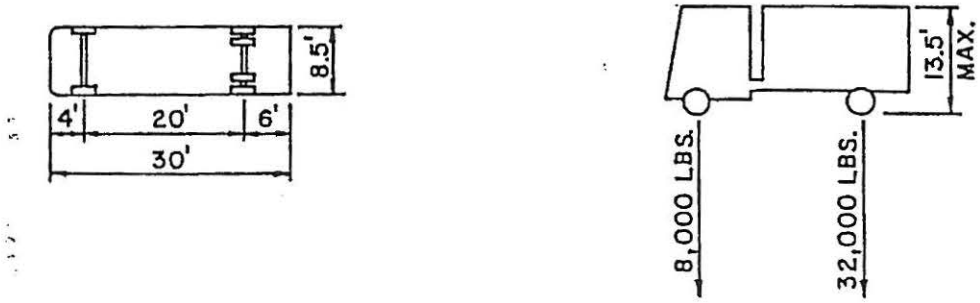
NEAR SIDE

SIGHT DISTANCE AT INTERSECTIONS

FIGURE 7



WB-50 DESIGN VEHICLE



SU DESIGN VEHICLE

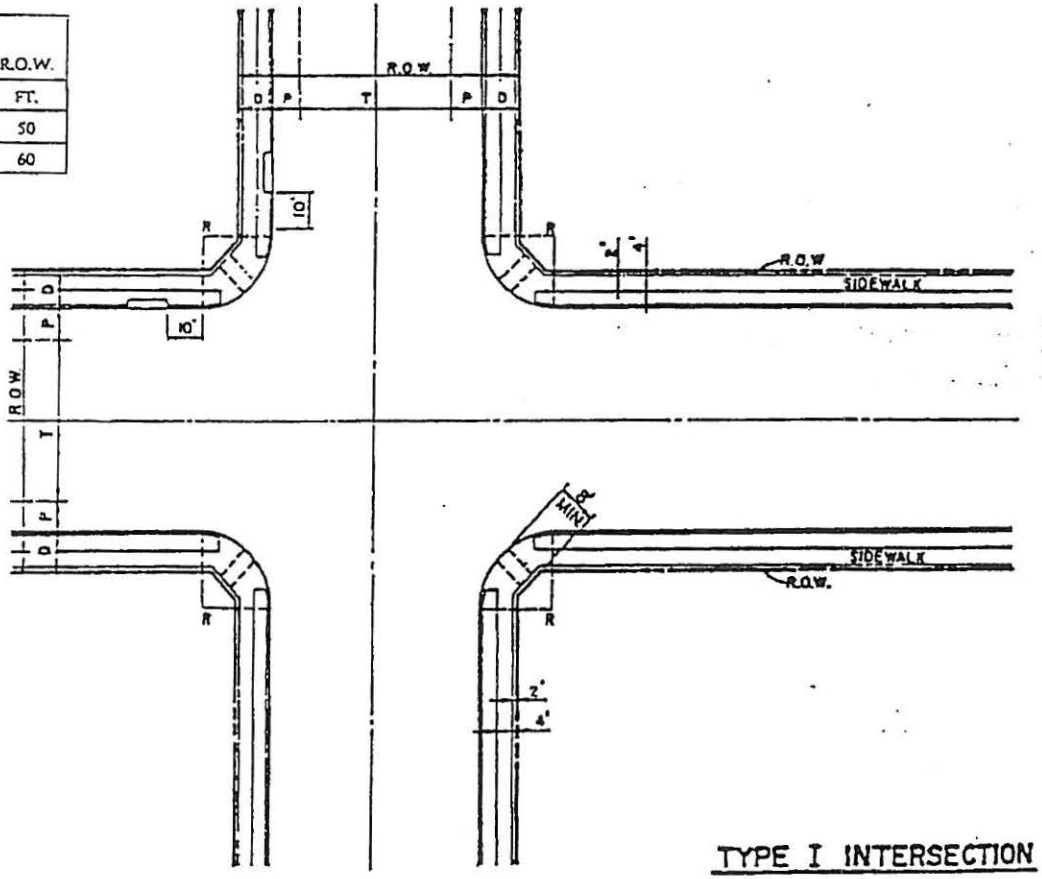
PASSENGER CAR DESIGN VEHICLE

LOADING & DIMENSIONS FOR DESIGN VEHICLES

INTERSECTION DATA

STREET TYPE	TRAFFIC LANES NO.	TRAFFIC LANES WIDTH	T FT.	PARKING LANES (P) NO.	PARKING LANES (P) FT.	D FT.	R.O.W. FT.
RESIDENTIAL	1	10	26	2	8	12	50
COLLECTOR	2	12	24	2	8	10	60

INTERSECTING STREETS		R FT.
MAJOR STREET	MINOR STREET	20
MAJOR STREET	SECONDARY STREET	20
MAJOR STREET	MAJOR STREET	30
SECONDARY STREET	MINOR STREET	20
SECONDARY STREET	SECONDARY STREET	20
MINOR STREET	MINOR STREET	20



TYPE I INTERSECTION

STREET WITHOUT MEDIAN
INTERSECTING
STREET WITHOUT MEDIAN

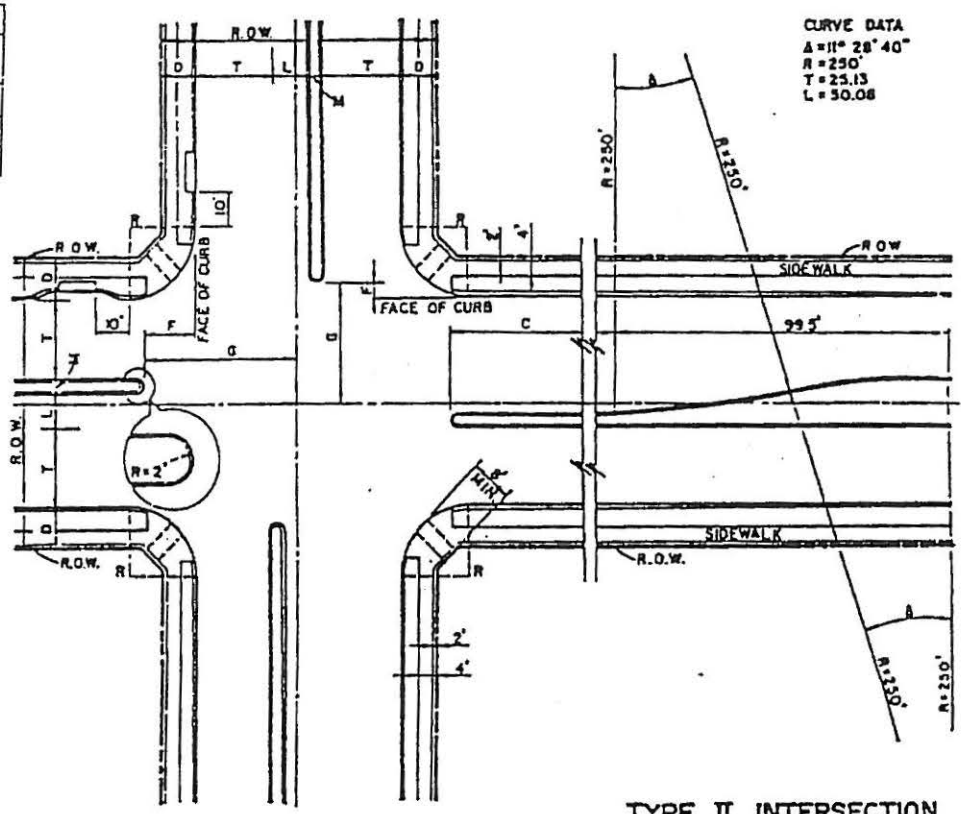
FIGURE 8

INTERSECTION DATA

STREETS WITH MEDIAN							
STREET TYPE	TRAFFIC LANES		T	LEFT TURN (L)	M	D	R.O.W.
	NO.	WIDTH	FT.	FT.	FT.	FT.	FT.
PRINCIPAL ARTERIAL	3	11	33	10	4	10	100
MINOR ARTERIAL	2	11	22	10	4	11	80

INTERSECTING STREETS		C	R
		FT.	FT.
SECONDARY STREET	MAJOR STREET	150	20
MAJOR STREET	SECONDARY STREET	150	20
MAJOR STREET	MAJOR STREET	200	30
SECONDARY STREET	SECONDARY STREET	150	20

NOTE: LOCATION OF MEDIAN NOSE AND DIMENSIONS F & G SHALL BE DETERMINED BY USE OF WB-50 AND S U TURNING RADII.



TYPE II INTERSECTION

STREET WITH MEDIAN
INTERSECTING
STREET WITH MEDIAN

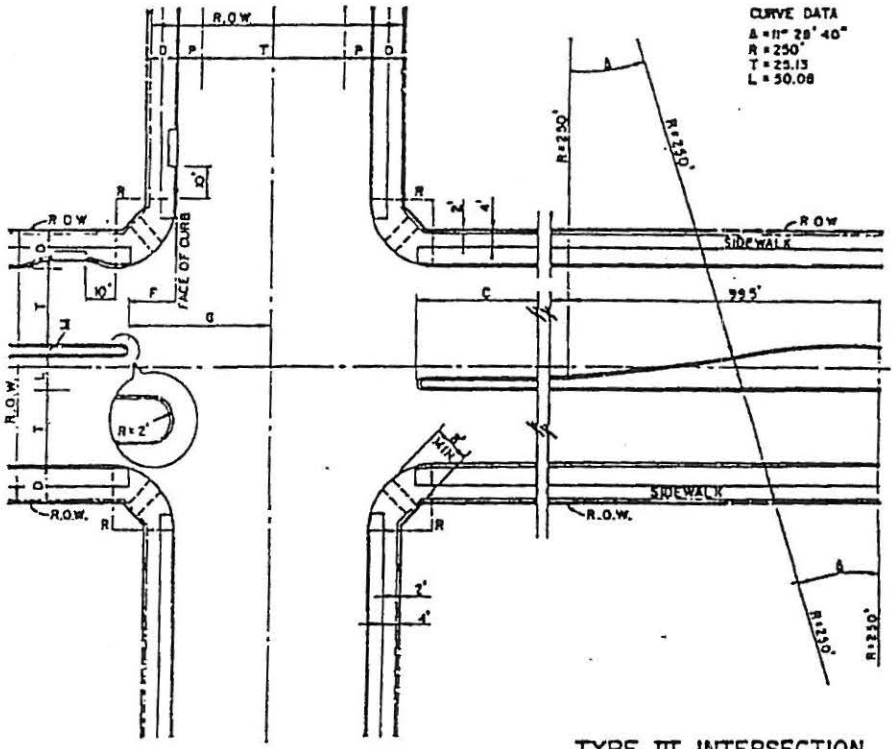
FIGURE 9

INTERSECTION DATA

STREETS WITH MEDIAN							
STREET TYPE	TRAFFIC LANES		T	LEFT TURN (L)	M	D	R.O.W.
	NO.	WIDTH	FT.	FT.	FT.	FT.	FT.
PRINCIPAL ARTERIAL	3	11	33	10	4	10	100
MINOR ARTERIAL	2	11	22	10	4	11	80

STREETS WITHOUT MEDIAN							
STREET TYPE	TRAFFIC LANES		T	PARKING LANES (P)		D	R.O.W.
	NO.	WIDTH	FT.	NO.	FT.	FT.	FT.
RESIDENTIAL	1	10	26	2	8	12	50
COLLECTOR	2	12	24	2	8	10	60

INTERSECTING STREETS		C	R
		FT	FT
MAJOR STREET	MINOR STREET	100	20
MAJOR STREET	SECONDARY STREET	150	20
MAJOR STREET	MAJOR STREET	200	30
SECONDARY STREET	MINOR STREET	100	20
SECONDARY STREET	SECONDARY STREET	150	20
SECONDARY STREET	MAJOR STREET	150	20



NOTE: LOCATION OF MEDIAN NOSE AND DIMENSIONS F & G SHALL BE DETERMINED BY USE OF WB-50 AND S U TURNING RADII.

TYPE III INTERSECTION

STREET WITH MEDIAN
INTERSECTING
STREET WITHOUT MEDIAN

FIGURE 10

DIVISION 500 WATER AND SANITARY SEWER SYSTEMS DESIGN

500.01 PURPOSE AND SCOPE

Public water and sanitary sewer transmission main alignments and their relative pipe sizes shall meet or exceed TCEQ regulations and comply with the City's water and sanitary sewer master plans. Water lines shall be looped were possible. The developer shall provide for future land development of abutting properties by installing water and sanitary sewer lines extending through the parcel according to the City of Cedar Hill Master Plan or towards an adjacent property currently having no access to public water or sanitary sewer service. The minimum diameter for both water and sanitary sewer mains is 8-inches. In general, water mains are placed on the north and west sides of a street, at a distance of six (6) feet behind the curb or at the midpoint between back of curb and ROW line unless directed otherwise by the Public Works Department. See Figure "A" at the end of this section for details of typical locations of service lines, mains, meters and valves.

Water and sanitary sewer easements in or adjacent to an access easement or ROW shall be minimum 15-feet in width. Off-site water and shallow depth sanitary sewer easements shall be 20-feet in width. Deep (12' or deeper) sanitary sewer mains shall be contained in a sanitary sewer easement of at least 25-feet wide.

500.02 WATER LINES

For water mains exceeding 600 feet in length in commercial and manufacturing districts, 12-inch or larger water line may be required as indicated in the City's Master Plan. Dead end mains shall not exceed 600 feet in length, and a one (1) inch water meter service in a double lock meter box will be located at the end of the main. Isolation valves shall be placed just downstream of a connection or tee of a dead end extension. Additional water line easements may be required on the final plat for water line extensions for looping or alternate supply purposes. Water mains must be adequately sized for the building total fire flow.

No water main shall be located closer than eight (8) feet from any tree or structure.

Water Main Material:

a. All water mains 8-inch in diameter shall be AWWA C900 PVC DR14 pipe. All water mains that are 10" – 12" PVC shall be DR18 class pipe, mechanical joint, or a joint of the type which provides a recession in the bell for the employment of a single rubber gasket to be placed before the intersection of the succeeding spigot. Joint material for PVC shall conform to ASTM F477.
b. All water mains 14-inch in diameter and larger shall be either Ductile Iron, AWWA C905 PVC DR21, or Reinforced Concrete (Steel Cylinder Type), complying with American Water Works Association Specifications C-303.
c. All mains supplying fire sprinkler systems outside of utility easements shall be minimum 200 PSI working pressure and U. L. listed.

Valves 12-inch and under shall be placed on or near street ROW lines not over 800 feet apart in residential areas. For all other areas such as duplex and apartment districts isolation gate valves shall not be over 500 feet apart. Valve placement shall be in such a manner as to require preferably two (2), but not more than three (3) valves to shut down each City block, or as may be required to prevent shutting off more than one fire hydrant. On cross-feed mains without services, a maximum of four (4) valves shall be used to shut down each block. Also, valves shall be placed at or near the ends of mains in such a manner that a shut-down can be made for a future main extension without causing loss of service on the existing main. Valves larger than 12-inch shall be placed on or near street ROW lines not over 1200 feet apart as approved by the Public Works Director. Valves shall be Resilient Seat Gate Valves (RSGV).

Valve boxes shall be provided for buried valves. Valve boxes shall be one complete assembled unit composed of the valve box, extension stem and debris washer. All moving parts of the extension stem shall be enclosed in a housing to prevent contact with the soil. Valve box assembly shall be adjustable to accommodate variable trench depths. The entire assembly shall be made of heavy wall high-density polyethylene except for the lid, which shall be cast iron. All exterior components shall be joined with stainless steel screws. The valve box top section shall be adaptable to fit inside a valve box upper section. The valve box lid shall be made of cast iron and designed to close by turning 90 degrees and locked in place by a stainless steel bolt. The stem assembly shall be of a telescoping design that allows for variable adjustment length. The stem material shall be of galvanized steel square tubing. The stem assembly shall have a built in device that keeps the stem assembly from disengaging at its fully extended length. The extension stem must be torque tested to 1000 foot pounds. The valve box shall be American Flow Control's Trench Adapter or approved equal.

The minimum cover to the top of the pipe must consider the depth of the valve stem. In general, the minimum cover below the top of the street subgrade should be as follows: 8-inch, 4.0 feet; 12-inch, 4.5 feet to 5-feet; 16-inch, 5.0 feet to 5.5 feet. Lines larger than 16-inch shall have a minimum of 6-feet of cover that is sufficient to allow water and sewer and other utilities to go over the large main. For water lines to be constructed along county-type roads commonly built with a high crown about the surrounding property, increase the cover as required to allow for future paving grade changes. All lines 12inch and larger shall be shown in profile. All underground lines regardless of diameter shall be included and profiled at creek crossings, culvert crossings, highway crossings and when the natural or final finished grade exceeds 10%. The maximum grade for any water line shall be 15% except in special cases as approved by the city.

A service with a meter box is constructed from the main to a point just in front of ROW line, usually in advance of paving. The location of the meter box is at or near the corner of the front of the lot to be served (See Figure "A"). On multiple apartments and business properties, the owners or architect usually specifies the desired size and location. Minimum requirements for water service sizes are:

a. One-inch Driscopipe® 5100 Ultra-Line® polyethylene pipe (Municipal Service Tubing, Copper Tube Size – OD ASTM D-2737 – SDR 9 (PE 3408) or approved equal) services are required to serve all residential lots including townhouse lots, patio homes and duplex lots (one for each unit). A one-inch brass angle stop with a 1" x ¾" brass bushing shall be installed at the end of the service.
b. The size of apartment, condominium, or multi-family services will depend on the number of units served with a minimum of one meter per building.
c. All services to existing residential lots on existing water mains that are 2" or smaller should be made by the Water Department.
d. Meter boxes or vaults, if not placed within the ROW, shall be contained within a public water line easement.

500.03 FIRE HYDRANTS

A sufficient number of fire hydrants shall be installed to provide hose stream protection for every point on the exterior wall of the building with the lengths of hose normally attached to the hydrants. There shall be sufficient hydrants to concentrate the required fire flow, as recommended by the publication "GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOW" published by the Insurance Service office, around any building with no hose line exceeding the distances hereinafter established and with an adequate flow available from the water system to meet this required flow. In addition, the following guidelines shall be met or exceeded:

a. SINGLE FAMILY AND DUPLEX RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between

intersections at a maximum spacing of 500 feet between fire hydrants as measured along the route that fire hose is laid by a fire vehicle.

b. MULTIFAMILY RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 300 feet as measured along the length of the centerline of the roadway, and the front of any structure at grade shall be no further than 300 feet from the minimum of two fire hydrants as measured along the route that a fire hose is laid by a fire vehicle.
c. OTHER DISTRICTS - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 300 feet as measured along the length of the centerline of the roadway, and the front of any building at grade shall be no farther than 300 feet from the minimum of two fire hydrants as measured along the route that a fire hose is laid by a fire vehicle.
d. PROTECTED PROPERTIES - Fire hydrants required to provide a supplemental water supply for automatic fire protection systems shall be within 100 feet of the Fire Department connection for such system.
e. BUILDING FIRE SPRINKLERS - An 8-inch fire line stub-out with valve shall be provided for all buildings to be sprinkled. A smaller stub-out can only be used with Fire Department approval.
f. Fire hydrants shall be installed along all fire lane areas as follows:

    1. Non-Residential Property or Use

        a) Within 150 feet of the main entrance.
        b) Within 100 feet of any Fire Department connection.
        c) At a maximum intermediate spacing of 300 feet as measured along the length of the fire lane.

    2. Apartment, Townhouse, or Cluster Residential Property or Use

        a) Within 100 feet of any Fire Department connection.
        b) At a maximum intermediate spacing of 300 feet as measured along the length of the fire lane.

g. Generally, no fire hydrant shall be located closer than fifty (50) feet to a non-residential building or structure unless approved by the Engineering and Fire Departments.
h. In instances where access between the fire hydrant and the building that it is intended to serve may be blocked, extra fire hydrants shall be provided to improve the fire protection. Railroads, divided thoroughfares, expressways, and other man-made or natural obstacles, subject to buildings restricting movement, are considered as barriers.

All fire hydrants shall meet the following minimum requirements:

a. The water line and the fire hydrant must be within a dedicated public right-of-way (ROW) or easement.
b. The water line and the fire hydrant must be designed and constructed in accordance with the City of Cedar Hill standards and using approved materials.
c. All required fire hydrants shall be of the national standard three (3) way break-away type no less than five and one-fourth (5 ¼) inches in size and shall conform to the provisions of the latest AWWA Specifications C-502 and shall be placed upon water mains of no less than eight (8) inches in size. Steamer nozzles shall be four (4) inches I.D. and side nozzles shall be two and one-half (2 ½) inches. Fire hydrants shall be as specified in the Specifications and/or Special Provisions. Fire hydrants shall have a maximum bury depth of 5-feet.
d. Valves shall be placed on all fire hydrants leads.
e. Required fire hydrants shall be installed so the break-away point will be no less than two (2) inches, and no greater than six (6) inches above the grade surface.

f. Fire hydrants shall be located a minimum of three (3) feet and a maximum of six (6) feet behind the curb line, based on the location of the sidewalk. The fire hydrant shall not be in the sidewalk.
g. All required fire hydrants placed on private property must be within dedicated easements and shall be adequately protected by either curb stops or concrete posts or other methods approved by the Fire Department. Such stops or posts to be the responsibility of the landowner on which the said fire hydrant is placed.
h. All required fire hydrants shall be installed so that the steamer connection will face the fire lane or street, or as directed by the Fire Department.
i. Fire hydrants, when placed at intersections or access drives to parking lots, when practical, shall be placed so that no part of the fire truck will block the intersection or parking lot access when connections to the fire hydrants are made.
j. Fire hydrants, required by this article, and located on private property, shall be accessible to the Fire Department at all times and isolated by backflow devices and valves.
k. Fire hydrants shall be located at street or fire lane intersections, when feasible.
l. A Blue Stimsonite, Fire-Lite reflector (or approved equal) shall be placed in the center of the street opposite fire hydrants.
m. Existing water mains smaller than 8-inch used for hydrant supply shall be replaced and dead-ends eliminated where practical. New 8-inch lines shall be connected to new or existing fire hydrants.
n. A domestic service connection shall not be allowed on 6-inch fire hydrant leads except as authorized by the Public Works Department.
o. An 8-inch pipe and an 8-inch gate valve are required for long fire hydrant leads exceeding 50' in length or that crosses under a paved street.

500.04 SANITARY SEWERS

Sizes and the general alignment of sanitary sewers shall be as required by the City's Sanitary Sewer Master Plan. Consideration shall be given as to possible extensions for future development and if zoning changes require higher demands for service. In general, sewer shall be placed in the center of the street. Each addition has its individual design; therefore, no fixed rules will apply to all cases. See Figure "A" for details of locations for public water and sanitary sewer line placement.

Minimum cover shall be 3.5-feet; unless otherwise authorized by the Public Works Department and shallow pipe shall have concrete protection. In general, for single family developments, the minimum depth for a sewer line to serve the given property with the lateral shall be 3-feet plus the height required for a 2% slope times the length of the lateral (the distance from the sewer line to the center of the house). Finished grading 20-feet past the building line will be required to verify that this criteria is met. For sanitary sewer lines deeper than 14 feet, SDR26 PVC pipe shall be used. A parallel sewer line will be required when laterals are to be attached to a deep main of more than 14-feet. This requirement should be discussed with the City and approval obtained from the Public Works Director.

Sewage flow shall be computed in accordance with Table 1, with the exceptions, as required by the Public Works Department. Pipes should be placed on a consistent grade and in a straight horizontal alignment such that the velocity when flowing full is not less than two (2) feet or more than ten (10) feet per second. Minimum grades shall be as follows:

insert. The insert shall be Knutson Manhole insert marketed by J.C. Utility Sales Inc. Dallas, Texas (214) 340-7866 or approved equal. Insert manufacturer shall have been in continuous production of the inserts for 6 years.

LATERALS - The size and locations of laterals shall be as designated by the Public Works Department. In general, for single family dwellings, the lateral size shall be 4-inch minimum; for multiple units, apartments, local retail and commercial the size shall be 6-inch" minimum; for manufacturing and industrial, the size should be 8-inch or larger as required. House laterals usually come out to the center of the lot and shall have a 10-foot minimum lateral separation from the water service. Manholes will be required on 6-inch and larger laterals where they connect to the main line. Vertical stack drops shall be used for any sewer main deeper than 12-feet. The City will make sanitary sewer taps for existing platted residential lots not having a viable existing tap and the existing main is less than 10-feet deep. A minimum of one (1) lateral per building shall be required. Also, a minimum of one (1) lateral per each lot shall be required. No multiple users for a single lateral are allowed.

Railroad, state highway and creek crossings, etc., shall be as approved by the Public Works Director and the related permits shall be submitted to the City of Cedar Hill for further application to the various agencies.

The developer's Engineer shall furnish line and grade stakes for construction. All property lines and corners must be properly staked to insure correct alignment. The City will not be liable for improper alignment or delay of any kind caused by improper or inadequate surveys by the developer or by utility conflicts.

In order to provide access to sewer lines for cleaning, manholes and/or cleanouts shall be so located that 250 feet of sewer rod can reach any point in the line. This means that manhole spacing shall be a maximum of 500 feet; that spacing between a manhole and an upstream cleanout shall be limited to no more than 250 feet. Clean outs shall be located at the end of the line only with no service lateral connection between manhole and clean out.

No sewer line shall be located closer than eight (8) feet from any tree or structure.

Sanitary sewer systems shall be placed in street right of ways unless otherwise approved by the Public Works Director. If sanitary sewer is not placed in street right-of–way then a sanitary sewer easement must be provided and shall include an all-weather road providing for access to the entire line.

Materials for sewer lines:

a. All sanitary sewer pipe shall be a minimum of 8-inches and made of PVC, unless otherwise approved by the Director of Public Works. Reinforced Concrete Pipe is not allowed for any sanitary sewer lines.
b. Sanitary sewer pipe installation shall conform to the City Standard Details and/or the NCTCOG Specifications.
c. Sanitary sewer pipe joint materials shall have resilient properties, conforming to the City Standard Details and/or the NCTCOG Specifications.

500.05 SANITARY SEWER LIFT STATIONS

Subdivisions shall be designed in such a manner that all sanitary sewer lines will be gravity flow lines, when possible. The lift station shall meet or exceed the minimum TCEQ requirements. They shall have adequate storage and/or means to provide back-up power. The following data shall be used to calculate size and capacity for sanitary sewer facilities.

TABLE 1

Pipe Size	Min. Grade
8-inch	0.40%
10-inch	0.28%
12-inch	0.24%
15-inch to 24-inch	0.16%
28-inch	0.12%

Grades may be less for short distances if approved by the Public Works Director. The maximum grade of any line size shall be no more than 10%. Pipe alignments shall have no horizontal or vertical curves between manhole or clean-outs. When the slope of a sewer changes, a manhole will be required. All grades shall be shown to the nearest 0.01 foot. Horizontal curves with a min. 200 foot radius for 8-inch pipe to match will allow for change in street alignment as approved by the Director of Public Works and shall not exceed recommended manufacturer specifications for deflection. Horizontal curved alignments will not be allowed across residential single family or duplex lots.

Finish floor elevation shall be at least 1.5 feet above the rim elevation of the closest downstream manhole.

The sizes and locations of manholes, wyes, bends, taps connections, cleanouts, etc., shall be accepted by the Public Works Department. In general, manholes shall be placed at all four-way connections and three-way connections. The diameter of a manhole constructed over the center of a sewer shall vary with the size of the sewer line. For 8- to 24-inch sewer lines, the manhole shall be 5-feet minimum diameter with a 30-inch lid required for all manholes; 27- to 36-inch sewer lines shall be 6-foot minimum in diameter. In flood plains, sealed bolted manholes "Type S" are used to prevent the entrance of storm water and vented manhole spacing is required per TCEQ specifications. For public mains with services, manholes shall be placed on the ends of all lines. Drop manholes shall be required when the inflow elevation is more than 18-inches above the outflow elevation. Manholes must be provided at each end of sewer lines that are installed by other than open cut and at each end of aerial crossing lines. Sewer mains and water mains shall meet or exceed minimum TCEQ requirements.

Manhole inserts shall be manufactured from corrosion resistant material suitable for atmospheres containing hydrogen sulfide and diluted sulfuric acid and other gases associated with wastewater collection systems. The body of the insert shall be made of high density, high molecular weight polyethylene copolymer meeting ASTM specification designation D1248 Class A, category 5, type 111 (the insert shall have a minimum impact brittleness temperature of –180°F). The thickness shall be a minimum 1/8" or greater throughout. Gaskets shall be made of closed cell neoprene. The gasket shall be installed by the manufacturer and shall have a pressure sensitive adhesive on one side. A lift strap shall be placed on the rising edge of the insert bowl and shall be 1-inch wide polypropylene web. The location of the strap shall be attached by means of a stainless steel rivet and be located such as to provide easy visual location. Ventilation of the insert shall be made by valve or vent hole. The vent hole located on the side wall of the dish ¾" below the lip is preferred as its ventilation is not effected by debris that might collect in the bottom of the insert. The insert shall have proof of durability in traffic impact loads and shall have engineer certified proof of test passing a collapse load of 2200 lbs. minimum applied to a 5 ½" square area in the center of the

SANITARY SEWER DAILY FLOW CALCULATIONS

Apartment Sanitary Sewer Flow
95 gal. x .75 = 71.25 gal. per day per person
22 units per acre with 3 persons per unit
Calculations (71.25) (22) (3) = 4,702 or 4,700 gallons per day per acre.

Office Sanitary Sewer Flow
3100 parking spaces for 34.7 acres
One person per parking space
20 gallons per person per day
34.7 acres = 89.33 persons per acre (20 gal.) = 1,786.7 or 1,790 gals. per day per acre.

Residential Sanitary Sewer Flow
95 gallons per person per day
4 units per acre
3.5 person per unit
(95) (4) (3.5) = 1330 gallons per day

Hospital Sanitary Sewer Flow
200 gallons per day per bed
200 x 200 = 40,000 gallons per day

Nursing Home Sanitary Sewer Flow
90 gallons per day per bed
90 x 150 = 13,000 gallons per day

Patio Home Sanitary Sewer Flow
95 gallons per person per day
10 persons per unit
(95) (10) (3.5) = 3,325 gallons per day/acre

500.06 CONTROL AND MONITORING FOR SANITARY SEWER LIFT STATIONS

If the use of a sanitary sewer lift station is approved, the lift station will be connected to the city's Supervisory Control and Data Acquisition (SCADA) system. The developer will pay all cost associated with the SCADA to include all labor, equipment, materials, programming of the city's computer, and testing. The SCADA equipment installed shall conform to the standard as noted per this section, Computerized Monitoring and Control Specifications for Sanitary Sewer Lift Stations.

The design for the sanitary sewer lift stations shall include a Remote Terminal Unit (RTU), radio, antenna and tower, alarms, switches, wiring, conduit, primary devices, and all necessary appurtenances. The design shall be in such a manner that the proposed monitoring and control function shall be transmitted by radio between the lift station and the Kingswood Storage Tank and the following information can be transmitted by radio:

Discrete Input	Discrete Output
Power Failure	Pump Control
Intrusion Alarm	
Entry Switch Status	Remote Start Capability
Pump Status	
Wet Well Level	
Wet Well/Dry Well Flood Alarms	

The following items shall be maintained at the RTU:

1. Motor Run Time in Minutes.
2. High and Low Wet Well Alarms
3. Number of Pump Starts

All alarms, levels, and pump functions shall be compatible with all modes of the City's existing Computerized Monitoring System.

The City's existing computerized monitoring and control system was furnished and installed by GE Team Controls, Dallas, Texas in 1997, utilizing Motorola equipment and Wonder Ware InTouch V5.6 and 911 Alarm Dialer software. The design shall be such that all the installed equipment be completely compatible with all existing equipment. Modification to the software package at the Service Center shall be undertaken under the supervision of GE Team Controls under the authority, control, and cost of Contractor.

RADIO - A remote radio shall be supplied and mounted inside a NEMA 4 Cabinet that houses the RTU. Radio shall be connected to the RTU by VF audio lines. The radio shall operate in the UHF frequency, which is compatible with the frequencies for the Cedar Hill system.

ANTENNA AND TOWER - The antenna shall be a 9dbd directional Yagi antenna, horizontal polarized. The antenna shall be pointed towards the Kingswood Elevated Storage Tank. The antenna shall be affixed to a self-supporting steel tower. The antenna shall be a minimum of 25-feet above the lift station pad. A line of site profile shall be prepared to confirm antenna height. All anchor bolts shall be stainless steel.

The antenna tower shall be of steel, welded or bolted. All tower pieces shall be hot-dip galvanized after fabrication, to both internal and external surfaces. Towers shall be capable of withstanding, without damage, a 100 MPH wind load within a 1-square foot projected load at the top. It shall be possible to install support clamps for 1/2-inch cable and for 3/4-inch rigid electrical conduit every 3-feet or closer. The coax shall be grounded with a grounding kit and attached to 8-feet x 3/4-inch ground rod with #6 copper wire. The ground shall be separate from the Motor Control Center grounding rod.

The antenna shall be affixed to an offset bracket or extension tube of sufficient strength to hold the antenna within 3-degrees of horizontal in a 100-MPH wind.

Connection between the radio and the antenna shall be by 1/2-inch diameter foam dielectric, conductor utilizing Type N connectors at all connections. All connections shall be wrapped with Vapor Seal.

REMOTE TERMINAL UNIT (RTU) - The RTU shall be a Motorola Moscad Unit of modular design, or approved equivalent. The unit shall include a 3-slot rack for the mounting of the CPU module and the mixed I/O module. The unit shall have local intelligence.

The CPU module shall be a computer with RAM and ROM memory, real time clock and two RS 232 serial data I/O ports. Programming shall be based on Ladder Logic language through the use of easy to use toolbox programs.

The CPU shall be capable of communicating with the MODBUS protocol.

The CPU module shall be a Motorola Series 300, or approved equal.

The Mixed I/O module shall include 8 isolated digital inputs, 2 analog inputs and 4 digital outputs. The module shall contain LED diagnostics.

The RTU shall be capable of dual power supplies. AC power and minimum 30-minute rechargeable batteries. The batteries shall be recharged from the AC power supply. Batteries shall not have a memory. RAM shall have a separate battery for a four-day duration.

The RTU shall be grounded to the ground rod with #6 copper wire.

STATUS INPUT - The equipment shall be protected against voltage surges on all inputs. The equipment shall meet the IEEE surge withstand test without sustaining permanent damage. No relays or other electromechanical devices are acceptable. Optical isolation is required on all inputs.

Contractor shall coordinate the electrical and SCADA supplies to determine dry contacts required and installed for proper monitoring of the system.

CABINETS - The RTU shall be inside a NEMA 4 enclosure located next to the lift station's motor control center. The cabinet shall be constructed of a minimum thickness of 14-gauge stainless steel with the door being at least 12-gauge stainless steel.

Terminal blocks shall be supplied to which the inputs and outputs may be wired. The status and control terminal blocks shall be capable of accepting wire up to size 12 AWG, when terminated with solderless insulated lugs. The blocks use nickel-plated brass screws or other non-corrosive equivalents.

The AC power to the RTU enclosure shall be switched and an appropriate size circuit breaker shall be provided in the RTU cabinet. A 110 VAC duplex outlet shall be provided in the enclosure to provide AC power for test equipment. The cabinet shall be lockable (4 keys provided to the City) and be provided with an intrusion alarm connected to the SCADA system.

SECURITY - To minimize the chance of false operation or failure of the equipment, the equipment proposed shall have as a minimum the following features:

The RTU shall verify the correctness of the communication message before activating outputs. Control outputs shall be controlled by relay ladder logic such that the supervisory control command acts as a permissive contact and does not directly energize the output so as to avoid bypassing equipment protection logic.

Message security shall be ensured by use of a security code for all information transfers between the station and master computer.

No false commands shall be generated during power off/recycle start in the RTU.

SERVICE - Services of a factory-trained service man shall be provided for start-up of all equipment. During this start-up period, it will be the Contractor's responsibility to demonstrate to the satisfaction of the City Engineer that all performance requirements of the specifications regarding range, accuracy, response speed, etc., have been met.

All data and signals shall be fed to the central computer. The proposed monitoring and control system addition shall be capable of being operated from the computer at Cedar Hill Service Center during this time.

SYSTEM COMPATIBILITY - Contractor shall be responsible to make the entire proposed systems compatible and operational. Contractor shall provide and install all necessary electricity, connections, etc. Contractor shall make the necessary software modifications at the Cedar Hill Service Center and bring the proposed lift station on-line to the computers.

ENCLOSURES - The RTU enclosure shall contain the following minimum equipment that shall be located in the NEMA 4 RTU cabinet:

Item	Manufacturer	Part No.
Radio	Motorola	Darcom 900
Batteries	Motorola	FRN 4666A
3-Slot Rack	Motorola	F 6974+V214
Power Supply	Motorola	FPN 5522
CPU Series 3000	Motorola	V426
Mixed I/O	Motorola	V245
Relays	IDEC	
Terminal Block	Entrelec	
Poly Phaser	Polyphaser	
Duplex Receptacle	Hubbel	CP-151
Tubular Light & Switch		

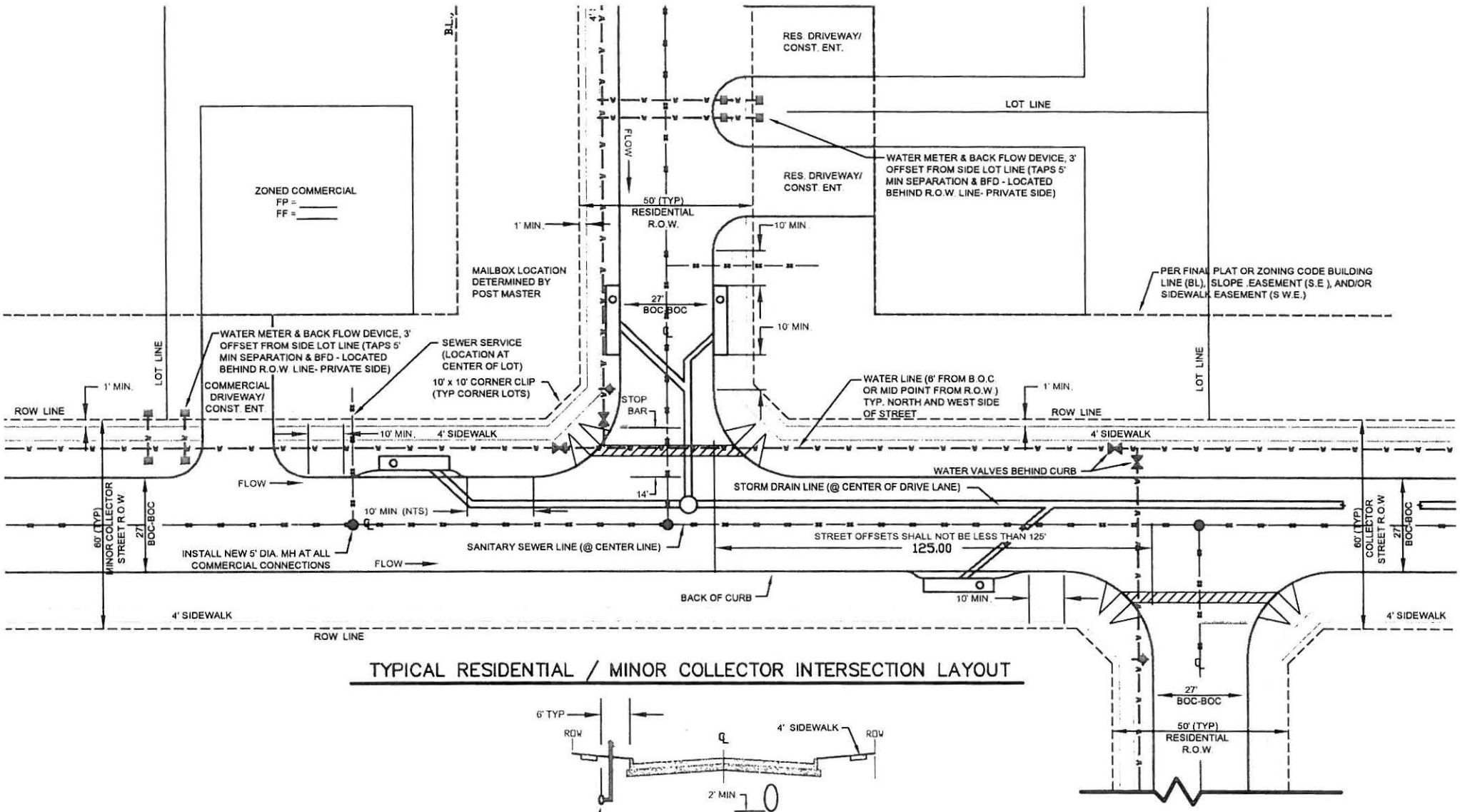
WATER PRESSURE STATION - Each lift station site shall include a potable water pressure station. This shall consist of taping into the City's distribution line and furnishing and installing an electronic pressure transmitter. The transmitter shall be a Foxboro 841 GMCI 1 0-300 psig, liquid fill, 1/2-inch NPT, 4-20mA mounted in a NEMA 4X enclosed mounted to a pipe. The pressure transmitter station shall have the ability to be valved off from the City's distribution system.

The signal from the pressure transmitter shall be connected to the RTU and the pressure read at the master computer located at the City's service center.

CONDUIT RUNS - Minimum conduit size shall be 3/4-inches and be watertight. All splices shall occur in junction boxes. All conduits shall be securely attached. All conduit underground shall be Schedule 40 PVC. All conduits above ground shall be rigid, hot dipped galvanized. All conduits entering the SCADA enclosure shall be sealed to prevent gases from entering the RTU enclosure.

MANUFACTURER'S WARRANTY - The manufacturer of the lift station shall guarantee, for a period of one year from the date of City acceptance, that the structure and all equipment shall be free from defects in design, materials and workmanship. The manufacturer shall furnish parts, at no cost to Owner or City, for any component proven defective during the warranty period except those items that are normally consumed in service.

SCADA CONTRACTOR QUALIFICATIONS - The SCADA Contractor shall have completed a minimum of ten municipal SCADA systems in the past five years. The SCADA Contractor shall have a service facility within 100-miles of Cedar Hill that has been in continuous operation for five years.



TYPICAL RESIDENTIAL / MINOR COLLECTOR INTERSECTION LAYOUT

TYPICAL UTILITY LOCATIONS WITHIN R.O.W.

FIGURE A

CITY OF CEDAR HILL
DEPARTMENT OF PUBLIC WORKS

DIVISION 800 MISCELLANEOUS CONSTRUCTION AND MATERIALS

800.01 Street Lighting

Lighting standards for streetscapes and public places shall adhere to the City's Zoning Ordinance Sections 3.13, 3.14.5 and 5.6. In addition, Subdivision Ordinance Section 20:22(e) describes street light regulations for subdivisions. Construction plans shall show and label both adjacent existing and proposed street light locations.

The following table summarizes the design guidelines for street lighting. Requests for lighting levels above the guidelines listed in this table will require cost participation in an amount equal to the cost incurred by the City for lighting that exceeds the standard.

Alternate street lighting design must be approved by the Public Works Director.

Any pedestrian lighting design must be approved by the Public Works Director.

STANDARD DESIGN GUIDELINES FOR STREET LIGHTING

STREET TYPE, WIDTH	LIGHT SOURCE	NOMINAL LAMP SIZE	SPACING (FEET)	POLE STYLE, CONFIGURATION
27' RESIDENTIAL	HPS	100 WATTS TO 150 WATTS	400 TO 550	EXISTING UTILITY POLE, STEEL OR FIBERGLASS POLE
37' COLLECTOR	HPS	150 WATTS TO 200 WATTS	200 TO 300	EXISTING UTILITY POLE, STEEL OR FIBERGLASS POLE
MINOR ARTERIAL THOROUGHFARE TWO-24 FT. LANES DIVIDED	HPS	150 WATTS TO 200 WATTS	220 TO 280	TWIN LUMINAIRES ON SINGLE STEELPOLE IN MEDIAN
PRINCIPAL ARTERIAL THOROUGHFARE TWO-36 FT. LANES DIVIDED	HPS	150 WATTS TO 250 WATTS	175 TO 280	TWIN LUMINAIRES ON SINGLE STEELPOLE IN MEDIAN

HPS = HIGH PRESSURE SODIUM

DIVISION 900 - DRAINAGE

901.01 INTRODUCTION

This design manual provides guidelines for design of storm drainage facilities in the City of Cedar Hill. The procedures outlined herein shall be followed for all drainage design and review of plans submitted to the City.

This division concerns itself with storm drainage conditions which are generally relative to the City of Cedar Hill and the immediate geographical area. Accepted engineering principles are applied to these situations in the City of Cedar Hill's documented procedures.

901.02 APPLICATION

Drainage systems, including all conveyances, inlets, conduits, structures, basins, or outlets used to drain storm water must be designed and constructed to promote the health, safety, and welfare of the property owners and the public. Adequate provisions must be made for the acceptance, collection, conveyance, detention, and discharge of storm water runoff drainage onto, through, and originating within the area and areas being developed.

901.03 PLATTING/DEDICATION OF WATER COURSE AND BASINS

Property developments containing Floodway Easements, Detention/Retention Easements, or Drainage Easements shall have on the plat standard language addressing the easements and on-ground monumentation. Fill or development is prohibited in designated or undesignated 100-year floodplain areas except as already allowed under the floodplain fill/permit process.

a. Floodway Easements: Flooding easements are generally to be used for open waterways in non-residential areas. The floodway easements will be maintained by the property owner.
b. Floodway Common Areas: Floodway common areas are generally to be used for open waterways in residential areas and are owned and maintained by a neighborhood association.
c. Public Drainage Systems: Public drainage systems are those which contain public runoff. Public storm water drainage systems must be designed and constructed in strict conformance with Department of Public Works Standards.
d. Private Drainage Systems: Private drainage systems are those which serve more than one lot or tract, or any open system that serves more than one lot or tract for which a private entity has ownership and maintenance obligations. Private storm water drainage systems must be designed and constructed in general conformance with design standards of the Department of Public Works as set forth in this design manual.
e. Drainage Easements: A drainage easement is used for a manhole, drainage channel, storm drain pipe or a drainage structure in an area not owned by the City but maintained by the City. In commercial/industrial areas, open channels may be retained in Floodway easements. Drainage and floodway easements shall be provided for all open channels. Drainage and floodway easements for storm sewer pipe shall not be less than 15 feet, and easement width for open or lined channels shall be at least 30 feet wider than the top of the channel, 15 feet of which shall be on one side to serve as an access for maintenance purposes.
f. Detention/Retention Area Easements: Detention/Retention basins shall be maintained in Detention/Retention Area Easements. Detention/Retention basins constructed through private development activities shall be maintained by the property owner or neighborhood association. Detention/Retention basins constructed for the City shall be maintained by City forces.

g. Access Easement: All Floodway Easements, Detention/Retention Easements, and Drainage Easements shall include provisions for adequate maintenance such as dedicated and maintained Access Easements. These shall be sufficient to provide ingress and egress for maintenance. Access Easements are needed only when the area to be maintained does not border a public right-of-way

902.01 FLOODPLAIN DESIGNATION

Floodplain means any land area susceptible to inundation by design flood. A floodplain designation is not a zoning classification but refers to a specific area subject to flooding. When this designation is noted by an "FP" prefix on the official FEMA map, the area designated is referred to as a floodplain area. Floodplain areas include those identified as areas of special flood hazards by FEMA in the 2001 (or most current) flood insurance study for the City of Cedar Hill, Texas.

902.02 FLOODPLAIN ALTERATIONS

The addition to or removal from an official FEMA map of an FP prefix must be initiated in the following ways:

a. An owner of property located within a floodplain area may apply for the review of a floodplain designation based upon evidence of a mapping error provided by the owner.
b. The Director of Public Works may on his own initiative review the status of a floodplain designation.
c. An owner of property located within a floodplain area may apply for a fill permit and removal of the floodplain prefix by following the following procedure. There shall be no deposits or store any fill, place any structure, excavate, grade, or engage in any other development activity(ies) in a floodplain area without securing a fill permit from the Public Works Department and adhere to all other applicable permits required by county, state, and/or federal agencies.

902.03 FLOODPLAIN ALTERATION PERMIT OR FILL PERMIT

Fill permit for a Floodplain designation may be processed either by obtaining a "Floodplain Fill or Grading Permit". The Director of Public Works may issue a floodplain alteration permit if he determines that the alteration does not remove a floodplain designation and the alteration complies with all applicable engineering practices. Examples where floodplain alteration permits are applicable include construction of a tennis court, a driveway, a playground, a swimming pool, a fence, a deck, an erosion control wall, or the installation of some landscaping.

902.04 FLOODPLAIN FILL PERMIT PROCESS

An applicant for a fill permit shall submit an application (found in Appendix C) signed by all owners of the property to the Director of Public Works for approval. Subsequently, the applicant must request a pre-application conference with the representatives from the Department of Public Works. In this pre-application conference the Director of Public Works will determine what information is necessary for a complete evaluation of the proposed fill project, including but not limited to the following:

- A vicinity map
- The acreage figures for the entire tract, the area located in the floodplain, and the area proposed to be filled
- A description of existing and proposed hydraulic and hydrologic analysis conducted
- A landscaping and erosion control plan. The landscaping plan must comply with the Landscaping and Tree Preservation regulations for the City of Cedar Hill
- A table of values for analysis of the engineering requirements criteria for filling
- A water surface profile based on fully developed conditions
- A plan view showing existing and proposed contours and grading

- Plotted cross sections
- An overall map of the project
- Environmental impacts of the project, including the property's ecological, scenic, historic, or recreational value

902.05 ENGINEERING REQUIREMENTS FOR FILLING IN A FLOODPLAIN

Except for detention/retention basins, alterations in the floodplain area may not increase the water surface elevation of the design flood of the creek upstream, downstream, or through the project area. Detention/Retention basins may increase the water surface elevation of the design flood provided the increase is within the detention/retention basin's boundary(ies). The alteration of the floodplain area shall not create or increase an erosive water velocity on or off-site. The mean velocity of stream flow at the downstream end of the site after fill shall not exceed the mean velocity of the stream flow under existing conditions. Further, the effects of the existing and proposed public and private improvements will be used to determine the water surface elevation and velocities. Furthermore, no loss of valley storage is allowed along a stream.

902.06 LETTER OF MAP REVISION (LOMR)

A letter of map revision must be obtained from FEMA before a floodplain prefix is removed from the official FEMA map. A building permit may be issued for construction of underground utilities if a conditional letter of map revision (CLOMR) is obtained. However, no building permit for construction of a structure may be issued until a final letter of map revisions (LOMR) is obtained.

902.07 PROCEDURE FOR FILLING IN A FLOODPLAIN

Fill and development of floodplains which is not unreasonably damaging to the environment is permitted where it will not create other flood problems. Following are the general engineering criteria for fill requested. For more detailed information regarding "Fill Permit Procedure", please refer to 902.04.

a. Alterations of the floodplain shall result in no increase in water surface elevation on other properties. No alteration of the channel or adjacent floodplain will be permitted which could result in any degree of increased flooding to other properties, adjacent, upstream, or downstream. Alterations which could result in an increase in the flood elevation will require a letter of map revision (LOMR) from FEMA.

b. Alterations of the floodplain shall not create an erosive water velocity on or off site. The mean velocity of stream flow at the downstream end of the site after fill shall be no greater than the mean velocity of the stream flow under existing conditions. No alteration to the floodplain will be permitted which would increase velocities of flood waters to the extent that significant erosion of floodplain soils will occur either on the subject property or on other property up or downstream. Soil erosion results in loss of existing vegetation as well as augments destructive sedimentation downstream. Eventual public costs in channel improvements and maintenance (such as removal of debris and dredging of lakes) can be expected as a result. Staff's determination of what constitutes an "erosive" velocity will be based on analysis of the surface material and permissible velocities for specific cross-sections affected by the proposed alteration, using standard engineering tables as a general guide.

c. Alterations of the floodplain shall be permitted only to the extent permitted by equal conveyance on both sides of the natural channel. Staff's calculation of the impact of the proposed alteration will be based on the "equal conveyance" principle in order to insure equitable treatment for all property owners. Under equal conveyance, if the City allows a change in the flood carrying capacity (capacity to carry a particular volume of water per unit of time) on one side of the creek due to a proposed alteration of the floodplain, it must also allow an equal change to the owner on the other side. The combined change

in flood carrying capacity, due to the proposed alteration plus a corresponding alteration to the other side of the creek, may not cause either an increase in flood elevation or an erosive velocity (Criteria "a" and "b" above) or violate the other criteria. Conveyance is mathematically expressed as $KD = 1.486/n\ AR^{2/3}$ where n = Manning's friction factor, A = cross sectional area, and R = hydraulic radius.

d. The proposed grading for the fill slope shall parallel the natural channel to prevent an unbalancing of stream flow in the altered floodplain. If the alignment of the proposed fill slope departs from the contours of the natural floodplain, the flow characteristics of the flood waters may be altered, causing possible damaging erosion and deposition in the altered floodplain. If the fill slope follows the natural channel, it will also tend to minimize the visual impact of the alteration.

e. To insure maximum accessibility to the floodplain for maintenance and to lessen the probability of slope erosion during periods of high water, maximum slopes of filled area shall usually not exceed 4 to 1. Vertical walls, terracing and other slope treatments will be considered only as a part of a landscaping plan submission and complies with Criteria "d" above. The purpose of the slope restrictions are to maintain stability and prevent erosion of the slopes, to ease maintenance (e.g. mowing) on the slopes themselves, and to provide accessibility to the areas below the slopes. As a result of being more frequently inundated and subject to erosion, cut slopes must be shallower than fill slopes.

f. Landscaping plan submission shall include plans for erosion control of cut and fill slopes, restoration of excavated areas, and tree protection where possible in and below fill area. Landscaping should incorporate natural materials (earth, stone, wood) on cut or fill slopes wherever possible. Applicant should show in plan the general nature and extent of existing vegetation on the tract, and which areas will be preserved, altered, or removed as a result of the proposed alterations. Locations and construction details should be provided showing how trees will be preserved in areas which will be altered by filling or paving within the drip line of those trees. Applicant should also submit plans showing location, type, and size of new plant materials and other landscape features planned for altered floodplain areas.

g. Erosion control plans should demonstrate how the developer intends to minimize soil erosion and sedimentation from his site during and after the fill operation. Plans should include a timing schedule showing anticipated starting and completion dates for each step of the proposed operation. Area and time of exposed soils should be minimized, and existing vegetation should be retained and protected wherever feasible. Disturbed areas should be sodded or covered with mulch and/or temporary vegetation as quickly as possible. Structural measures (e.g. drop structures, sediment ponds, etc.) should be utilized where necessary for effective erosion control, but measures should also minimize structures and materials which detract from the natural appearance of the floodplain.

902.08 FILLING IN A 100 YEAR FLOODPLAIN FRINGE

Filling in an area shown on the FEMA maps as being in the 100 year floodplain requires a permit and shall conform to the Flood Damage Prevention and Control Ordinance (refer to 902.04 and 902.05).

902.09 FILLING OPERATION

If a fill permit is approved by the Director of Public Works the filling operations must comply with the following requirements:

a. Building pad sites must be filled to an elevation of at least 1.5 feet above the 100-year flood elevation. The lowest floor of any structure must be constructed at least two (2) feet above the 100-year flood elevation. Fill material must consist of natural material

including but not limited to soil, rock, gravel, or broken concrete. Decomposable matter, including but not limited to lumber, sheetrock, trees, tires, refuse, or hazardous toxic matter is prohibited as fill material.

b. Fill must be compacted to 95% standard proctor density at a moisture water content of +/- 3% of the optimum moisture water content.
c. Storm water pollution prevention plan (SWP3) must also be submitted to the Public Works Department for review, approval, and implementation. If compliance with a National Pollutant Discharge Elimination System (NPDES) permit is required for construction activities, a copy of the Notice of Intent (NOI) or the individual NPDE permit must be submitted to the Director of Public Works prior to the filling operation.
d. Fill should be placed no more than five feet above the design flood elevation except where necessary to match the existing elevation of the adjacent property as determined by the Director of Public Works. In determining when it is necessary to match the existing elevation, the Director of Public Works must consider the effects on local drainage and storm water management, the access needs of the property, and other public health and safety concerns.
e. A copy of the approved fill permit must be posted and maintained at the fill site for inspection purposes until fill operations have been completed.
f. After the completion of the fill operation, the applicant's engineer shall submit a certification to the Director of Public Works that proper fill materials have been used, the proper fill elevations have been obtained, and the compaction requirements and all other specifications have been adhered to. If applicable, the applicant must also submit a copy of the letter of map revision (LOMR) issued by FEMA.

902.10 PARKING AREAS IN THE FLOODPLAIN

All surface parking spaces must be constructed at a minimum elevation of two-feet above the 100-year flood elevation. Regarding underground parking garages, the entrance elevation and any other openings on underground parking garages constructed within or adjacent to the flood prone area may not be lower than two-feet above the 100-year flood elevation.

902.11 PARKING LOT DISCHARGE

The storm water runoff generated from a paved parking area and roof structures shall not discharge more than 5 cfs at one driveway location into a street or roadway. Excess runoff shall be directed to an existing or proposed underground drainage system or controlled to not exceed the 5 cfs limit to one single driveway entrance. Velocities at the driveway entrance shall not be excessive in order to prevent runoff crossing the center of the road.

902.12 PARKING LOT DRAINAGE

As part of the design of parking lots, special attention shall be given to the drainage. If the 100-year storm drainage runoff of a parking lot exceeds the 100-year curb capacity of the street, provided that one lane has to stay dry at all times, then an underground storm drainage system must be designed in accordance with the drainage criteria as part of the parking lot.

902.13 MINIMUM LOT AND FLOOR ELEVATIONS:

Minimum lot and floor elevations shall be established as follows:

a. Lots abutting a natural or excavated channel shall have a minimum finish floor elevation for the buildable area of the lot at least two (2) feet higher at the highest elevation of the drainage floodway easement described in 901.03.
b. Any habitable structure on property in or abutting a floodplain shall conform to the Flood Damage Prevention & Control Ordinance.
c. For areas in the Lake Ridge Subdivision or lots with excessively steep grades shall adhere to City Standard Details and City Ordinance #2009-376,R401.3 (regulation for building standards, drainage) Typically, where lots do not abut a natural or excavated channel, minimum floor elevations shall be a minimum of one (1) foot above the street

curb or edge of alley, whichever is lower, unless otherwise approved by the Public Works Director.

903.1 LOT-TO-LOT DRAINAGE

For all new developments, each lot must be drained to an abutting street or alley unless the Director of Public Works determines that drainage to a street or alley is infeasible. If the Director of Public Works makes this determination, the drainage may be provided as follows:

a. If no more than the rear 15-feet of a lot drain toward the rear lot line, a well-pronounced swale must be provided as approved by the Director of Public Works.
b. If more than the rear 15-feet of a lot drains toward the rear lot line, a paved invert in a common area or private drainage easement is required. In order to accommodate the 100-year storm, an enclosed, private, drainage system with inlets may be designed within the private drainage easement. The private drainage easement(s) must be obtained from downstream property owners, executed and filed. Further, the recording information must be reflected on the final plat.

904.01 DETENTION/RETENTION

Regardless of the size of the area being developed, the proposed development must account for and provide the means to control the increased storm water runoff. The inflow and discharge flow calculations shall be based on the 100-year storm frequency and fully developed conditions. Detention/Retention shall be provided in the following instances:

- The property/tract for a non-residential development is larger than two acres.
- Any size development where adverse impacts to downstream property are evident or potentially will take place after development.
- Any size development where the existing downstream drainage structures or systems do not have adequate capacity for the total flow based on 100-year frequency runoff and fully developed conditions, unless the downstream drainage is upgraded to convey the 100-year storm frequency at fully developed conditions.

The design engineer shall consider and verify in writing the downstream impacts and the capacity for the existing downstream drainage systems. For developments less than two acres, the engineer can either upgrade the downstream constraints or detain the excess storm water; the difference of flow based on existing conditions and fully developed conditions.

904.02 DETENTION PONDS

For any development other than single-family development where the tract of land for the development is larger than two acres, detention/retention shall be required based on the following criteria:

- If the downstream drainage system does not have the capacity to convey the 100-year frequency storm water runoff based on fully developed conditions; then the detention pond must be designed to accommodate the difference between the following flows:
  - 100-year frequency storm water runoff calculated based on fully developed conditions, and
  - Storm water runoff calculated based on existing conditions
- If the downstream drainage system has the capacity to convey the 100-year frequency storm water runoff based on fully developed conditions, then the detention pond must be designed to accommodate the difference between the following flows:
  - 100-year frequency storm water runoff calculated based on fully developed conditions, and
  - Storm water runoff calculated based on single-family development with a runoff capacity of C=0.6

For commercial developments above ground detention basins will not be allowed in parking lots. However, underground detention basins will be allowed in parking lots. Such design must be approved by the Public Works Director.

Inflow volumes shall be calculated for the 2 and 100 year storm frequencies. For areas less than 600 acres a form of the Rational Method will be acceptable, while for area 600 acres and larger an inflow hydrograph graph will be required. See Table 1 for C factors.

Any type of pond design shall be designed with a freeboard not less than 1.0 foot. The maximum allowable head water must be kept within the range of slope stability of the embankment construction. All design calculations including storage capacity, discharge and elevation at 1 foot intervals are a calculation table and the detention calculation table shall be a part of the construction plans.

A stage detention/retention for the 100-year frequency storm with a minimum of dual outlet control structure is required for 2-year and 100-year storms. Dual outlet design provides control of peak rates for more frequent storms, thus reducing chances of flooding and erosion downstream. Furthermore, the outlet design must accommodate the design of an emergency spillway. An outlet control structure such as an orifice or weir placed at the inlet end of the outfall pipe is to provide an integrated stage-discharge such that a wide range of storms can be effectively controlled. Perforated riser pipes, weirs and special outlet control boxes are acceptable. Pipe/culvert type outlet control will only be allowed with approval from the City. All vertical structures shall have anti-vortex and trash rack devices. Emergency overflow structures and paved positive overflow channels shall be included with the design of detention systems.

Whenever possible, detention ponds shall fit in the natural contour of the land, be aesthetically pleasing and be free draining. A grading plan with one-foot intervals shall be placed on the construction plans. Maintenance access shall be provided for each pond. The bottom slope shall be a minimum of 2% towards the outfall structure. Detention basins shall be designed with short and long term erosion control.

A detention system maintenance program shall be prepared and submitted to the City for approval before final acceptance of the construction plans.

904.03 REGIONAL DETENTION

If regional detention/retention is already designed and constructed, a local detention/retention may not be required unless the downstream drainage system is not adequate to convey the 100-year frequency storm.

904.04 EROSION CONTROL/DOWNSTREAM ASSESSMENT

As part of the site plan development, the downstream impacts of the development must be carefully evaluated. The purpose of the downstream assessment is to protect downstream properties from increased flooding and downstream channel from increased erosion potential due to upstream development. The "Lake Ridge Erosion Guidelines" which were developed in 2009 and addresses the erosion concerns must be utilized to perform the downstream assessment. As part of this assessment, the peak discharges and velocities for at least the following two 24-hour conveyance storm events must be evaluated for stream bank protection and two capacity requirements for a 2-year event and a 100-year event.

These peak discharges and velocities must be in accordance with the requirements of "Lake Ridge Erosion Guidelines". Further, the principles of these guidelines must also be used for any proposed permanent erosion control measures for open channels and bends along the creeks as well as bar ditches.

905.01 DRAINAGE DESIGN CRITERIA AND PROCEDURES

This section contains storm drainage design criteria and demonstrates the design procedures to be employed on drainage projects in the City of Cedar Hill. Applicable forms which can be used for the design of various storm drainage facilities are contained in Section VI of this manual and shall be part of the drainage submittal to the City.

905.02 RAINFALL

In determining the estimated runoff from a special drainage area, it is necessary to predict the amount of rain which can be expected. FIGURE 1, RAINFALL INTENSITY AND DURATION, has been prepared to graphically illustrate anticipated rainfall intensity for storm duration from 5 minutes to six hours for selected return frequencies and shall be used for determining rainfall rates as required.

905.03 DESIGN STORM FREQUENCY

All the storm drainage facilities including alleys, streets, and roadways must be designed and constructed to safely drain a 100-year storm. All runoff calculations must be based upon a fully developed watershed and existing zoning. Storm water must be discharged in an acceptable form and at a controlled rate so as not to endanger human life or public or private property. Bridges and culverts shall be designed to carry the 100-year design frequency flow.

905.04 DETERMINATION OF DESIGN DISCHARGE

The Rational Method for computing storm water runoff is to be used for hydraulic design of facilities serving a drainage area of less than 600 acres. For drainage areas of more than 600 acres and less than 1200 acres, the runoff shall be calculated by both the Rational Method and the Unit Hydrograph Method with the larger of the two values being used for hydraulic design. For drainage areas larger than 1200 acres the runoff shall be calculated by the Unit Hydrograph Method.

In lieu of the Unit Hydrograph Method a HEC-HMS (Flood Hydrograph) Computer Analysis can be utilized. The City at its option can require the use of HEC-HMS Computer Analysis in lieu of the unit Hydrograph Method. The HEC-HMS Computer Program is available from the U.S. Army Corps of Engineers, the Hydrologic Engineering Center, 609 Second Street, Davis, California 95616, Phone: 530-756-1104.

A standard form, STORM WATER RUNOFF CALCULATIONS, FORM A, is to record the data used in various drainage area calculations. In general, this form will be used in calculation of runoff for design of open channels, culverts and bridges.

905.05 RUNOFF COEFFICIENTS AND TIME OF CONCENTRATION

Runoff coefficients, as shown in TABLE 1, shall be used, based on total development under existing land zoning regulations. Where land uses other than those listed in TABLE 1 are planned, a coefficient shall be developed utilizing values comparable to those shown.

Times of concentration shall be computed based on the minimum inlet times shown in TABLE 1. Where conditions obviously warrant a deviation from the minimum inlet times as shown, FIGURE 2 may be used.

905.06 GUTTER FLOW AND INLET LOCATION

Inlets shall be placed to ensure that the 100-year flow in a street does not exceed top-of-curb elevation and that encroachment into the travel way does not violate the following dry lane requirements:

a. Major or minor arterials must have one dry lane in each direction at all times.
b. If, in the judgment of the engineer, the flow in the gutter is still excessive, the storm drain shall be extended to a point where the gutter flow can be effectively intercepted by inlets. To minimize water drainage through an intersection, inlets shall be placed upgrade from

an intersection. Inlets should also be located in alleys upstream of an intersection and where necessary to prevent water from entering intersections in amounts exceeding allowed street capacity. Inlets at sag points require a minimum of 10-feet of opening. All the inlets along minor and principal arterials must be recessed inlets. The end of the recessed inlet box shall be at least 10-feet from a curb return or driveway; and the inlet shall be located to minimize interference with the use of adjacent property. Inlets shall not be located across from median openings where a drive may be added.

c. Grate type inlets or curb/grate combination inlets shall be avoided and will only be allowed if there is no other option. The design of grate type inlets must be approved by the Public Works Director. The minimum size of lateral line and less than 50' long pipe for inlets must be 18" in diameter.

FIGURE 3, CAPACITY OF TRIANGULAR GUTTERS, applies to all street widths having a straight cross slope varying from 1/8-inch per foot to 1/2-inch per foot which are the minimum and maximum allowable slopes. Cross slopes other than 1/4-inch per foot shall not be used without prior approval from the Public Works Director.

FIGURES 4 and 5, CAPACITY OF PARABOLIC GUTTERS, apply to streets with parabolic crowns.

905.07 INLET DESIGN

FIGURE 7, STORM DRAIN INLETS, is a tabulation for the various types and sizes of inlets and their prescribed uses.

The information in FIGURE 7 and the general requirements of beginning the storm drain conduit where the street gutter capacity is reached will furnish the information necessary to establish inlet locations.

FIGURES 8 through 22 shall be used to determine the capacity of specific inlets under various conditions.

In using the graphs for selection of inlet sizes, care must be taken where the gutter flow exceeds the capacity of the largest available inlet size. This is illustrated with the following example.

Known: Major Street,
Pavement Width = 24 Feet
Gutter Slope = 1.00%
Pavement Cross Slope = 1/4-inch/1 Foot
Gutter Flow = 11 cfs

Find: Length of Inlet Required (Li)

Solution: Refer to FIGURE 8
Enter Graph at cfs
Intersect Slope = 1.00%
Read Li = 16.9 Feet
DO NOT USE 14-FOOT INLET IN COMBINATION WITH 4-FOOT INLET
Enter Graph at Li = 14 Feet
Intersect Slope = 1.00%
Read Q = 8.8 cfs
Enter Graph at Li = 4
Intersect Slope = 1.00%
Read Q = 1.9 cfs
Therefore, the two inlets have a total capacity of 10.7 cfs which is less than the gutter flow of 11 cfs.

USE TRIAL AND ERROR SOLUTION
Try 12-Foot Inlet plus 6-Foot Inlet

Enter Graph at Li = 12 Feet
Intersect Slope = 1.00%
Read Q = 7.3 cfs
Enter Graph at Li = 6 Feet
Intersect Slope = 1.00%
Read Q = 3.1 cfs

The two inlets have a capacity of 10.4 cfs which is less than the gutter flow.

Try two 10-foot Inlets
Enter Graph at Li = 10 Feet
Intersect Slope = 1.00%
Read Q = 5.7

2 x 5.7 = 11.4 cfs capacity which is equal to the gutter flow.

USE EITHER TWO 10-FOOT INLETS OR OTHER SUITABLE COMBINATIONS; WHICHEVER WILL BEST FIT THE PHYSICAL CONDITIONS. CONSIDERATION SHOULD BE GIVEN TO ALTERNATE INLET LOCATIONS OR EXTENSION OF THE SYSTEM TO ALLEVIATE THE PROBLEM OF MULTIPLE INLETS AT A SINGLE LOCATION.

Provide a minimum10' curb inlet at each sag in the gutter. Inlets shall be sized to intercept all flow in the approaching gutter. In cases where the selection of particular size inlet would result in intercepting in excess of 90% of the gutter flow, consideration may be given to such an inlet on a minor or secondary street.

In order that the design procedure for determining inlet locations and sizes may be facilitated, a standard form, INLET DESIGN CALCULATIONS, FORM B, has been included in the Section VIII together with an explanation of how to use the form.

905.08 STREET INTERSECTION DRAINAGE

The use of surface drainage to convey storm water across a street intersection is subject to the following criteria:

a. An arterial street shall not be crossed with surface drainage unless approved by the Public Works Director.
b. Wherever possible, a minor collector street shall not be crossed with surface drainage.
c. Wherever possible, a collector street shall not be crossed with surface drainage in excess of 8 cfs.
d. At any intersection, only one street shall be crossed with surface drainage and this shall be the lower classified street.

905.09 ALLEY CAPACITIES

FIGURE 6 is a nomograph to allow determination for the storm drain capacity of various standard alley sections. In residential areas where the standard 10-foot wide alley section capacity is exceeded, a wider alley may be used to provide storm drain capacity.

As can be seen on FIGURE 6, the 20-foot wide alley section has the largest storm drain capacity. Curbs shall not be added to alleys to increase the capacity unless approved by the Public Works Director. Where a particular width alley is required, such as a 12-foot width, a wider alley, such as a 16-foot width, may be required for greater capacity. Approximate increases in right-of-way widths will be necessary. Alley capacities are calculated to allow the entire alley right-of-way to carry the flow, 2-1/2 inches above paving edge.

905.10 MANHOLE PLACEMENT

A manhole will be required where two or more pipes connect into a main at the same joint. A construction detail may be necessary at such locations. In cases where the diameter of the main line is at least twice as large as the diameter of the largest adjoining pipe, a manhole may not be required. The manholes must be 5' in diameter and must be provided at intervals of no greater than 500 feet. The design of the manholes shall be in accordance with the latest edition of NCTCOG Standard Specifications for Public Works Construction.

905.11 ENERGY DISSIPATERS

Energy dissipaters are used to eliminate the excess specific energy of flowing water. Effective energy dissipaters must be able to retard the flow of fast moving water without damaging the structure or the channel downstream of the structure. All energy dissipaters should be designed to facilitate maintenance. The design of outlet structures in or near parks or residential areas must be given special consideration to appearance. The City of Cedar Hill recognizes the Bureau of Reclamations publications on the "Hydraulic Design of Stilling Basins and Energy Dissipaters" as an acceptable reference for the design of energy dissipaters.

905.12 HYDRAULIC GRADIENT OF CONDUITS

A storm drainage conduit must have sufficient capacity to discharge a design storm with a minimum of interruption and inconvenience to the public using streets and thoroughfares. The size of the conduit is determined by accumulating runoff from contributing inlets and calculating the slope of a hydraulic gradient from Manning's Equation:

$$S = [(Qn)/(1.486\ AR^{2/3})]^2$$

Beginning at the upper most inlet on the system a tentative hydraulic gradient for the selected conduit size is plotted approximately 2 feet below the gutter between each contributing inlet to insure that the selected conduit will carry the design flow at an elevation below the gutter profile. As the conduit size is selected and the tentative hydraulic gradient is plotted between each inlet pickup point, a head loss due to a change in velocity and pipe size must be incorporated in the gradient profile.
Also at each point where an inlet lateral enters the main conduit the gradient must be sufficiently low to allow the hydraulic gradient in the inlet to be below the gutter grade.

At the discharge end of the conduit (generally a creek or stream) the hydraulic gradient of the creek for the design storm must coincide with the gradient of the storm drainage conduit and an adjustment is usually required in the tentative conduit gradient and, necessarily, the initial pipe selection could also change. The hydraulic gradient of the creek or stream for the design storm can be calculated by use of the HEC-2 Computer Program.

Concrete pipe conduit shall be used to carry the storm water, a flow chart, Figure 23, based on Manning's Equation may be used to determine the various hydraulic elements including the pipe size, the hydraulic gradient and the velocity. Special hydraulic calculators are also available for solution of Manning's Equation.

With the hydraulic gradient established, considerable latitude is available for establishment of the conduit flow line. The inside top of the conduit must be at or below the hydraulic gradient thus allowing the conduit to be lowered where necessary. The hydraulic gradient for the storm sewer line and associated laterals shall be plotted directly on the construction plan profile worksheet and adjusted as necessary.

There will be hydraulic conditions which cause the conduits to flow partially full and where this occurs, the hydraulic gradient should be shown at the inside crown (soffit) of the conduit. This procedure will provide a means for conservatively selecting a conduit size which will carry the flood discharge.

905.13 VELOCITY IN CLOSED CONDUITS

TABLE 3 is a tabulation of minimum pipe grades which will produce a velocity of not less than 2.5 fps when flowing full. Grades less than those shown will not be allowed. Only those pipe sizes shown in TABLE 3 should be used in designing concrete pipe storm sewer systems.

TABLE 4 shows the maximum allowable velocities in closed conduits.

905.14 ROUGHNESS COEFFICIENTS FOR CONDUITS

Recommended values for the roughness coefficient "n" are tabulated in TABLE 5. Where engineering judgment indicates values other than those shown should be used, special note of this variance should be taken and the appropriate adjustments made in the calculations.

905.15 MINOR HEAD LOSSES

The values of Kj to be used are tabulated for various conditions in TABLE 6. In designing storm sewer systems, the head losses which occur at points of turbulence shall be computed and reflected in the profile of the hydraulic gradient.

905.16 PROCEDURE FOR HYDRAULIC DESIGN OF CLOSED CONDUITS

STORM SEWER CALCULATIONS, FORM C, has been included in Section 911.01 (List of Forms), together with explanation for its use to facilitate the hydraulic design of a storm sewer.

906.01 CRITERIA FOR CHANNELS, BRIDGES AND CULVERTS

Discharge flows and water surface elevations shall be based on 100 year storm event and applicable free board.

a. Flood Insurance Study, Federal Emergency Management Agency (FEMA), 100-year Design Flood. Water surface elevations shall not exceed an elevation that is two (2) feet below building finish floor elevations; bottom of girders or stringers of bridges; or gutter elevations in streets at culverts. Flows at points not shown in the Flood Insurance Study can be determined by a proration based on the area drained. (See Figure 24)

b. Design storm frequency of 100 years, calculated by the City's design criteria. Water surface elevations shall not exceed an elevation that is above any of those listed in (1) above. Where a unit hydrograph is used to determine the design flows, Coefficients for "Ct" and "Cp640" should be as shown in Table 2.

906.02 OPEN CHANNELS

Open channels are to be used to convey storm waters where closed conduits are not justified. Consideration must be given to such factors as relative location to streets, schools, parks and other areas subject to frequent pedestrian use as well as basic economics.

Where a recommended side slope and a maximum side slope are shown on a channel section, the recommended slope shall be used unless prior approval has been obtained from the City of Cedar Hill or soil conditions required a flatter slope.

The most efficient cross section of an open channel, from a hydraulic standpoint, is the one which, with a given slope, area and roughness coefficient, will have the maximum capacity. This cross section is the one having the smallest wetted perimeter. There are usually practical obstacles to using cross sections of the greatest hydraulic efficiency, but the dimensions of such sections should be considered and adhered to as closely as conditions will allow.

Landscaping is intended to protect the channel right-of-way from erosion, as well as present an aesthetically pleasing view. In areas where erosion must be controlled, the Engineer shall include in his plans the type of grass and placement to be furnished. Full coverage of grass must be established prior to acceptance by the City.

Design water surface shall be as shown on Figure 24 and as outlined in 906.01. Floodway easements shall be provided as indicated in 901.03.

Special care must be taken at entrances to closed conduits, such as culverts, to provide for the headwater requirements. These calculations and the required explanations are included in 906.14, PROCEDURE FOR HYDRAULIC DESIGN OF CULVERTS.

On all channels the water surface elevations, which may be assumed as coincident with the hydraulic gradient, shall be calculated and shown on the construction plans. One exception to the water surface coinciding with the hydraulic gradient would be in supercritical flow which generally is not encountered in this geographical area. Designs utilizing supercritical flow should be discussed with the City of Cedar Hill in the preliminary stages of design.

Hydraulic calculations for Type I Channels Figure 24 shall be made as outlined on FORM "D". This procedure is applicable to a stream with an irregular channel and utilizes Bernoulli's Energy Equation to establish the water surface elevations at succeeding points along the channel.

Hydraulic calculations for Types II and III Channels shall be made as outlined on FORM "E". In general, the use of existing channels in their natural condition or with a minimum of improvement and with reasonable safety factors is encouraged.

906.03 TYPES OF CHANNELS

It is the intent of the City of Cedar Hill to promote "earthen channels" as shown on the standard drawings (Figure 24). The design, allowed velocities, construction, and the vegetative slope stabilization of all earthen channels must adhere to the "Lake Ridge Erosion Control Guidelines" dated November 2009. The use of concrete lining channels will only be allowed if an earthen channel proves to be impractical. The design and construction of any concrete lining channel must be approved by the Director of Public Works in advance.
The channels (earthen channels as well as concrete lining channels) must be designed based on 100-year flow and fully developed conditions and a free-board of 1-foot. Any exceptions to these guidelines regarding the open channel design must be approved in advance by the Director of Public Works.

FIGURE 24 illustrates the classifications and geometrics of various channel types which are to be used wherever possible.

Type I Channel is to be used when the development of land will allow. It is intended to be left as nearly as possible in its natural state with improvements primarily limited to those which will allow the safe conveyance of storm waters, minimize public health hazards and make the floodplain usable for recreation purposes. In some instances it may be desirable to remove undergrowth.

Type II Channel Figure 24 is an improved section recommended for use where larger storm flows are to be conveyed.

Type III Channel, Figure 24, is a concrete lined section to be used if approval has been obtained from the Public Works Director.

906.04 QUANTITY OF FLOW

In the design of open channels it is usually necessary that quantities of flow be estimated for several points along the channel. These are locations where recognized discharge points enter the channel and the flows are calculated as previously outlined under "Determination of Design Discharge."

906.05 CHANNEL ALIGNMENT AND GRADE

While it is recognized that channel alignments must necessarily be controlled primarily by existing topography and right-of-way, changes in alignment should be as gradual as possible. Whenever practicable, changes in alignment should be made in sections with flatter grades.

Normally, the grade of channels will be established by existing conditions, such as an existing channel at one end and a storm sewer at the other end. There are times, however, when the grade is subject to modification, especially between controlled points.

Whenever possible the grades should be sufficient to prevent sedimentation and should not be overly steep to cause excessive erosion.

For any given discharge and cross section of channel, there is always a slope just sufficient to maintain flow at critical depth. This is termed critical slope and a relatively large change in depth corresponds to relatively small changes in energy. Because of this instability, slopes at or near critical values should be avoided.

Maximum allowable velocities are shown in TABLE 7. When the normal available grade would cause velocities in excess of the maximums, plans shall include details for any special structures required to retard this flow.

906.06 ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

Roughness coefficients to be used in solving Manning's Equation are shown in TABLE 7, together with maximum allowable velocities.

906.07 PROCEDURE FOR WATER SURFACE PROFILE CALCULATION FOR UNIMPROVED CHANNELS

FORM "D" included in Section VIII, together with the explanation for its use, shall be used for calculating a profile of the water surface along an unimproved channel. The HEC-RAS Computer Program is an alternate method to the use of Form "D" and may be required by the City.

906.08 PROCEDURE FOR HYDRAULIC DESIGN OF OPEN CHANNELS

FORM "E", included in Section VIII, together with the explanation for its use, shall be used in the design for open channels. The HEC-RAS Computer Program is an alternate method to the use of Form "D" and may be required by the City.

906.09 HYDRAULIC DESIGN OF CULVERTS

The function of a culvert or bridge is to pass storm water from the upstream side of a roadway to the downstream side without submerging the roadway or causing excessive backwater which floods upstream property.

The Engineer shall keep head losses and velocities within reasonable limits while selecting the most economical structure. In general, this means selecting a structure which creates a headwater condition and has a maximum velocity of flow safely below the allowed maximums.

The vertical distance between the upstream design water surface and the roadway elevation should be maintained to provide a safety factor to protect against unusual clogging of the culvert and to provide a margin for future modifications in surrounding physical conditions. In general, a minimum of two feet shall be considered reasonable when the structure is designed to pass a design storm frequency of 100 years calculated by Cedar Hill's criteria. Unusual surrounding physical conditions may be cause for an increase in this requirement.

906.10 CULVERT HYDRAULICS

In the hydraulic design of culverts an investigation shall be made of four different operating conditions, all as shown on FORM "F". It is not necessary that the Engineer know prior to the actual calculations which condition of operation (Case I, II, III or IV) exists. The calculations will make this known.

Case I operation is a condition where the capacity of the culvert is controlled at the inlet with the upstream water level at or below the top of the culvert and the downstream water level below the top of the culvert.

Case II operation is also a condition where the capacity of the culvert is controlled at the inlet with the upstream water level above the top of the culvert with the downstream water level below the top of the culvert.

Case III operation is a condition where the capacity of the culvert is controlled at the outlet with the upstream and downstream water levels above the top of the culvert.

Case IV operation is a condition where the capacity of the culvert is controlled at the outlet with the upstream water level above the top of the culvert and the downstream water level equal to one of two levels to be calculated.

906.11 QUANTITY OF FLOW

The quantity of flow which the structure must convey shall be calculated in accordance with the Procedure for Determination of Design Discharge utilizing FORM "A".

906.12 HEADWALLS AND ENTRANCE CONDITIONS

Headwalls are used to protect the embankment from erosion and the culvert from displacement. The headwalls, with or without wingwalls and aprons, shall be constructed in accordance with the standard drawings as required by the physical conditions of the particular installation.

In general, straight headwalls should be used where the approach velocities in the channel are below 6 feet per second, where headwater pools are formed and where no downstream channel protection is required. Headwalls with wingwalls, downstream energy dissipaters and aprons should be used where the approach velocities are from 6 to 12 feet per second and downstream channel protection is desirable.

Special headwalls and wingwalls may be required where approach velocities are in excess of 12 to 15 feet per second. This requirement varies according to the axis of the approach velocity with respect to the culvert entrance.

A table of culvert entrance data is shown on FORM "F". The values of the entrance coefficient, Ke, are a combination of the effects of entrance and approach conditions. It is recognized that all possible conditions may not be tabulated, but an interpolation of values should be possible from the information shown. Where the term "round" entrance edge is used, it means a 6-inch radius on the exposed edge of the entrance.

906.13 CULVERT DISCHARGE VELOCITIES

Velocities in culverts should be limited to no more than 15 feet per second, but downstream conditions very likely will impose more stringent controls. Consideration must be given to the effect of high velocities and turbulence on the channel, adjoining property and embankment. TABLE 8 is a tabulation of maximum allowable velocities based on downstream channel conditions.

906.14 PROCEDURE FOR HYDRAULIC DESIGN OF CULVERTS

FORM "F", included in 911.00, together with the explanation for its use, shall be used for the hydraulic design of culverts.

906.15 HYDRAULIC DESIGN OF BRIDGES

Wherever possible the proposed bridge should be designed to span a channel section equal to the approaching channel section. If a reduction in channel section is desired this should be accomplished upstream of the bridge and appropriate adjustments made in the hydraulic gradient.

Wherever possible bridges should be constructed to cross channels at a 90 degree angle, which normally will result in the most economical construction. Wherever the bridge structure is skewed the bents should be constructed parallel to the flow of water. Values of Kb, head loss coefficient, normally will vary from 0.2 to 0.5 with the exact value to be determined by an appraisal of the particular hydraulic conditions associated with the specific project. With a minimum of constriction and change in velocity, a clear span bridge would have a minimum coefficient. This would increase for a multispan bridge, skewed or with piers not placed perpendicular to the flow. The Federal Highway Administration "Hydraulic of Bridge Waterways" should be used for determining the K coefficient.

In more complex bridge design such as long multiple spans and relief structures crossing an irregular channel section, the procedures outlined in the Texas Highway Department "Hydraulic Manual" or the Federal Highway Administration "Hydraulics of Bridge Waterways", should be utilized.

A distance of 2 feet between the maximum design water surface and the lowest point of the bridge stringers shall be maintained.

906.16 QUANTITY OF FLOW

The quantity of flow which the structure must convey shall be calculated in accordance with the Procedure for Determination of Design Discharge utilizing FORM "A". The HEC-1 Computer Program is an alternate method to the use of Form "A" and may be required by the City.

906.17 PROCEDURE FOR HYDRAULIC DESIGN OF BRIDGES

FORM "G", included in 911.01, together with the explanation for its use, shall be used for the hydraulic design of bridges.

The Engineer should investigate several different bridge configurations on each project to determine the most economical that can be constructed within the velocity limitations and other criteria included in this manual.

906.18 ROADWAY DITCH REQUIREMENTS

City Council approval is required for roadway ditches to be used in lieu of curb and gutter streets. When roadway ditches are used the standards below are required. If any of the below requirements cannot be achieved, an alternative to mitigate the problem shall be submitted by the engineer and is subject to the approval of the Public Works Director.

a. The ditch shall be less than 18 inches in depth.
b. The side slopes shall be 5:1.
c. Provisions for vegetation for erosion control on the side slopes and bottom shall be shown on the plans.
d. The ditch shall carry the 100 year storm. When the 100 year storm exceeds the capacity of the ditch the excess storm water shall be conveyed by closed conduits.
e. The maximum velocity of the water in the ditch shall be 3 feet per second.

907.01 SUSTAINABLE PUBLIC RIGHTS-OF-WAY DESIGN

Goal: Cedar Hill supports the design and development of public rights-of-way that not only meet the needs of today but do not compromise the ability of future generations to meet tomorrow's needs. Sustainable public rights-of-way shall include the following:

1. Improve air and water quality
2. Create pedestrian and bicycle friendly community
3. Provide safer, healthier neighborhoods
4. Improve performance and reduce costs
5. Promote economic development
6. Provide safe pedestrian and bike routes to schools, neighborhoods, government buildings and retail areas.

Policy: Design and development of public rights-of way that balance multiple uses, multiple modes of transportation, environmentally friendly, and cost effective to construct and maintain are encouraged and shall be given strong consideration. The City of Cedar Hill will consider and support appropriate modifications or variances to the City's adopted subdivision and design standards in support of the development of sustainable public rights-of way.

By way of example in certain instances/locations a roadway may be designed with rain gardens and bioswales along the side. Further, the median can also be utilized to treat storm water runoff by accommodating vegetated medians, and/or creating bioswales and/or rain gardens. These types of medians, with appropriate maintenance arrangements can add considerably to the appearance and aesthetics of the roadway, as well as allow a greater amount of pervious surface, filter water runoff and create green space allowing improved air quality.

Procedures: Sustainable rights-of-way shall be designed and constructed in accordance with "Sustainable Rights-of-Way" guidelines which are prepared by the North Central Texas Council of Governments (NCTCOG). These guidelines can be found at: http://www.nctcog.org/envir/SEEDevEx/pubworks/ROW/index.asp. All proposals for sustainable public right-of-way that do not comply with the City's adopted subdivision regulations or design manual shall be submitted along with plans and written request and supporting justification to the Director of Public Works. Subsequently, The Director of Public Works, upon careful review and evaluation of the proposal, based on appropriateness and cost effectiveness, shall submit the application and a report along with a recommendation to the City Council for consideration. The City Council will have final approval on any modification to the adopted Subdivision Regulations or Design Manual.

908.01 DEFINITION OF TERMS

Angle of Flare: Angle between direction of wingwall and centerline of culvert or storm drain outlet.

Conduit: Any closed device for conveying flowing water.

Control: The hydraulic characteristic which determined the stage-discharge relationship in a conduit.

Critical Flow: The state of flow for a given discharge at which the specific energy is a minimum with respect to the bottom of the conduit.

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

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

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

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

HEC-1: Computer Program to analyze a Flood Hydrograph. This program is available from the U. S. Army Corps of Engineers.

HEC-2: Computer Program to analyze a Water Surface Profile. This program is available from the U. S. Army Corps of Engineers.

Hydraulic Gradient: A line representing the pressure head available at any given point within the system.

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

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

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

Roadway Ditch: Roadway ditch refers to an open channel along the roadway.

Steady Flow: Constant discharge.

Surcharge: Height of water surface above the crown of a closed conduit at the upstream end.

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

Total Head Line (Energy Line): A line representing the energy in flowing water. It is plotted a distance above the profiles of the flow line of the conduit equal to the normal depth plus the normal velocity head plus the pressure head for conduits flowing under pressure.

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

Uniform Flow: A condition of flow in which the discharge, or quantity of water flowing per unit of time, and the velocity are constant. Flows will be at normal depth and can be computed by the Manning Equation.

Watershed: The area drained by a stream or drainage system.

908.02 DETENTION SYSTEM DEFINITIONS

Detention Storage: Detention storage facilities are generally designed to control short, high-intensity local storms, as these are the major cause of flooding on small streams. Detention storage serves to attenuate the peak flow by reducing the peak outfall to a rate less than the peak inflow which effectively lengthens the time base of the outfall hydrograph. The total volume of water discharged is the same; it is merely distributed over a long period of time. Discharge from detention storage facilities begins immediately at the start of the storm, and the facility is usually completely drained within a day.

Retention Storage: Retention storage refers to those facilities where storm water is collected

and stored during the flood event. The stored water is released after the flood event by means of controlled outlet works. Alternatively, the water may be allowed to infiltrate into the ground or evaporate. For maximum effectiveness, the water contained in the retention storage facility must be released or lost before the next flood event occurs. In some cases, it may be desirable to maintain a permanent pool within the retention area. Such a facility is termed wet storage.

Conveyance Storage: As storm water enters and flows in channels, floodplains, drains, and storm sewers, the flow is being storage in transient form and is termed conveyance storage. Conveyance storage is generally obtained by constructing low-velocity channels with large cross-sectional areas.

Upstream Storage: This storage occurs upstream of the design area to be protected. It is intended to contain runoff which originates upstream and beyond the area to be protected.

Within-Area Storage: This storage occurs in the area to be protected. It is intended to store runoff originating in and around the area to be protected. It is common for such storage to be provided at the development sites.

Downstream Storage: This is storage located downstream from the area to be protected. The general purpose of downstream storage is to manage storm flows from the area to be protected and to control any detrimental downstream effects from development in the protected area.

Rainfall Storage: Rainfall storage refers to the storage of water in the vicinity of the rainfall occurrence or before storm water accumulates significantly. This storage classification is similar to "within-area storage" as mentioned above.

Runoff Storage: Runoff storage refers to the storage of larger quantities of water which have accumulated significantly and have begun to flow in the drainage system. This storage classification is closely related to "upstream storage" and "downstream storage" as mentioned previously.

Driveway Storage: This storage method involves the construction of depressed section in the driveway such that runoff from the lot and/or roof may be routed and stored there. A properly designed outlet system will regulate the discharge of this runoff into the drainage system.

Cistern/Infiltration: A cistern or tank can be located within the property area to collect runoff from the lot and roof. If local subsurface soil properties and geologic conditions permit, the water can be infiltrated after the storm subsides.

Cistern/Irrigation: This method is identical to the "cistern/infiltration" method except that the option is provided for the water in the cistern to be used for an irrigation water supply or to be discharged into the storm sewer system.

Rooftop Storage: This storage method is most applicable to industrial, commercial, and apartment buildings with large flat roofs. Rooftop storage is often an economical and effective alternative. Since it is common for buildings to be designed for snow loads, it is possible to accommodate an equivalent depth of water without any structural changes. A six-inch depth of water is equivalent to 31.2 pounds per square foot, less than most snow load requirements in the northern United States and Canada.

Special roof drains with controlled outlet capacity are typically installed as an integral part of the rooftop storage method. With proper installation of such drains, peak runoff from roofs may be reduced by up to 90 percent.

An important consideration for the rooftop storage method would be to provide overflow

mechanisms to ensure that the structural capacity of the roof is not exceeded. An additional consideration would be the water tightness of the rooftop.

Parking Lot Storage: Above ground detention basins will not be allowed in parking lots. However, underground detention basins will be allowed in parking lots. Designs for underground detention basin must be approved by the Public Works Director.

On-Site Ponds: On-site ponds provide for the collected storm water to be released in a controlled manner by overflow weirs or orifices. When properly designed, on-site ponds can serve the hydraulic function while providing recreational and aesthetic benefits.

Slow-Flow Drainage Patterns: This storage method involves the design of conveyance systems with reduced grades to provide reduced flow velocities. The desired effect is to obtain temporary ponding and a form of transient storage. Slow flow drainage may be augmented by providing controls (e.g., weirs, checks) along channels to create a system of linear reservoirs. Use of such controls will provide temporary storage while allowing for a possible increase in infiltration.

Open Space Storage: Open spaces such as parks and recreation fields generally have a substantial area of grass covering and provide increased infiltration opportunities. Such open spaces produce only minimal quantities of runoff. Therefore, open spaces provide excellent opportunities for the temporary storage of storm runoff, provided the primary use of the open space is not altered. This is generally not a problem since recreation areas are seldom used during storm events.

Retention Reservoirs: Retention reservoirs located in a watershed catchment generally represent major storage facilities. They are most effective when located in valleys or recessed areas and should have the ability to regulate stream flow. Retention reservoirs maintain a permanent pool in the form of ponds or lakes. As such, they are well suited for water-oriented recreational features.

Detention Reservoirs: Detention reservoirs are generally located on streams and are frequently located above the reaches where there is a continuous flow. Since a permanent pool is not maintained, detention reservoirs do not provide opportunities for water-oriented recreation. However, they may be conveniently integrated into a park and open space plan.

Gravel Pits and Quarries: Gravel pits and quarries are located off-channel such that a side-channel spillway is necessary to intercept and direct the peak flow to the pit location. Outfall from such storage facilities must generally be pumped.

908.03 ABBREVIATION OF TERMS AND SYMBOLS

A	Drainage area in acres of tributary watershed. Cross-sectional area of gutter flow in square feet. Cross-sectional area of flow through conduit in square feet.
As	Sub-section area in square feet as used on unimproved channel calculations.
b	Bottom width of channel in feet.
c	Runoff Coefficient for use in Rational Formula representing the estimated ratio of runoff to rainfall which is dependent on the slope of the watershed, the land use and the character of soil.
C_o	Street crown height in feet.
C_t	A coefficient related to drainage basin characteristics and used in Unit Hydrograph calculations.

C_p640	coefficient related to drainage basin characteristics and used in Hydrograph calculations.
c.f.s.	Cubic feet per second.
d	Depth of flow in feet.
d_n	Normal depth of flow in conduit feet.
d_c	Critical depth of flow in conduit feet.
FL	Flow line.
f.p.s.	Feet per second.
g	Gravitational acceleration (32.2 feet per second per second)
H	Depth of flow in feet required to pass a given discharge.
h	Depth of flow in feet.
HW	Headwater elevation or depth above invert at storm drain entrance in feet.
h_o	Vertical distance from downstream culvert flow lien to the elevation from which H is measured, in feet.
h_f	Head loss due to friction in a length of conduit in feet.
h_j	Head loss at junction structures, inlets, manholes, etc., due to turbulence in feet.
h_v	Velocity head loss in feet.
I	Intensity, in inches per hour, for rainfall over an entire watershed.
K_b	Head loss coefficient at bridges.
K_e	Coefficient of entrance loss.
K_j	Coefficient for head loss at junctions, inlets and manholes.
L	Length of channel in miles measured along flow line.
L_{ca}	Length of stream in miles from design point to center of gravity of drainage area and used in Unit Hydrograph calculations.
L_i	Length of curb opening inlet in feet.
L_{is}	Initial and subsequent rainfall losses in inches and used in Unit Hydrograph calculations.
n	Coefficient of roughness for use in Manning's Equation.
P	Length in feet of contact between flowing water and the conduit measured on a cross section. (Wetted Perimeter)
Q	Storm water flow in c.f.s.

Q_R Peak flow in c.f.s. as determined by Rational Method.

Q_u Peak flow in c.f.s. as determined by Unit Hydrograph Method.

q_p Peak rate of discharge of the Unit Hydrograph for unit rainfall duration of c.f.s. per square mile.

Q_p Peak rate of discharge of the Unit Hydrograph in c.f.s.

R Hydraulic Radius = $\frac{\text{cross section area of flow in sq. ft. (A)}}{\text{Wetted perimeter in ft. (P)}}$

R_T Total runoff in inches as used in Unit Hydrograph calculations.

S Slope of street, gutter or hydraulic gradient in feet per foot or percent.

s_c That particular slope in feet per foot of a given uniform conduit operating as an open channel at which normal depth and velocity equal critical depth and velocity for a given discharge.

S_D Design storm runoff in inches for a two-hour period.

S_f Friction slope in feet per foot in a conduit. This represents the rate of loss in the conduit due to friction.

t_c Time of Concentration in minutes.

t_p Lag time in hours from the midpoint of the unit rainfall duration to the peak of the Unit Hydrograph.

TW Tailwater elevation of depth above invert a culvert outlet.

V Velocity of flow in feet per second.

v Mean velocity of flow at upstream end of inlet opening in feet per second.

v_c Critical velocity of flow in a conduit in feet per second.

V_1 Upstream Velocity

V_2 Downstream Velocity

W Street width from face of curb in feet.

WP Wetted perimeter in feet.

Z Reciprocal of crown slope, $1/q_o$.

q_o Crown slope of pavement in feet per foot.

Y Conveyance factor calculated for unimproved channels.

909.01 LIST OF TABLES

Table No.	Content
1	Runoff Coefficients and Minimum Inlet Times
2	Coefficients "C_t" and "C_p 640"
3	Minimum Slopes for Concrete Pipes
4	Maximum Velocities in Closed Conduits
5	Roughness Coefficients for Closed Conduits
6	Velocity Head Loss Coefficients for Closed Conduits
7	Roughness Coefficients for Open Channels
8	Culvert Discharge Velocities
9	Culvert Entrance Losses

TABLE 1

RUNOFF COEFFICIENTS AND MINIMUM INLET TIMES

Land Use	Runoff Coefficient C	Minimum Inlet Time In Minutes
Residential	0.6	15
Commercial	0.9	10
Industrial	0.9	10
Multiple Unit Dwelling	0.8	10
Parks	0.4	15
Cemeteries	0.4	15
Pasture	0.4	15
Woods	0.3	15
Cultivated	0.6	20
Shopping Centers	0.9	10
Paved Areas	0.9	10
Schools	0.6	15
Patio Homes	0.6	15

TABLE 2

COEFFICIENTS "C_t" AND "C_p 640"

Drainage Area Characteristics	Approximate Value of **"C_t"**	Approximate Value of **"C_p 640"**
Sparsely Sewered Area		
Flat Basin Slope (less than 0.50%)	0.65	350
Moderate Basin Slope (0.50% to 0.80%)	0.6	370
Steep Basin Slope (greater than 0.80%)	0.55	390
Moderately Sewered Area		
Flat Basin Slope (less than 0.50%)	0.55	400
Moderate Basin Slope (0.50%) to 0.80%	0.5	420
Steep Basin Slope (greater than 0.80%)	0.45	440
Highly Sewered Area		
Flat Basin Slope (less than 0.50%)	0.45	450
Moderate Basin Slope (0.50% to 0.80%)	0.4	470
Steep Basin Slope (greater than 0.80%)	0.35	490

TABLE 3

MINIMUM SLOPES FOR CONCRETE PIPES

Pipe Diameter (Inches)	Slope (%)	Pipe Diameter (Inches)	Slope (%)
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

NOTE: Minimum pipe diameter to be used in construction of storm sewers shall be eighteen (18) inches. (Laterals not exceeding 50')

TABLE 4

MAXIMUM VELOCITIES IN CLOSED CONDUITS

Type of Conduit	Maximum Velocity
Culverts	15 f.p.s.
Inlet Laterals	30 f.p.s.
Storm Sewers	12 f.p.s.

Storm sewers shall discharge into open channels at a maximum velocity of 8 feet per second.

TABLE 5

ROUGHNESS COEFFICIENTS FOR CLOSED CONDUITS

Material of Construction	Recommended Roughness Coefficient "n"
New Monolithic Concrete Conduit	.015
Concrete Pipe Culverts	.012
Monolithic Concrete Culverts	.012
Concrete Pipe Storm Sewer:	
Good Alignment, Smooth Joints	.013
Fair Alignment, Ordinary Joints	.015
Poor Alignment, Poor Joints	.017

NOTE: Reinforced concrete pipe is the accepted material for construction of storm sewers. The use of other materials for the construction of storm sewers shall have prior approval from the Public Works Director.

TABLE 6

HEAD LOSS COEFFICIENTS DUE TO OBSTRUCTIONS

$\frac{A^*}{A_o}$	K_j	$\frac{A^*}{A_o}$	K_j
1.05	0.10	3.0	15.0
1.1	0.21	4.0.	27.3
1.2	0.50	5.0	42.0
1.4	1.15	6.0	57.0
1.6	2.40	7.0	72.5
1.8	4.00	8.0	88.0
2.0	5.55	9.0	104.0
2.2	7.05	10.0	121.0
2.5	9.70		

*$\frac{A}{A_o}$ = Ratio of area of pipe to area of opening at obstruction.

TABLE 7

ROUGHNESS COEEFFICIENTS FOR OPEN CHANNELS

Channel Description	Roughness Coefficient			Maximum Velocity (ft/sec)
	Minimum	Normal	Maximum	
MINOR NATURAL STREAMS - TYPE I CHANNEL				
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	0.040	0.040	*
Weeds, Heavy Brush on Banks	0.035	0.060	0.060	*
Weeds, Dense Willows on Banks	0.040	0.080	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	0.090	*
Flood Plain, Pasture				
Short Grass, No Brush	0.025	0.030	0.035	*
Tall Grass, No Brush	0.030	0.035	0.050	*
Flood Plain, Cultivated				
No Crops	0.025	0.030	0.035	*
Mature Crops	0.030	0.040	0.050	*
Flood Plain, 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	*

*** For Maximum Allowed Velocities, refer to sheet SD_403 of the Standard Construction Details.**

TABLE 7
(concluded)

ROUGHNESS COEEFFICIENTS FOR OPEN CHANNELS

Channel Description	Roughness Coefficient			Maximum Velocity (ft/sec)
	Minimum	Normal	Maximum	
MAJOR NATURAL STREAMS - TYPE I CHANNEL				
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	*
UNLINED VEGETATED CHANNELS - TYPE II CHANNEL				
Mowed Grass, Clay Soil	0.025	0.030	0.035	*
Mowed Grass, Sandy Soil	0.025	0.030	0.035	*
UNLINED NON-VEGETATED CHANNELS - TYPE II CHANNEL				
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 - TYPE III				
Smooth Finished Concrete	0.013	0.015	0.020	*
Riprap (Rubble)	0.030	0.040	0.050	*

*** For Maximum Allowed Velocities, refer to sheet SD_403 of the Standard Construction Details.**

TABLE 8

CULVERT DISCHARGE VELOCITIES

Culvert Discharges On	Maximum Allowable Velocity (f.p.s.)
Earth (Sandy)	6
Earth (Clay)	8
Sodded Earth	8
Concrete	15
Undisturbed Rock or Shale	10

TABLE 9

CULVERT ENTRANCE LOSSES

Culvert Entrance Losses Where:

$$h_e = K_e \frac{V^2}{2g}$$

... "h_e" is the entrance head loss (ft).

... "K_e" is the entrance loss coefficient as shown in the table below.

... "V" is the velocity of flow in culvert (ft/s).

The following table gives K_e values for different entrance conditions:

Type of Structure	K_e
Pipe, Concrete	
projecting from fill, socket and (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 = 0.0933D)	0.2
mitered to conform to fill slope	0.7
bevelled edges, 33.7° or 45°	0.2
side or sloped 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/unpaved slope	0.7
bevelled edges, 33.7° or 45° bevels	0.2
side or slope tapered inlet	0.2
Box, Reinforced Concrete	
headwall parallel to embankment (no wingwalls)	
squared on three sides	0.5
rounded on three sides to radius 1/12 barrel dimension, or bevelled on three sides	0.2

910.01 LIST OF FIGURES

Figure No.	Title
1	Rainfall Intensity and Duration
2	Time of Concentration for Surface Flow
3	Capacity of Triangular Gutters
4	Capacity of Parabolic Gutter (26' and 36' Streets)
5	Capacity of Parabolic Gutters (44' and 48' Streets)
6	Capacity of Alley Sections
7	Storm Drain Inlets
8	Recessed and Standard Curb Opening Inlet on Grade (1/4"/1' Cross Slope)
9	Recessed and Standard Curb Opening Inlet on Grade (3/8"/1' Cross Slope; 44' and 48' Streets)
10	Recessed and Standard Curb Opening Inlet on Grade (1/2"/1' Cross Slope; 36' Street)
11	Recessed and Standard Curb Opening Inlet on Grade (26' Street)
12	Recessed and Standard Curb Opening Inlet on Grade
13	Recessed and Standard Curb Opening Inlet at Low Point
14	Two Grade Combination Inlet on Grade
15	Four Grate Combination Inlet on Grade
16	Three Grate Inlet and Three Grate Combination Inlet on Grade
17	Two Grate Inlet on Grade
18	Four Grate Inlet on Grade
19	Six Grate Inlet on Grade
20	Combination Inlet at Low Point
21	Grate Inlet at Low Point
22	Drop Inlet at Low Point
23	Capacity of Circular Pipes Flowing Full
24A & 24B	Open Channel Types
25	Headwater Depth for Box Culverts with Inlet Control

26 ..... Headwater Depth for Concrete Pipe Culverts with Inlet Control

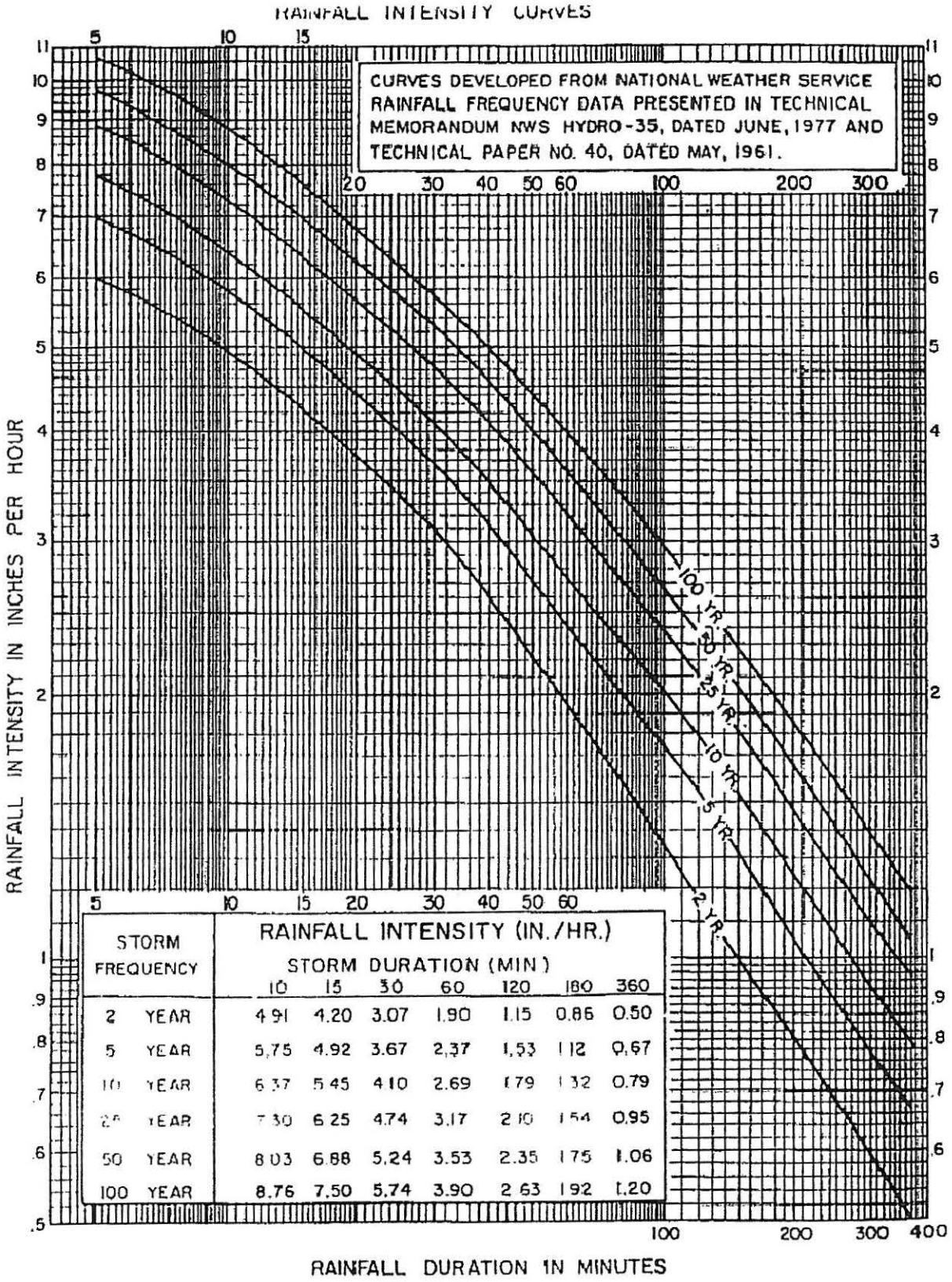
27 ..... Head for Concrete Box Culverts Flowing Full

28 ..... Head for Concrete Pipe Culverts Flowing Full

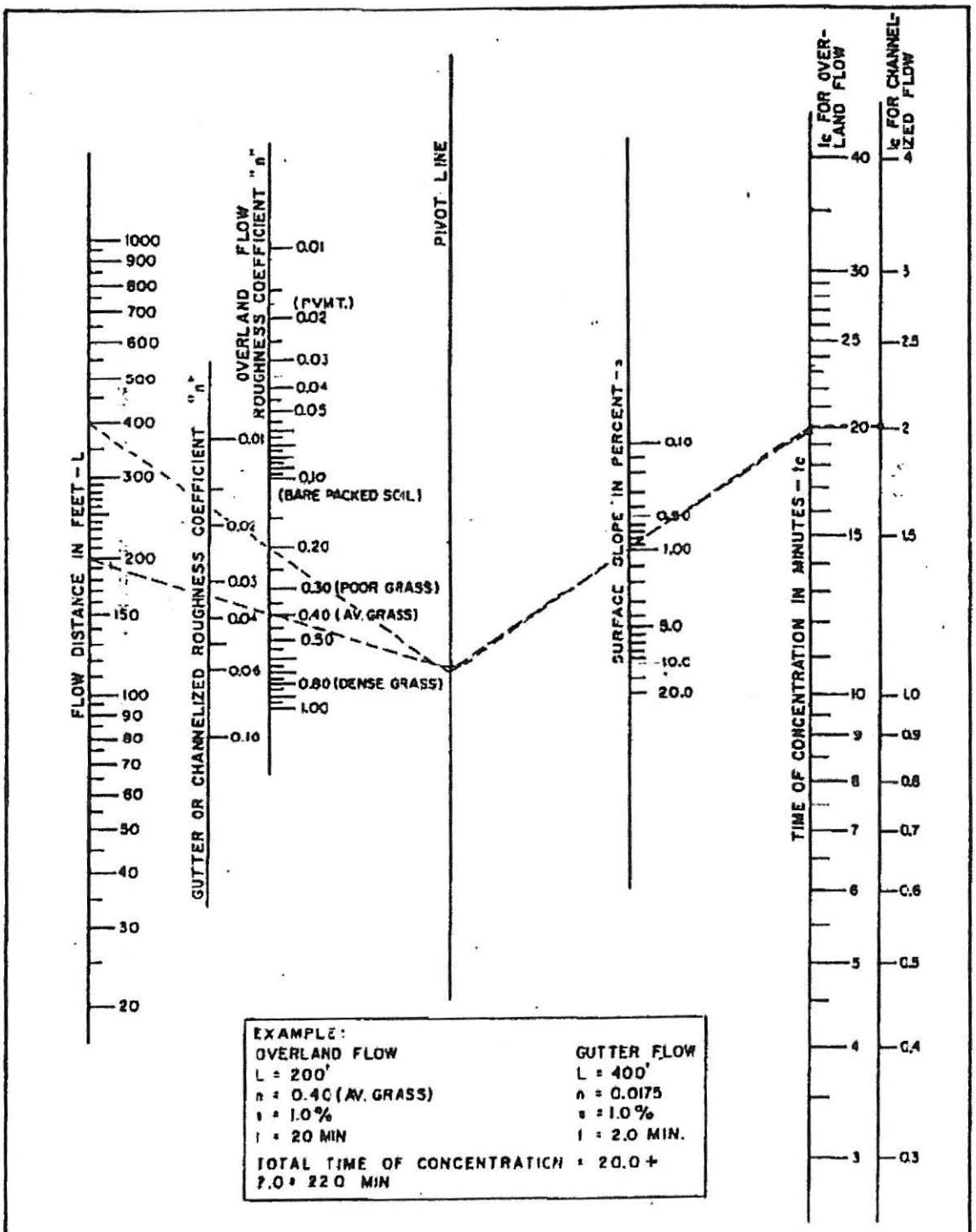
29 ..... Critical Depth of Flow for Rectangular Conduits

30 ..... Critical Depth of Flow for Circular Conduits

FIGURE 1



STORM FREQUENCY	RAINFALL INTENSITY (IN./HR.) STORM DURATION (MIN)						
	10	15	30	60	120	180	360
2 YEAR	4.91	4.20	3.07	1.90	1.15	0.86	0.50
5 YEAR	5.75	4.92	3.67	2.37	1.53	1.12	0.67
10 YEAR	6.37	5.45	4.10	2.69	1.79	1.32	0.79
25 YEAR	7.30	6.25	4.74	3.17	2.10	1.54	0.95
50 YEAR	8.03	6.88	5.24	3.53	2.35	1.75	1.06
100 YEAR	8.76	7.50	5.74	3.90	2.63	1.92	1.20



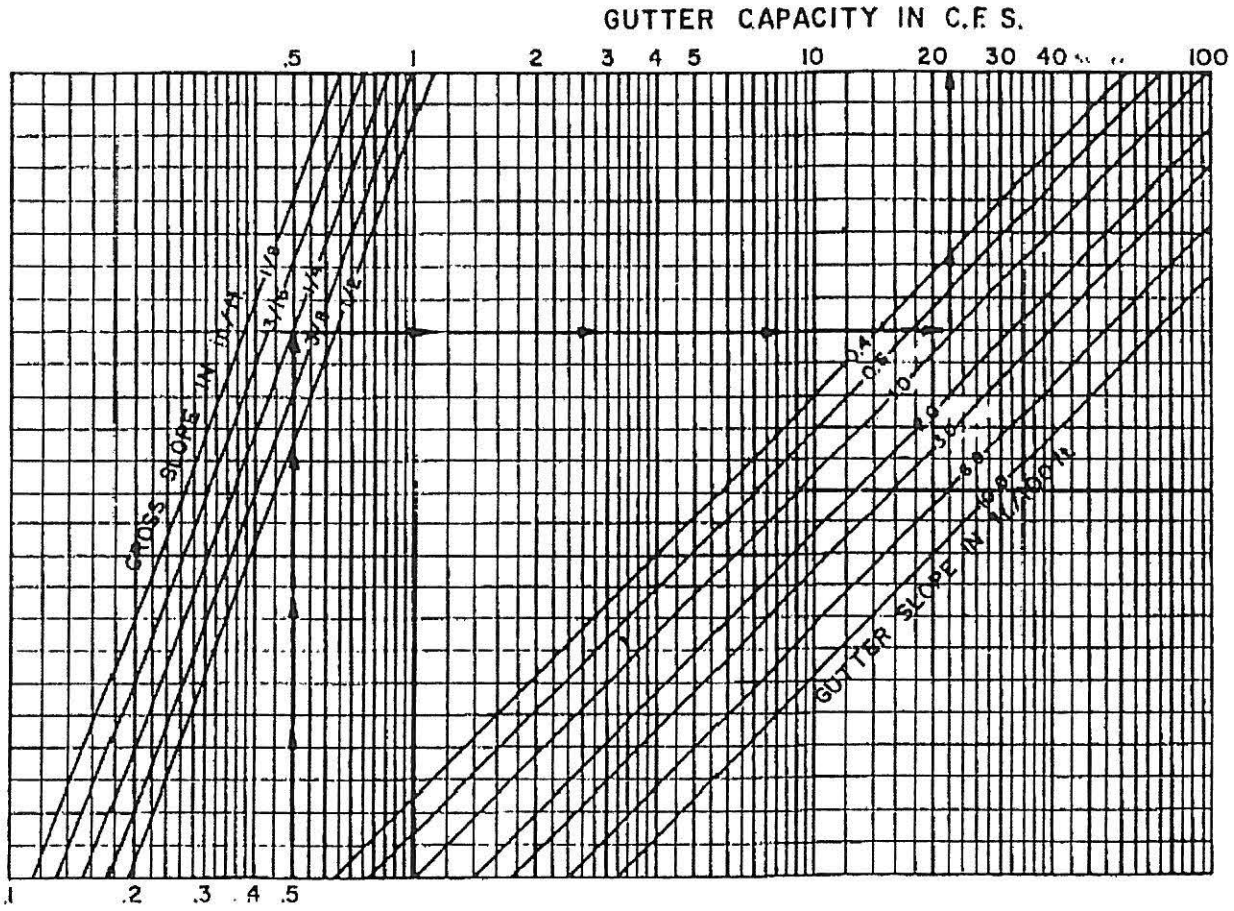
TIME OF CONCENTRATION
FOR
SURFACE FLOW

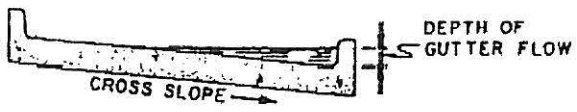
EXAMPLE

Known:
- Major Thoroughfare, Type C
- Pavement Width = 33'
- Gutter Slope = 1.0%
- Pavement Cross Slope = 1/4"/1'
- Depth of Gutter Flow = .5'

Find:
- Gutter Capacity

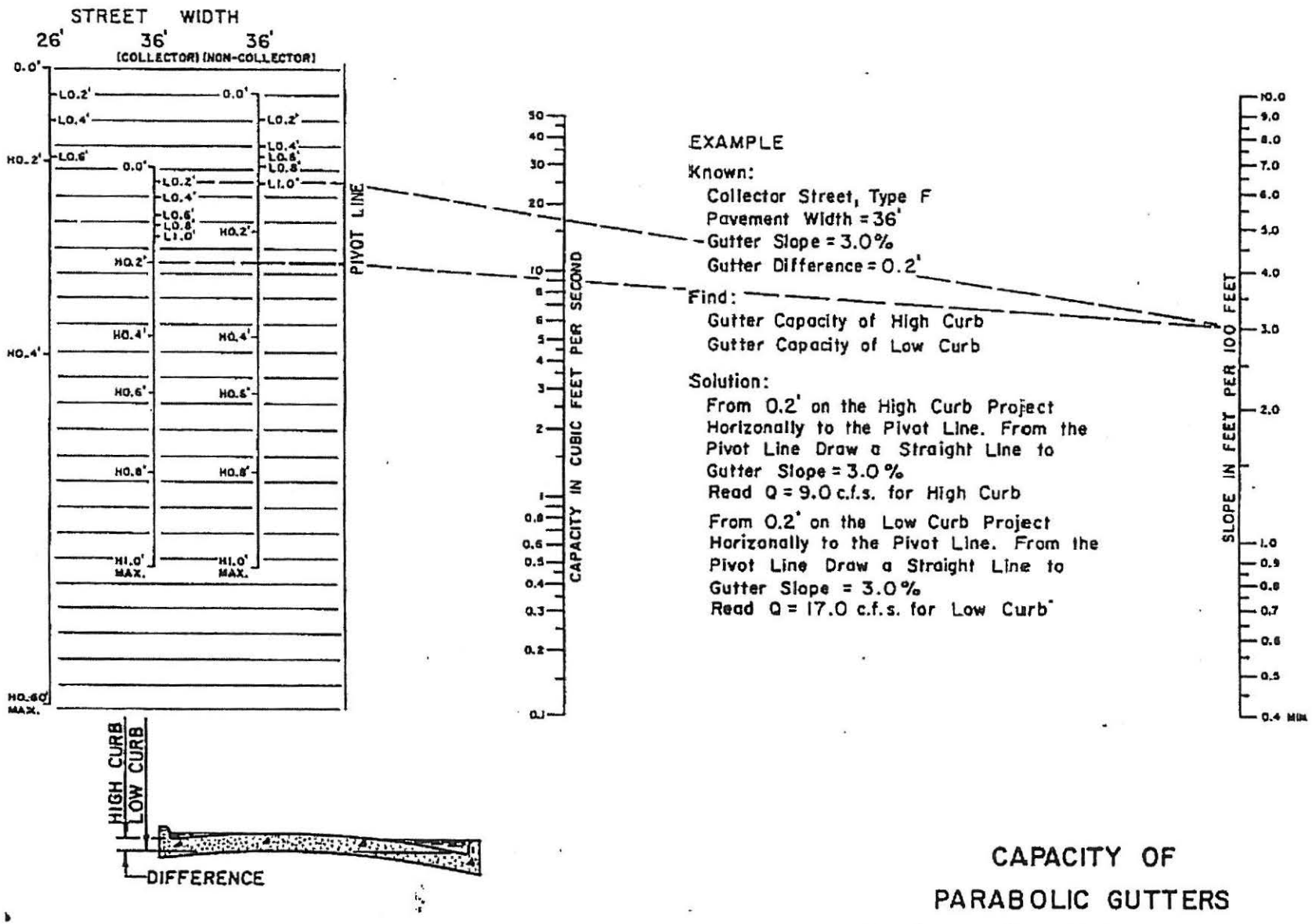
Solution:
- Enter Graph at .5'
- Intersect Cross Slope = 1/4"/1'
- Intersect Gutter Slope = 1.0%
- Read Gutter Capacity = 22 c.f.s.





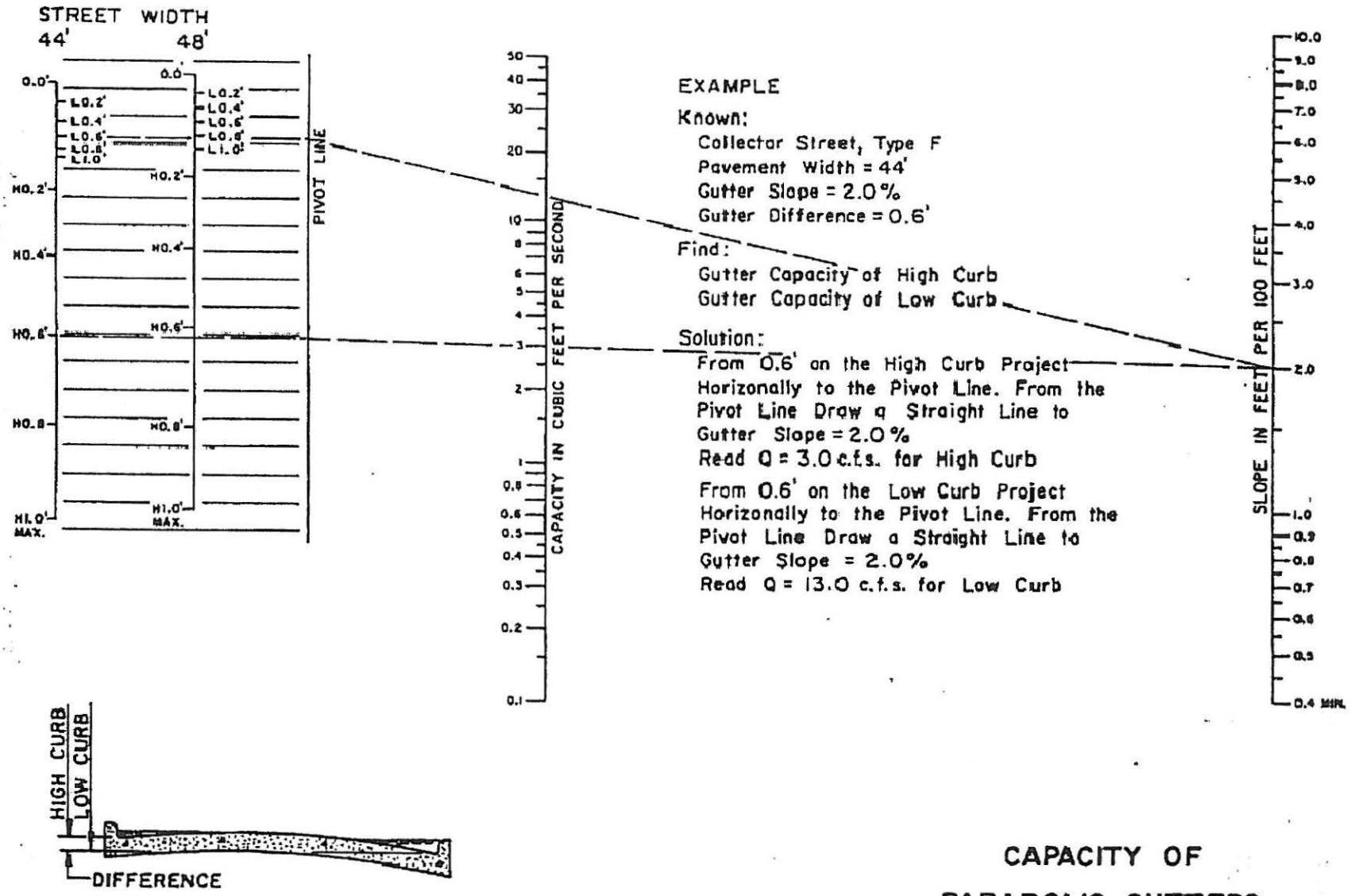
CAPACITY OF TRIANGULAR GUTTERS

(Roughess Coefficient n = .0175)



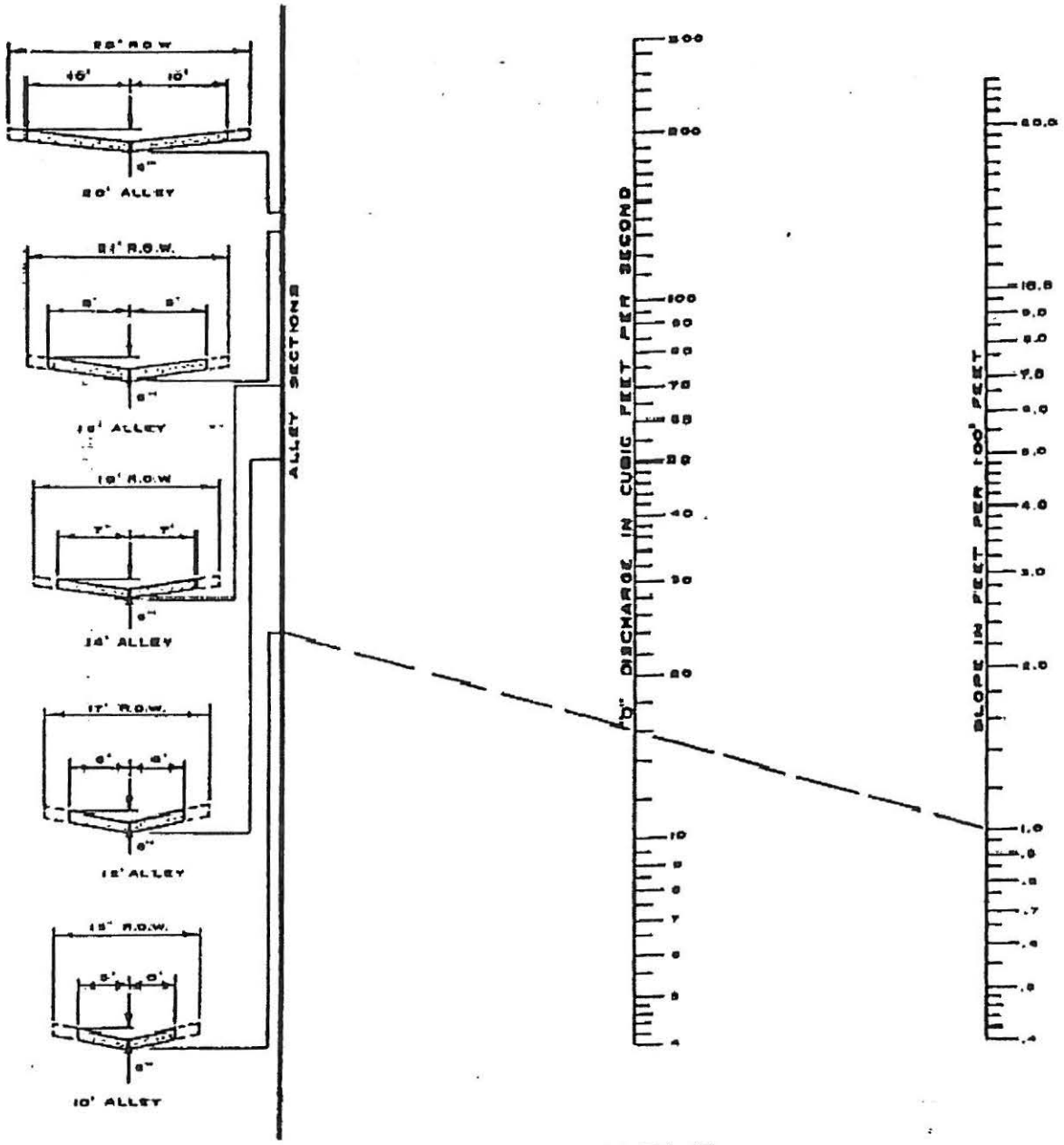
CAPACITY OF
PARABOLIC GUTTERS
(26' & 36' STREET WIDTHS)

FIGURE 4



CAPACITY OF
PARABOLIC GUTTERS
(44' & 48' STREET WIDTHS)

FIGURE 5



EXAMPLE

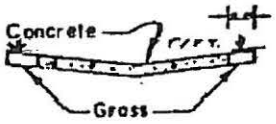
KNOWN:
Alley width = 10'
Alley depression = 5"
Gutter Slope = 1.0%

FIND:
Gutter Flow (Q)

SOLUTION:
Connect the 10' alley section with slope = 1.0%. Read Q = 16 c.f.s.

NOTE:

1. All Alley Capacities Are 2½" Above Paving Edge.

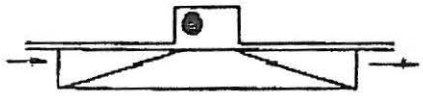
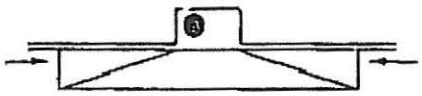
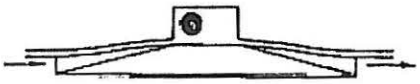
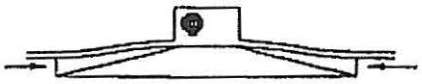
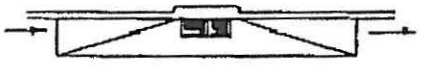
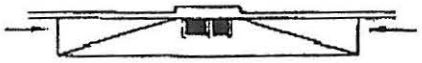
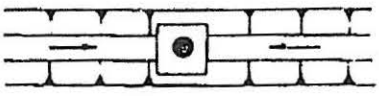


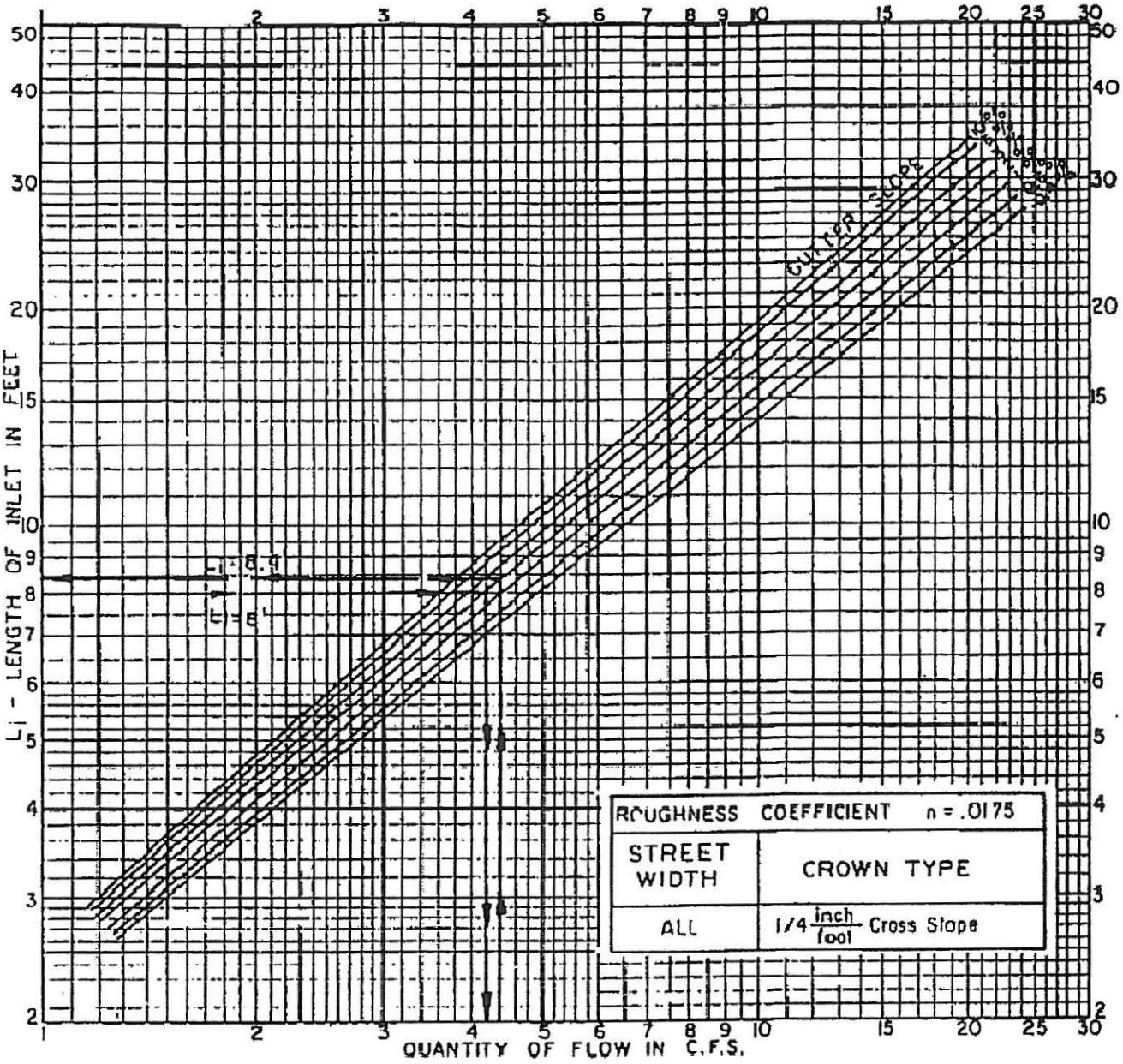
2. The Capacities Obtained From This Nomograph are Based on a Straight Horizontal Alignment. Curved Alignments May Result in Reduced Capacity.

CAPACITY OF ALLEY SECTIONS

Average n = 0.020

STORM DRAIN INLETS

INLET TYPE	INLET DESCRIPTION	AVAIL. INLET SIZES	WHERE USED	DESIGN CURVES
I	 STANDARD CURB OPENING INLET ON GRADE	4' 6' 8' 10' 12' 14'	26' LOCAL STREET, TYPE H 36' COLLECTOR STREET, TYPE F ALLEY	FIGURES 8 THROUGH 12
IA	 STANDARD CURB OPENING INLET AT LOW POINT	4' 6' 8' 10' 12' 14'	26' LOCAL STREET, TYPE H 36' COLLECTOR STREET, TYPE F ALLEY	FIGURE 13
II	 RECESSED CURB OPENING INLET ON GRADE	4' 6' 8' 10' 12' 14'	44' COLLECTOR STREET, TYPE F 40' SECONDARY STREET, TYPE E 2-24' MAJOR STREET, TYPE D 2-33' MAJOR STREET, TYPE C 2-36' MAJOR STREET, TYPE B 2-36' MAJOR STREET, TYPE A	FIGURES 8 THROUGH 12
IIA	 RECESSED CURB OPENING INLET AT LOW POINT	4' 6' 8' 10' 12' 14'	44' COLLECTOR STREET, TYPE F 40' SECONDARY STREET, TYPE E 2-24' MAJOR STREET, TYPE D 2-33' MAJOR STREET, TYPE C 2-36' MAJOR STREET, TYPE B 2-36' MAJOR STREET, TYPE A	FIGURE 13
III	 COMBINATION INLET ON GRADE	4' 6' 8'	COMBINATION INLETS TO BE USED WHERE SPACE BEHIND CURB PROHIBITS OTHER INLET TYPES	FIGURES 14 THROUGH 18
IIIA	 COMBINATION INLET AT LOW POINT	4' 6' 8'	COMBINATION INLETS TO BE USED WHERE SPACE BEHIND CURB PROHIBITS OTHER INLET TYPES	FIGURE 20
IV	 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 16, 17, 18, 19 & 21
V	 DROP INLET	2'x2' 3'x3' 4'x4'	OPEN CHANNELS	FIGURE 22



EXAMPLE

Known:
- Pavement Width = 24'
- Gutter Slope = 2.0 %
- Pavement Cross Slope = 1/4" / 1'
- Gutter Flow = 4.4 cfs

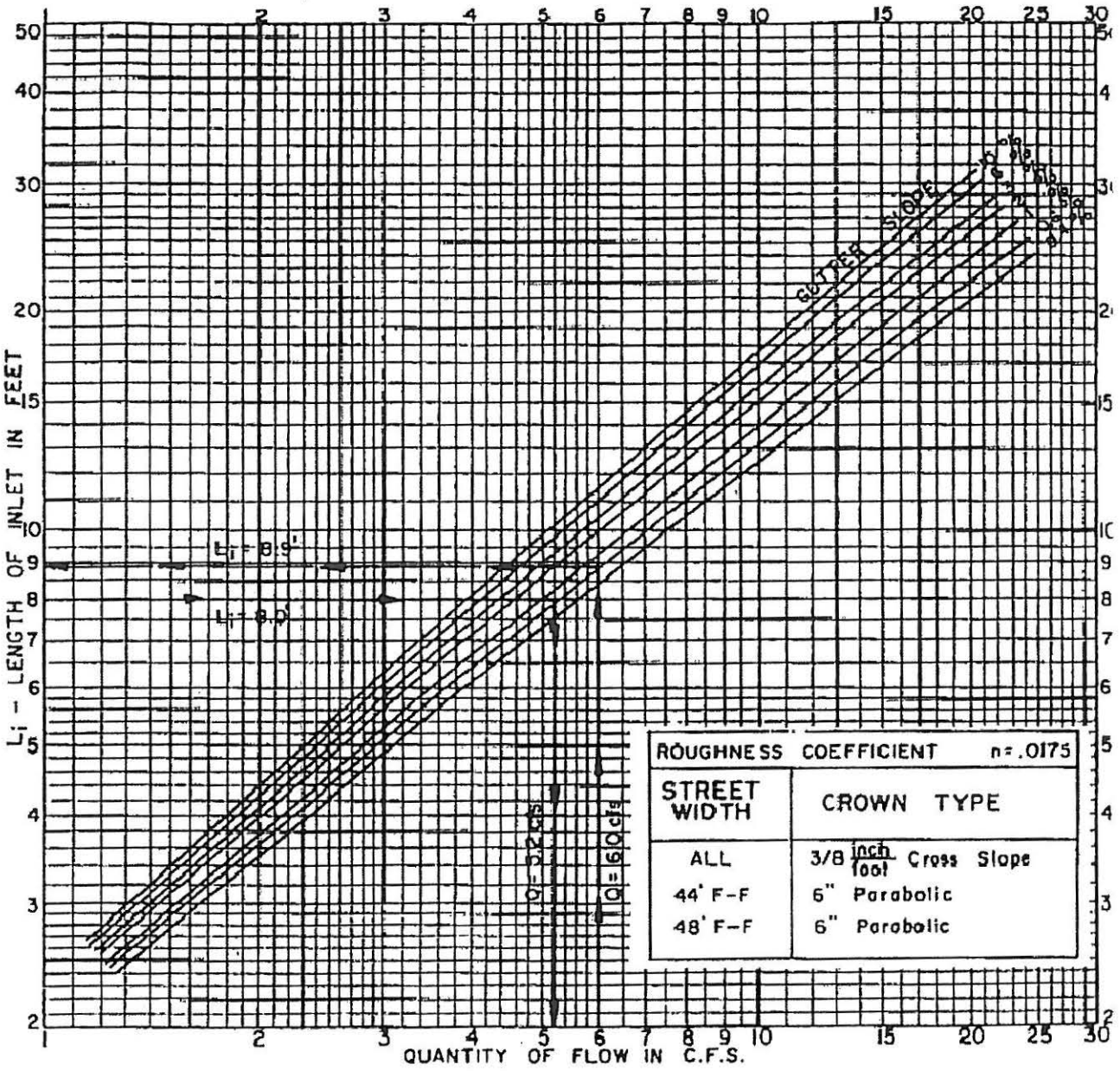
Find:
- Length of Inlet Required (L_i)

Solution:
- Enter Graph at 4.4 cfs
- Intersect Slope = 2.0 %
- Read L_i = 8.4'

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 = 4.2 cfs
Remaining Gutter Flow = 4.4 cfs − 4.2 cfs = 0.2 cfs

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE



EXAMPLE

Known:
- Pavement Width = 44'
- Gutter Slope = 0.6 %
- 6" Parabolic Crown
- Gutter Flow = 6.0 cfs

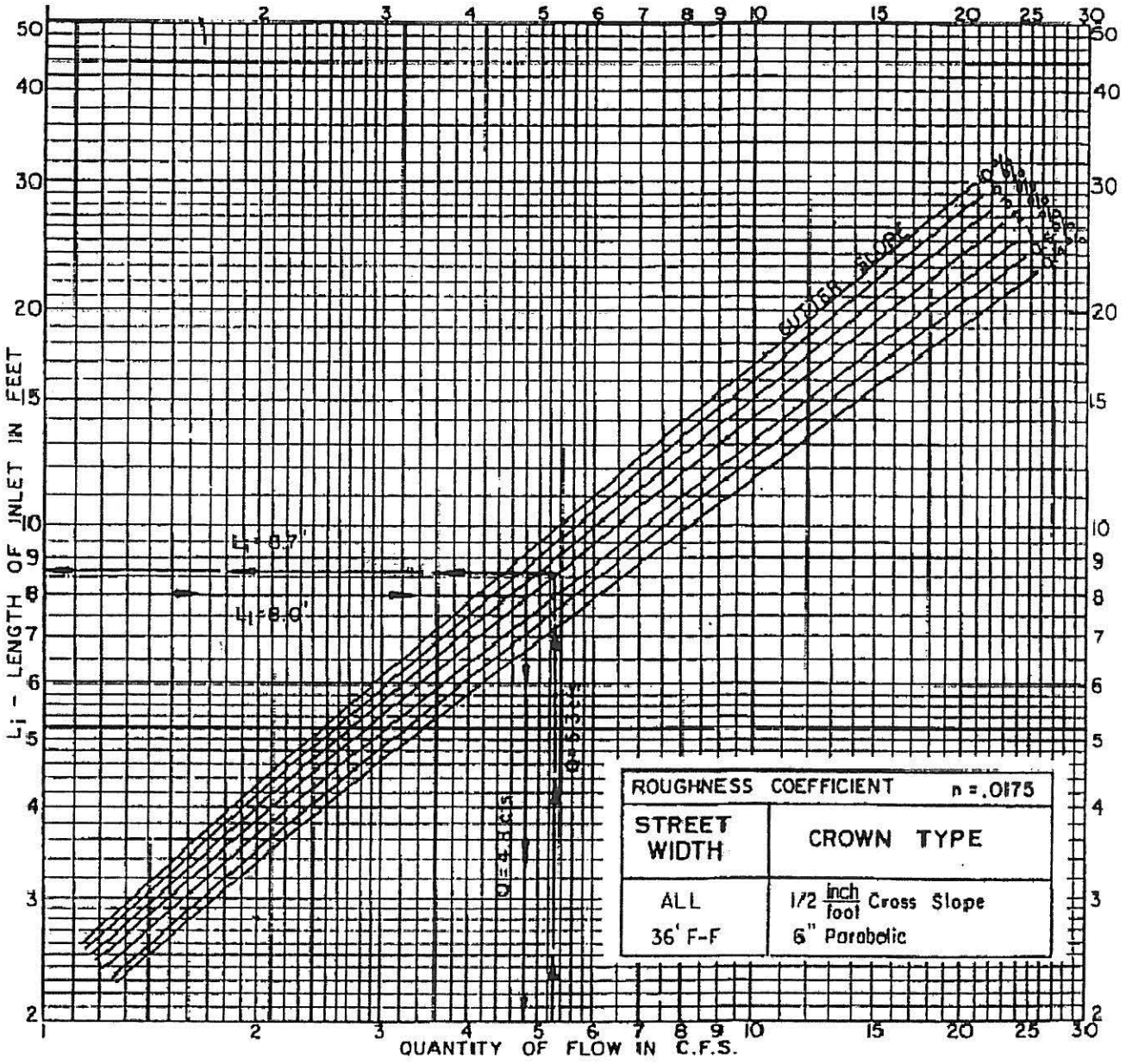
Find:
- Length of Inlet Required (L_i)

Solution:
- Enter Graph at 6.0 cfs
- Intersect Slope = 0.6 %
- Read L_i = 8.9'

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 = 0.6 %
Read Q = 5.2 cfs
Remaining Gutter Flow =
6.0 cfs − 5.2 cfs = 0.8 cfs

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE



EXAMPLE

Known:
- Pavement Width = 36'
- Gutter Slope = 2%
- 6" Parabolic Crown
- Gutter Flow = 5.3 c f s

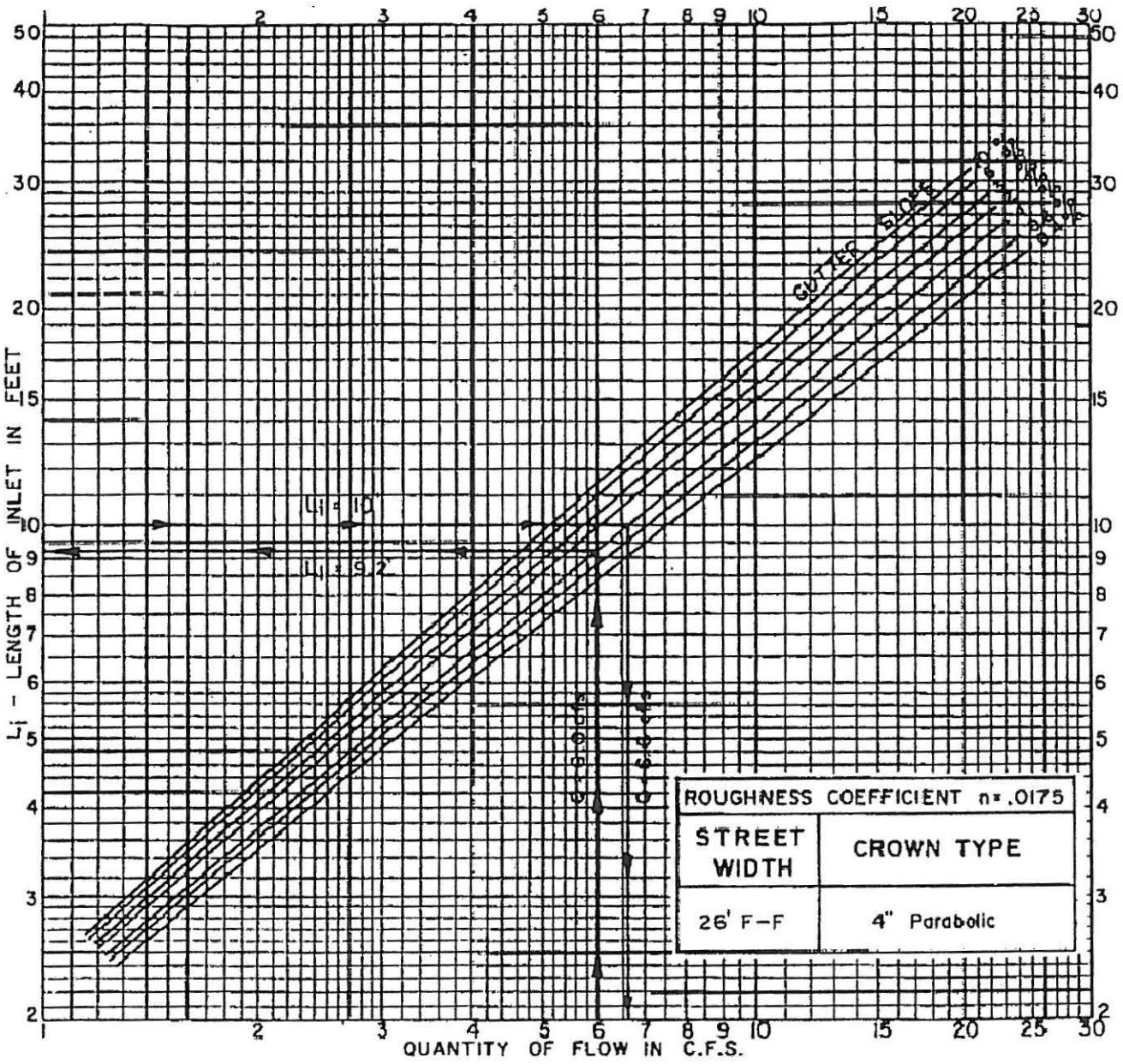
Find:
- Length of Inlet Required (L_i)

Solution:
- Enter Graph at 5.3 c f s
- Intersect Slope = 2%
- 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%
Read Q = 4.8 c f s
Remaining Gutter Flow =
5.3 c f s − 4.8 c f s = 0.5 c f s

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE



EXAMPLE

Known:
- Pavement Width = 26'
- Gutter Slope = 1%
- 4" Parabolic Crown
- Gutter Flow = 6.0 cfs

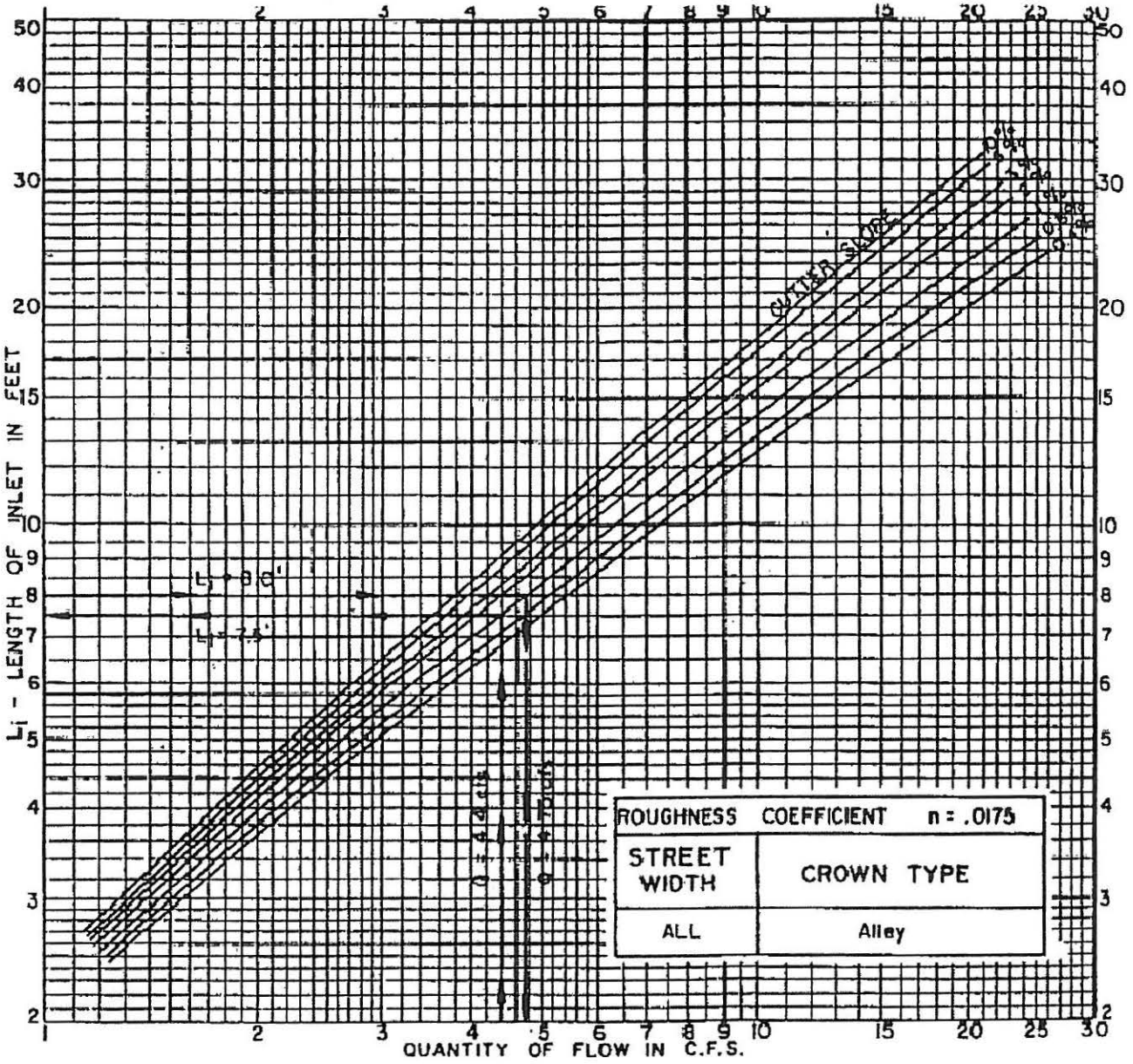
Find:
- Length of Inlet Required (L_i)

Solution:
- Enter Graph at 6.0 cfs
- Intersect Slope = 1%
- Read L_i = 9.2'

Decision:
1. Use 10' Inlet
   - No Flow Remains In Gutter
2. Use 8' Inlet
   - Intercept Only Part of Flow

Use 10' Inlet
Enter Graph at L_i = 10'
Intersect Slope = 1%
Read Q = 6.6 cfs
No Flow Remains in Gutter

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE



EXAMPLE

Known:
- Pavement Width = 16'
- Gutter Slope = 1%
- Pavement Cross Slope = 1/4"/1'
- Gutter Flow = 4.4 cfs

Find:
- Length of Inlet Required (L_i)

Solution:
- Enter Graph at 4.4 cfs
- Intersect Slope = 1%
- Read L_i = 7.5'

Decision:
1. Use 8' Inlet
   - No Flow Remains In Gutter
2. Use 6' Inlet
   - Intercept Only Part of Flow

Use 8' Inlet
Enter Graph at L_i = 8'
Intersect Slope = 1%
Read Q = 4.75 cfs
No Flow Remains In Gutter

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

EXAMPLE

Known:

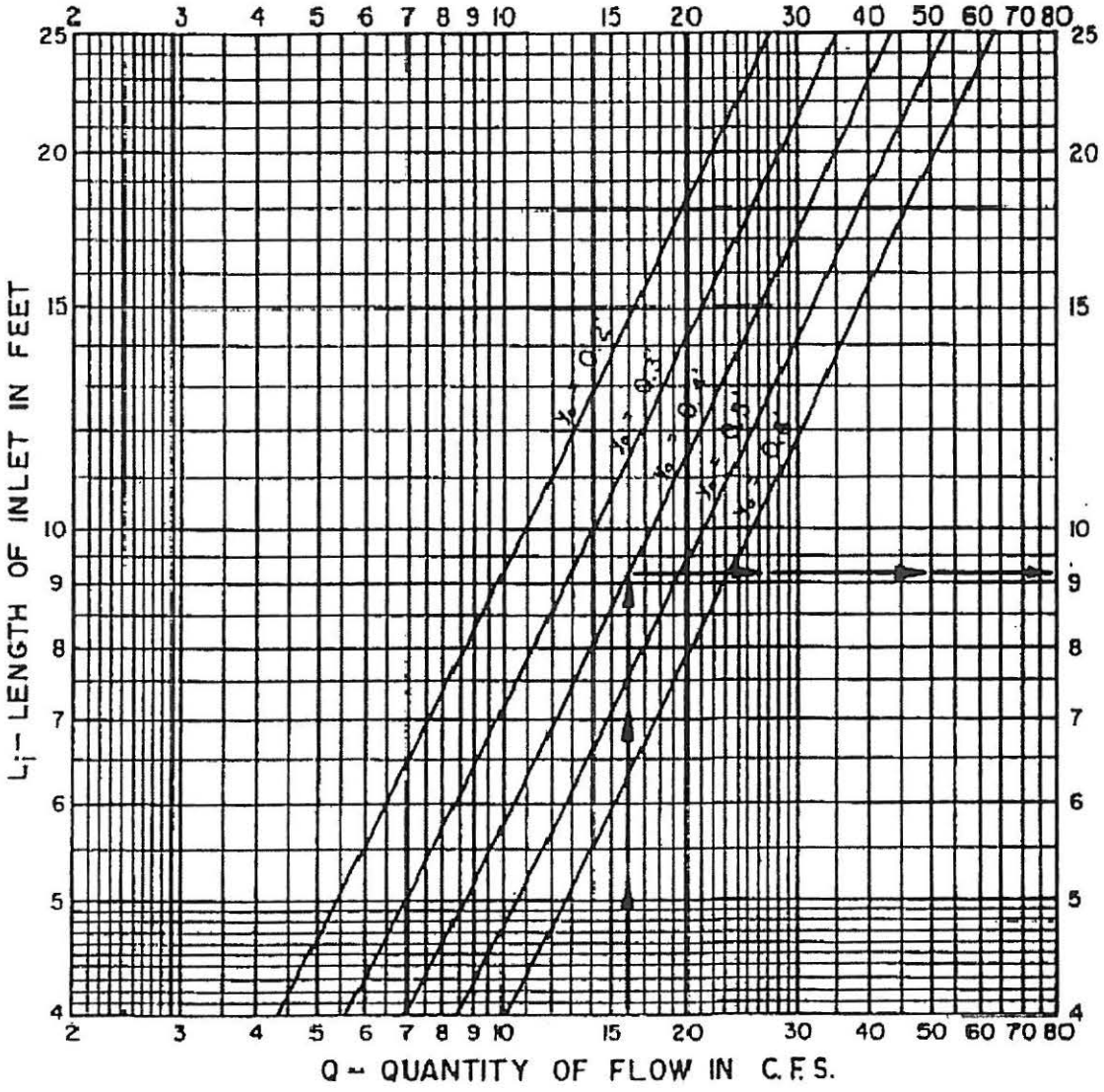
Quantity of Flow = 16.0 c.f.s.
Maximum Depth of Flow Desired in Gutter At Low Point (y_o) = 0.4'

Find:

Length of Inlet Required (L_i)

Solution:

Enter Graph at 16.0 c.f.s.
Intersect y_o = 0.4'
Read L_i = 9.2'
Use 10' Inlet



ROUGHNESS COEFFICIENT n = .0175	
STREET WIDTH	CROWN TYPE
ALL	Straight and Parabolic

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES AT LOW POINT

EXAMPLE

Known:

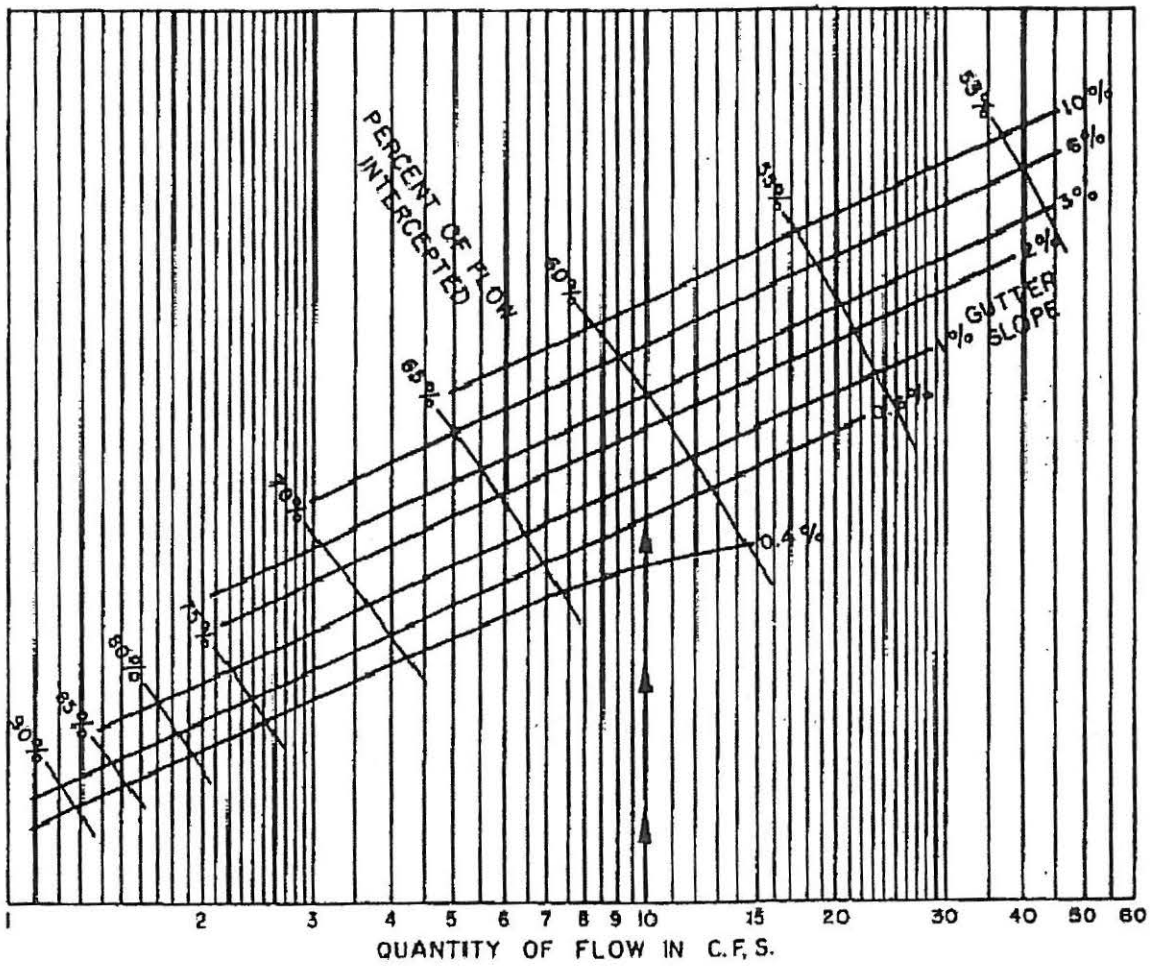
Quantity of Flow = 10.0 c.f.s.
Gutter Slope = 0.6 %

Find:

Capacity of Two Grate Combination Inlet

Solution:

Enter Graph at 10.0 c.f.s.
Intersect Slope = 0.6%
Read Percent of Flow Intercepted = 62 %
62 % of 10.0 c.f.s. = 6.2 c.f.s. as Capacity of Two Grate Combination Inlet
Remaining Gutter Flow = 10.0 c.f.s - 6.2 c.f.s. = 3.8 c.f.s.



TWO GRATE COMBINATION INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

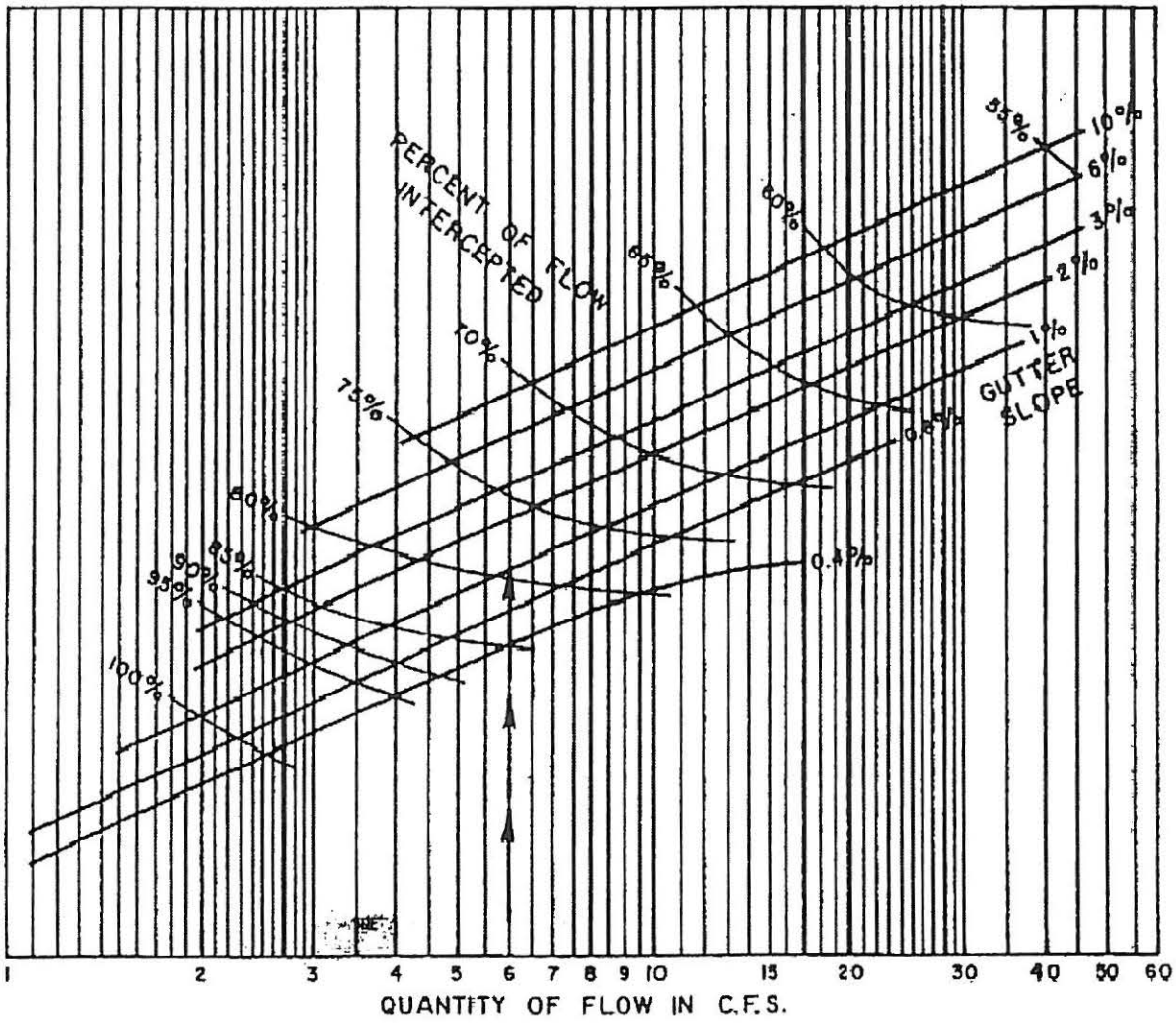
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Four Grate Combination Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow Intercepted = 79%
79% of 6.0 c.f.s. = 4.7 c.f.s. as Capacity of Four Grate Combination Inlet
Remaining Gutter Flow = 6.0 c.f.s. – 4.7 c.f.s. = 1.3 c.f.s.



FOUR GRATE COMBINATION INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

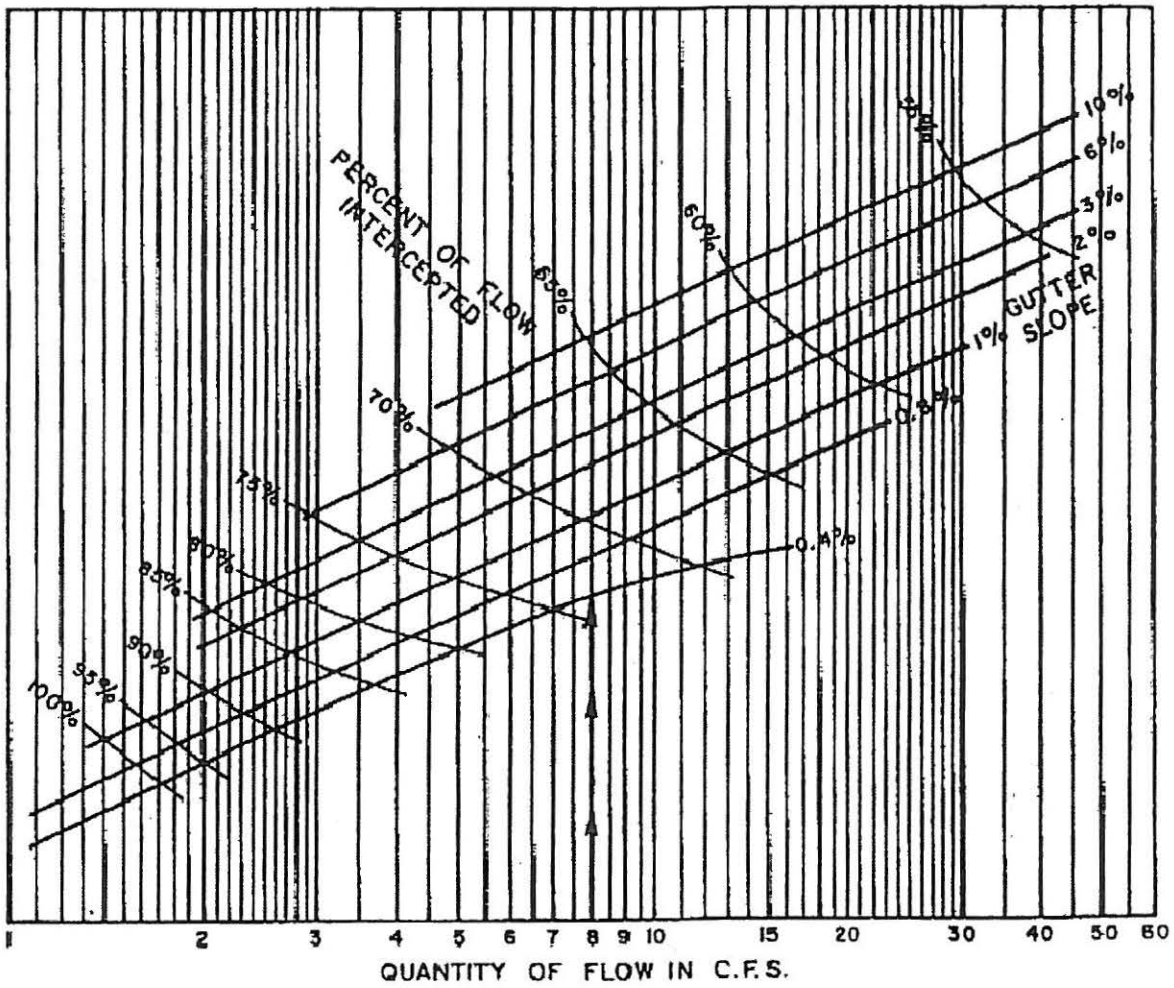
Quantity of Flow = 8.0 c.f.s.
Gutter Slope = 0.4%

Find:

Capacity of Three Grate Inlet

Solution:

Enter Graph at 8.0 c.f.s.
Intersect Slope = 0.4%
Read Percent of Flow
Intercepted = 74%
74% of 8.0 c.f.s. = 5.9 c.f.s.
as Capacity of Three Grate Inlet
Remaining Gutter Flow =
8.0 c.f.s. – 5.9 c.f.s. = 2.1 c.f.s.



THREE GRATE INLET AND
THREE GRATE COMBINATION INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

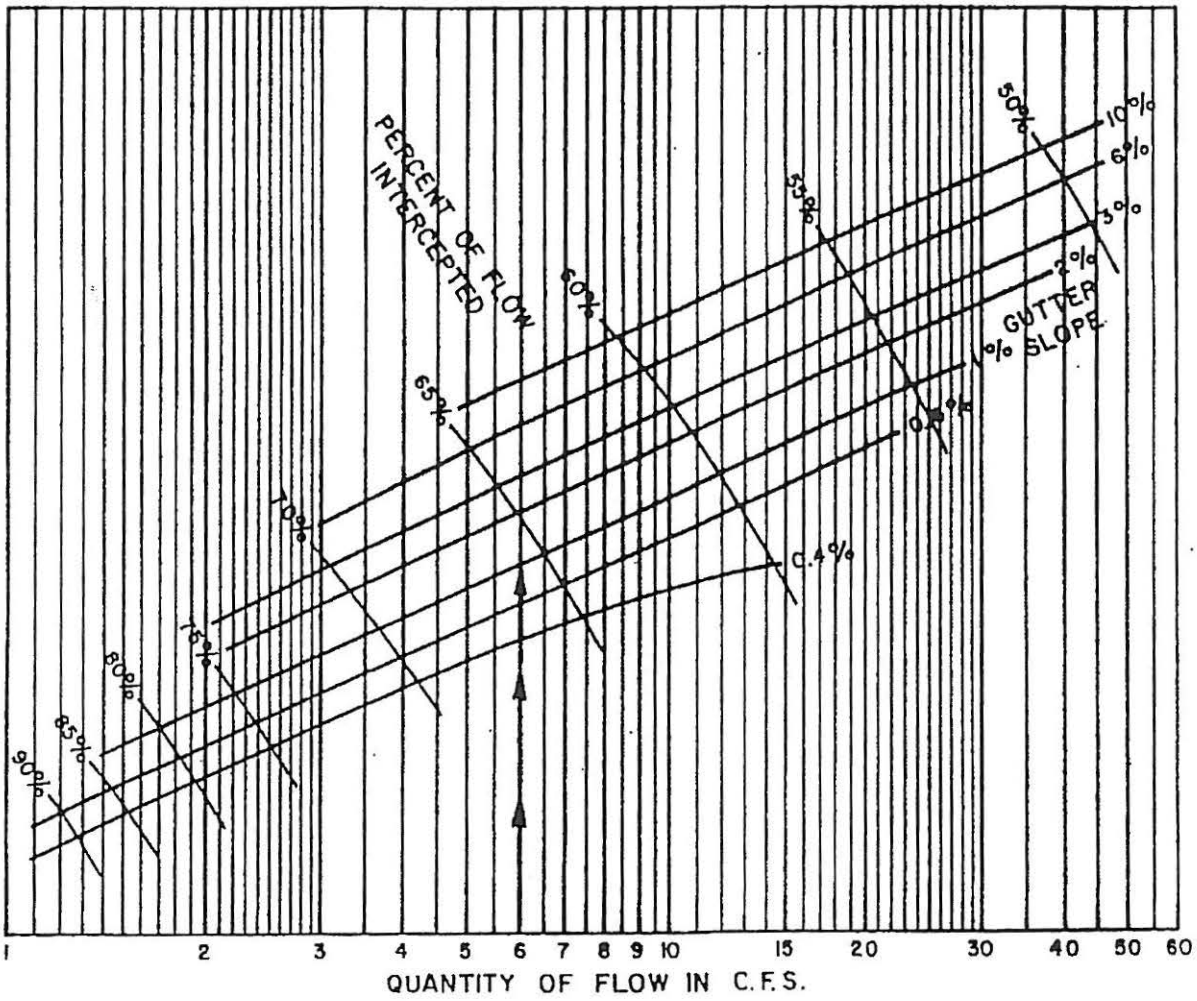
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Two Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow
Intercepted = 66%
66% of 6.0 c.f.s. = 4.0 c.f.s.
as Capacity of Two Grate Inlet
Remaining Gutter Flow =
6.0 c.f.s. – 4.0 c.f.s. = 2.0 c.f.s.



TWO GRATE INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

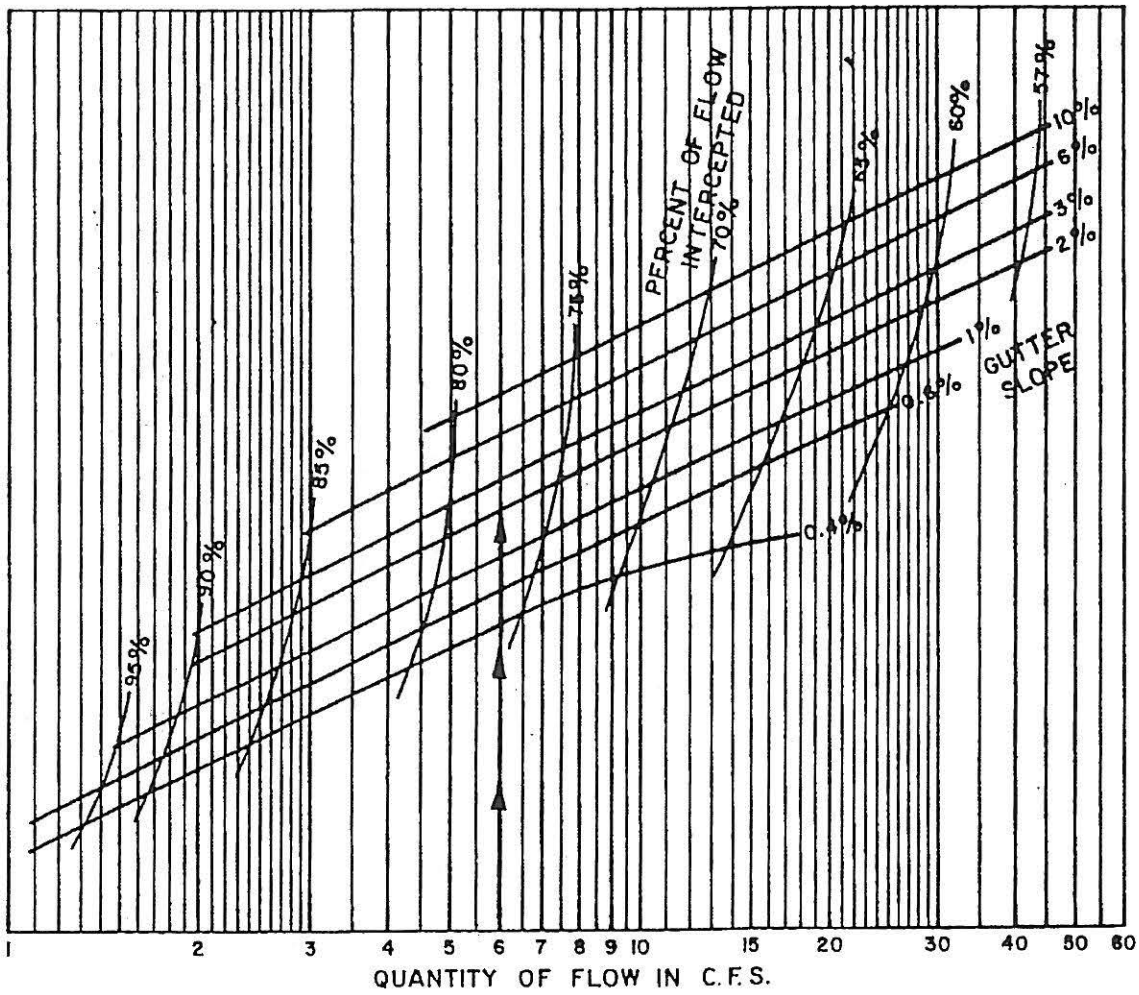
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Four Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow
Intercepted = 77%
77% of 6.0 c.f.s. = 4.6 c.f.s.
as Capacity of Four Grate Inlet
Remaining Gutter Flow =
6.0 c.f.s. – 4.6 c.f.s. = 1.4 c.f.s.



FOUR GRATE INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

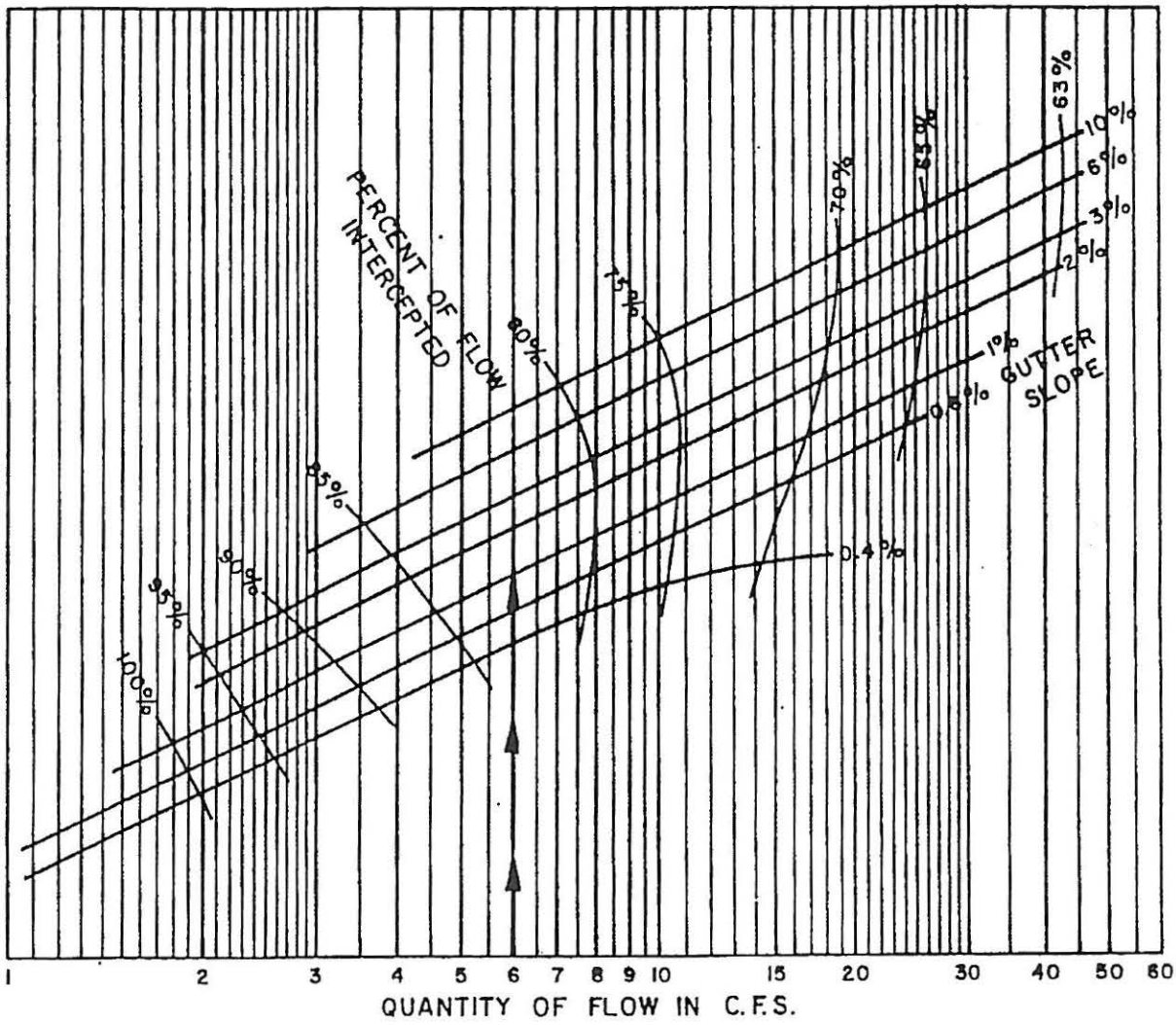
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Six Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow
Intercepted = 82 %
82 % of 6.0 c.f.s. = 4.9 c.f.s.
as Capacity of Six Grate Inlet
Remaining Gutter Flow =
6.0 c.f.s. – 4.9 c.f.s. = 1.1 c.f.s.



SIX GRATE INLET
CAPACITY CURVES
ON GRADE

EXAMPLE

Known:

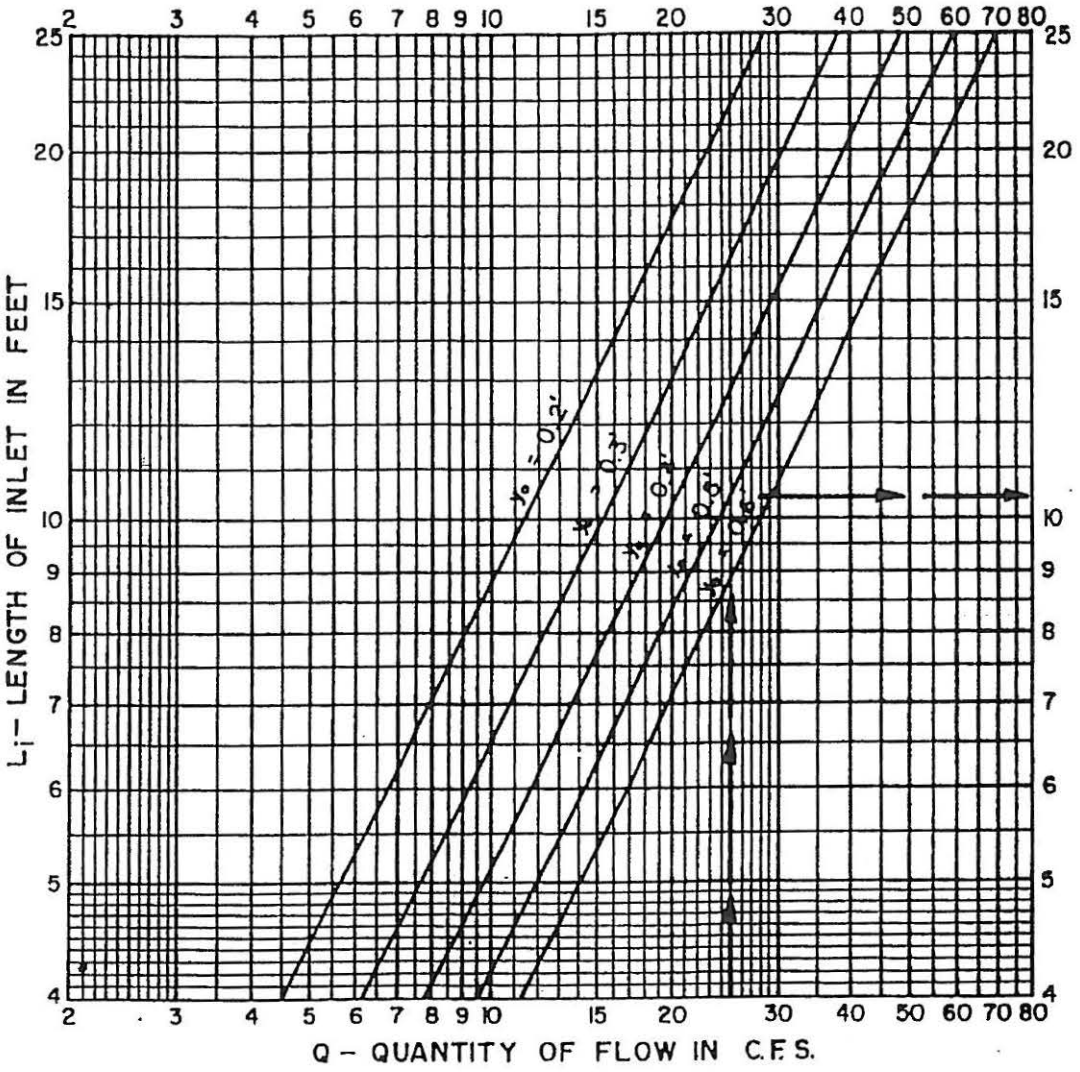
Quantity of Flow = 25.0 c.f.s.
Maximum Depth of Flow Desired
At Low Point (y_o) = 0.5'

Find:

Length of Inlet Required (L_i)

Solution:

Enter Graph at 25.0 c.f.s.
Intersect y_o = 0.5'
Read L_i = 10.4'
Use 12' Inlet



ROUGHNESS COEFFICIENT n = .0175	
STREET WIDTH	CROWN TYPE
ALL	Straight and Parabolic

COMBINATION INLET CAPACITY CURVES AT LOW POINT

EXAMPLE

Known:

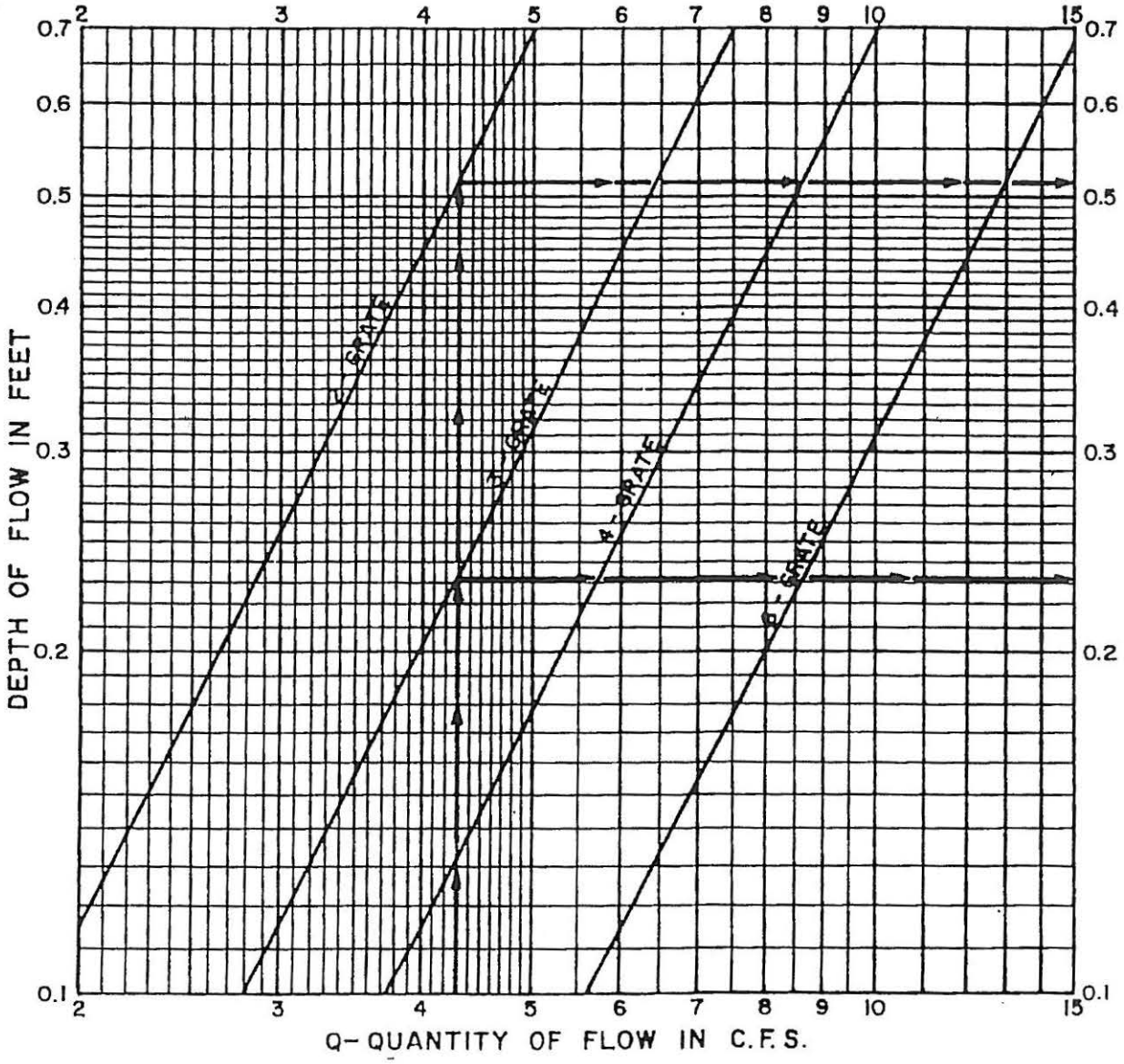
Quantity of Flow = 4.3 c.f.s.
Maximum Depth of Flow Desired at Low Point = 0.3'

Find:

Inlet Required

Solution:

Enter Graph at 4.3 c.f.s.
Intersect 3 - Grate at 0.23'
Intersect 2 - Grate at 0.51'
Use 3 - Grate



GRATE INLET
CAPACITY CURVES
AT LOW POINT

EXAMPLE

Known:

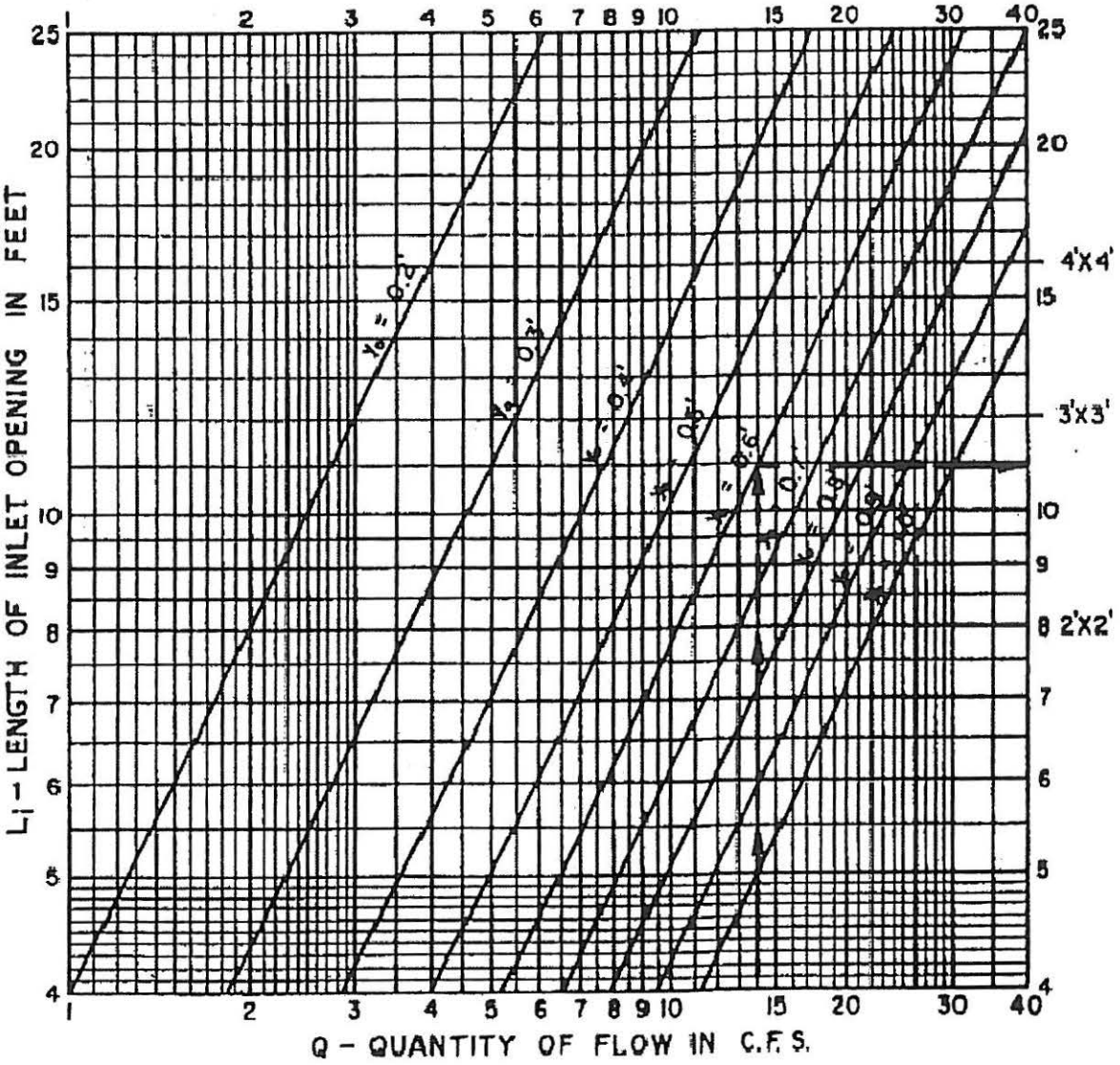
Quantity of Flow = 14.0 c.f.s.
Maximum Depth of Flow Desired
$(y_o) = 0.6'$

Find:

Length of Inlet Opening Required (L_i)

Solution:

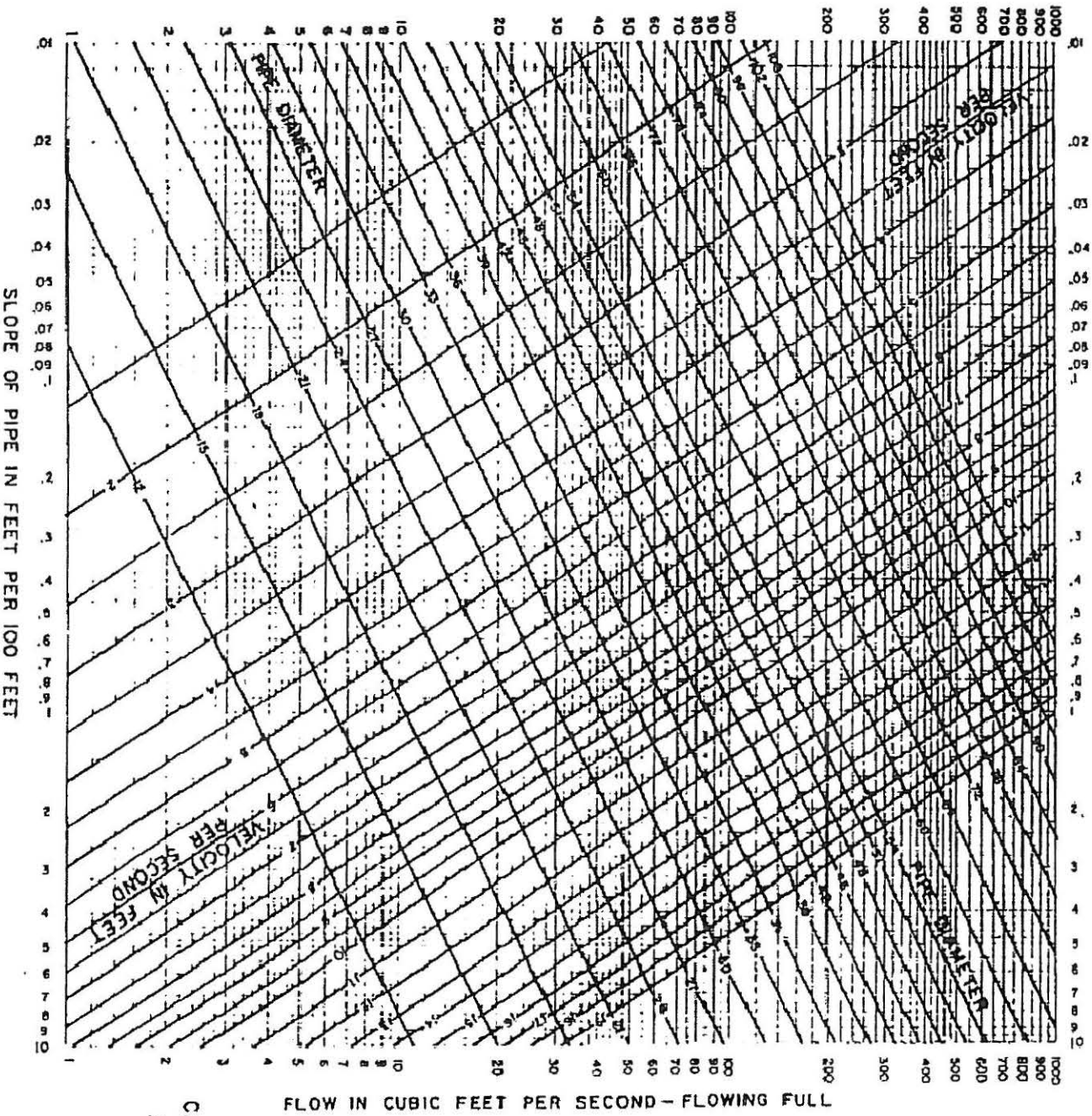
Enter Graph at 14.0 c.f.s.
Intersect $y_o = 0.6'$
Read $L_i = 10.9'$
Use 12' of Inlet; 3'X3'



Standard Drop Inlet Sizes:

2'X2'; Li = 8'
3'X3'; Li = 12'
4'X4'; Li = 16'

DROP INLET CAPACITY CURVES AT LOW POINT

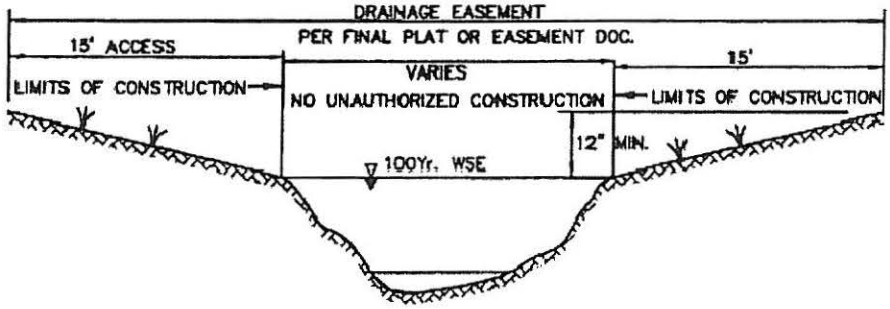


CAPACITY OF CIRCULAR PIPES FLOWING FULL

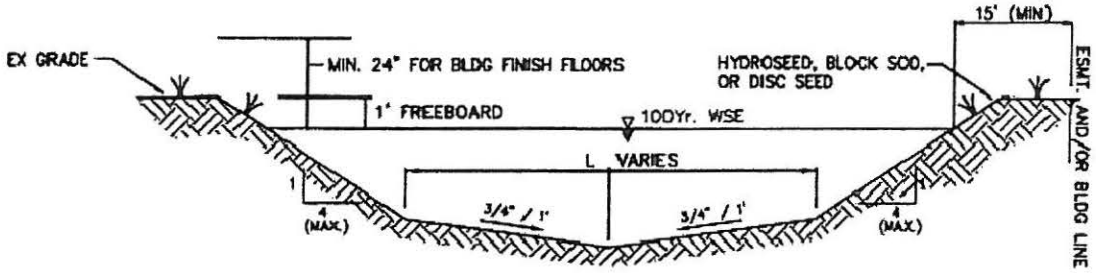
A GRAPHICAL SOLUTION OF MANNINGS EQUATION

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

n = 0.013



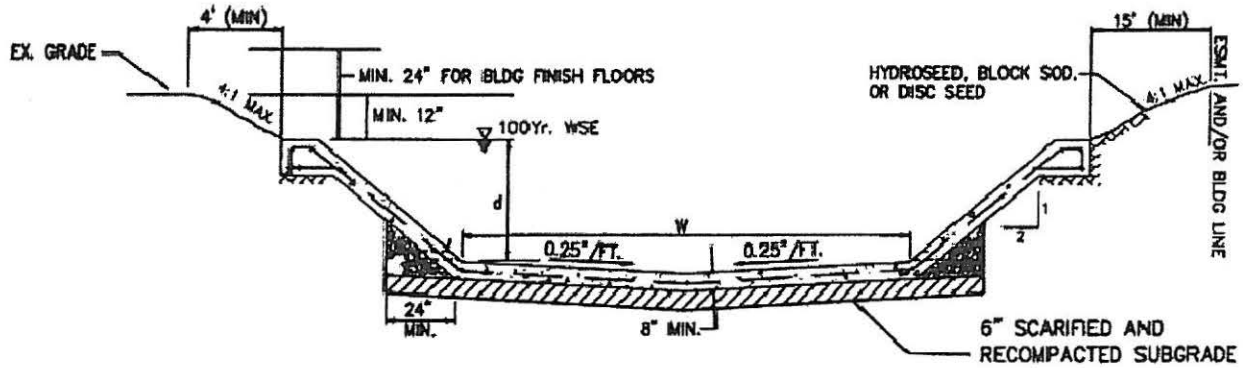
TYPE I – NATURAL CHANNEL



TYPE II – FORMED EARTHEN CHANNEL

N.T.S.

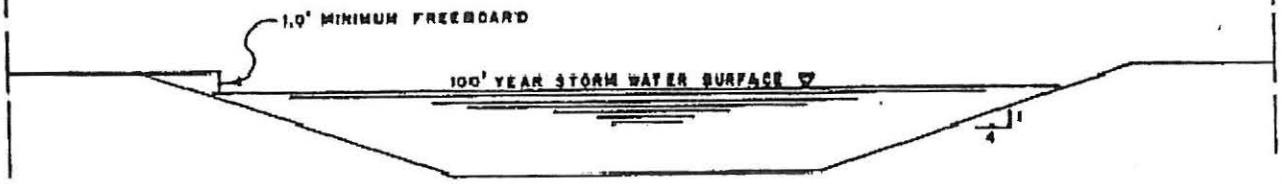
NOTE: DRAINAGE EASEMENT FOR NATURAL CHANNELS SHALL BE SAME FOR FORMED AND CONCRETE CHANNELS. BUILDING FINISH FLOORS SHALL BE AT LEAST 2' ABOVE 100 YR WSEL



TYPE III – REINFORCED CONCRETE CHANNELM

N.T.S.

OPEN CHANNEL WITH PILOT PIPE
ALTERNATIVE TYPE II

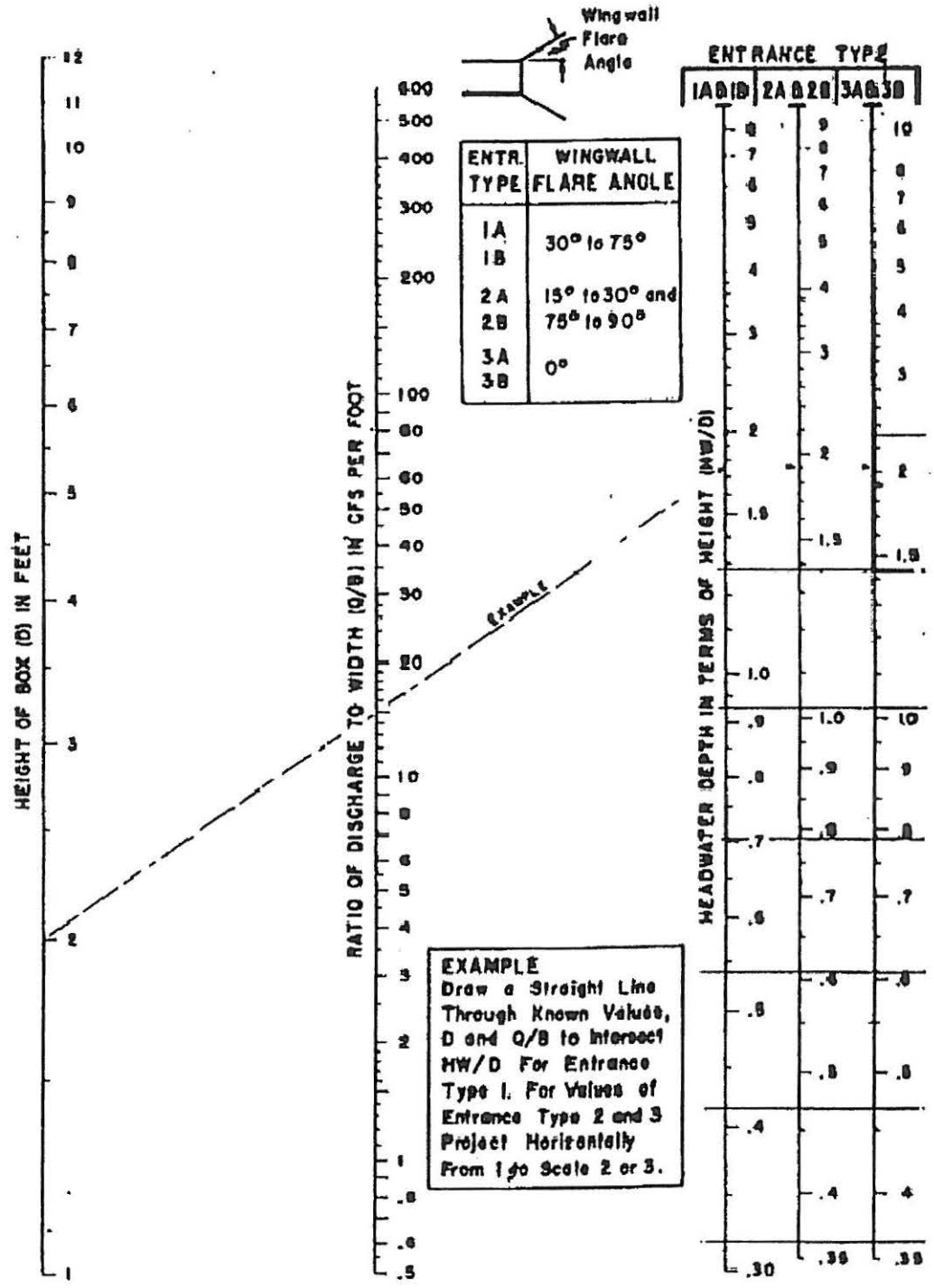


NOTE: Bank slopes and non-encroachment easement requirements same as for Type II.

PIPE SIZED TO CARRY MINIMUM 5-YEAR STORM.
MINIMUM SIZE – 18" DIAMETER

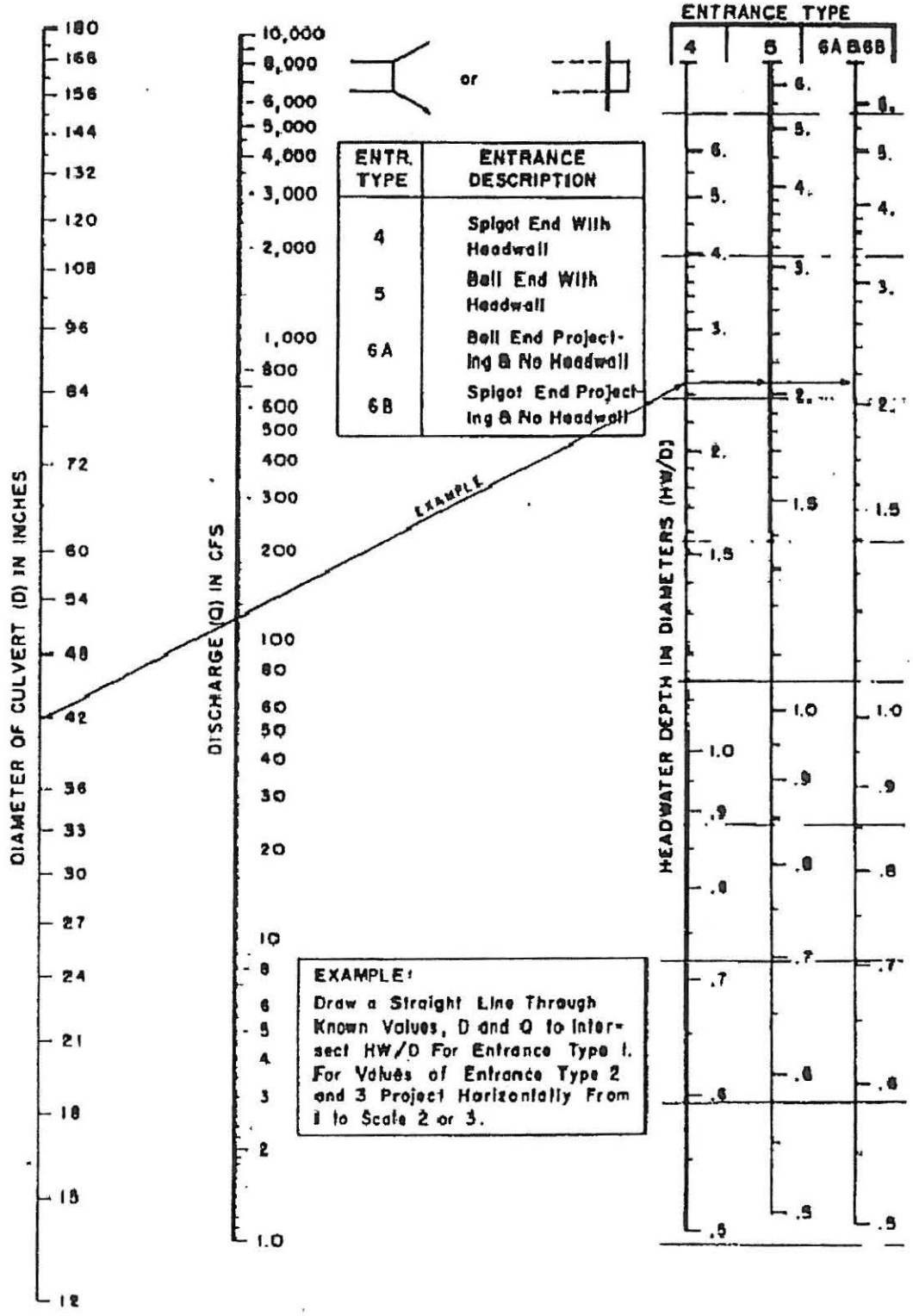
NOTE: There are conditions due to the excessive capacity of the open ditch section where a pilot pipe carrying less than a five-year storm may be used if approved by the Director of Public Works.

ALTERNATE OPEN CHANNEL TYPE II



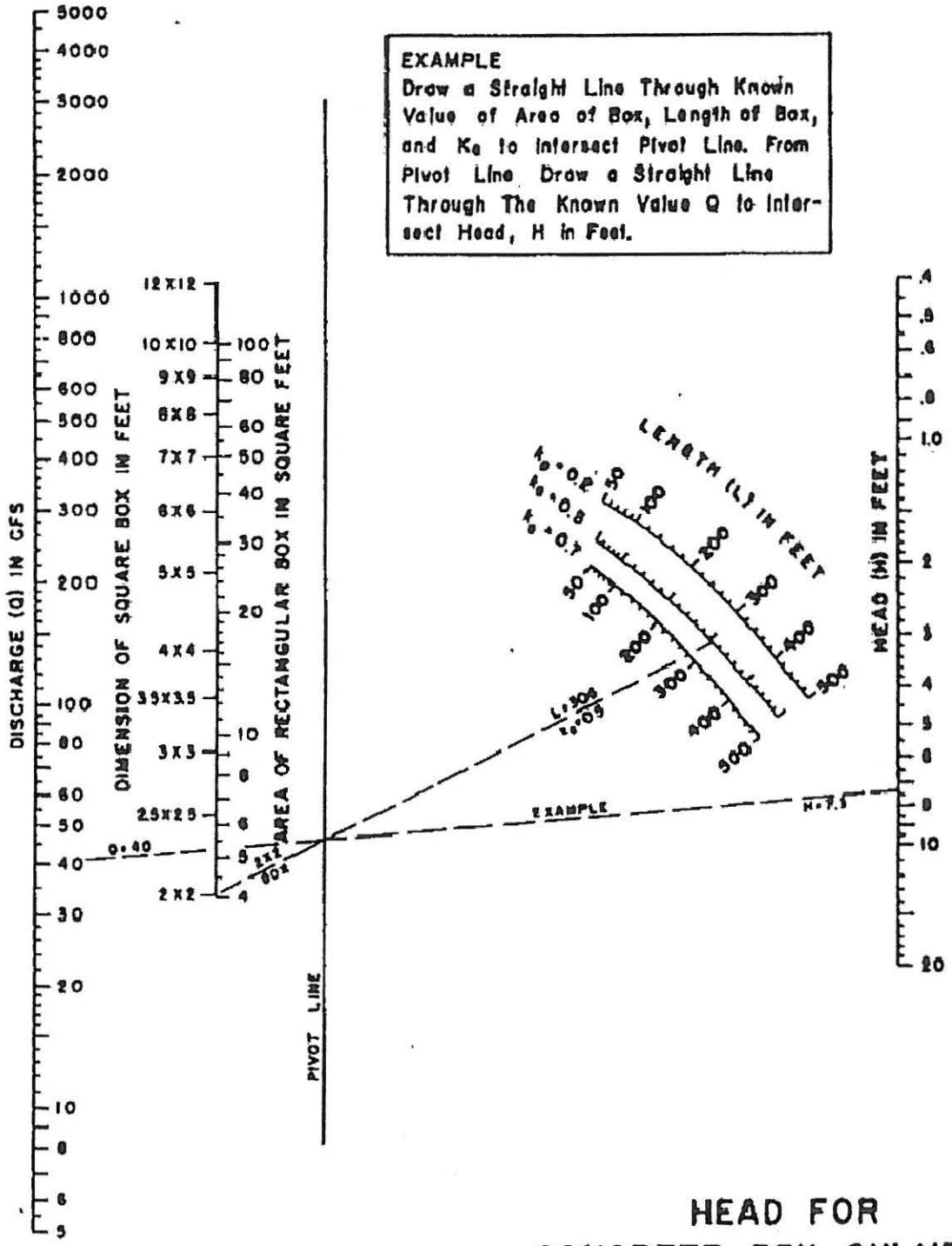
BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR CONCRETE BOX CULVERT WITH INLET CONTROL



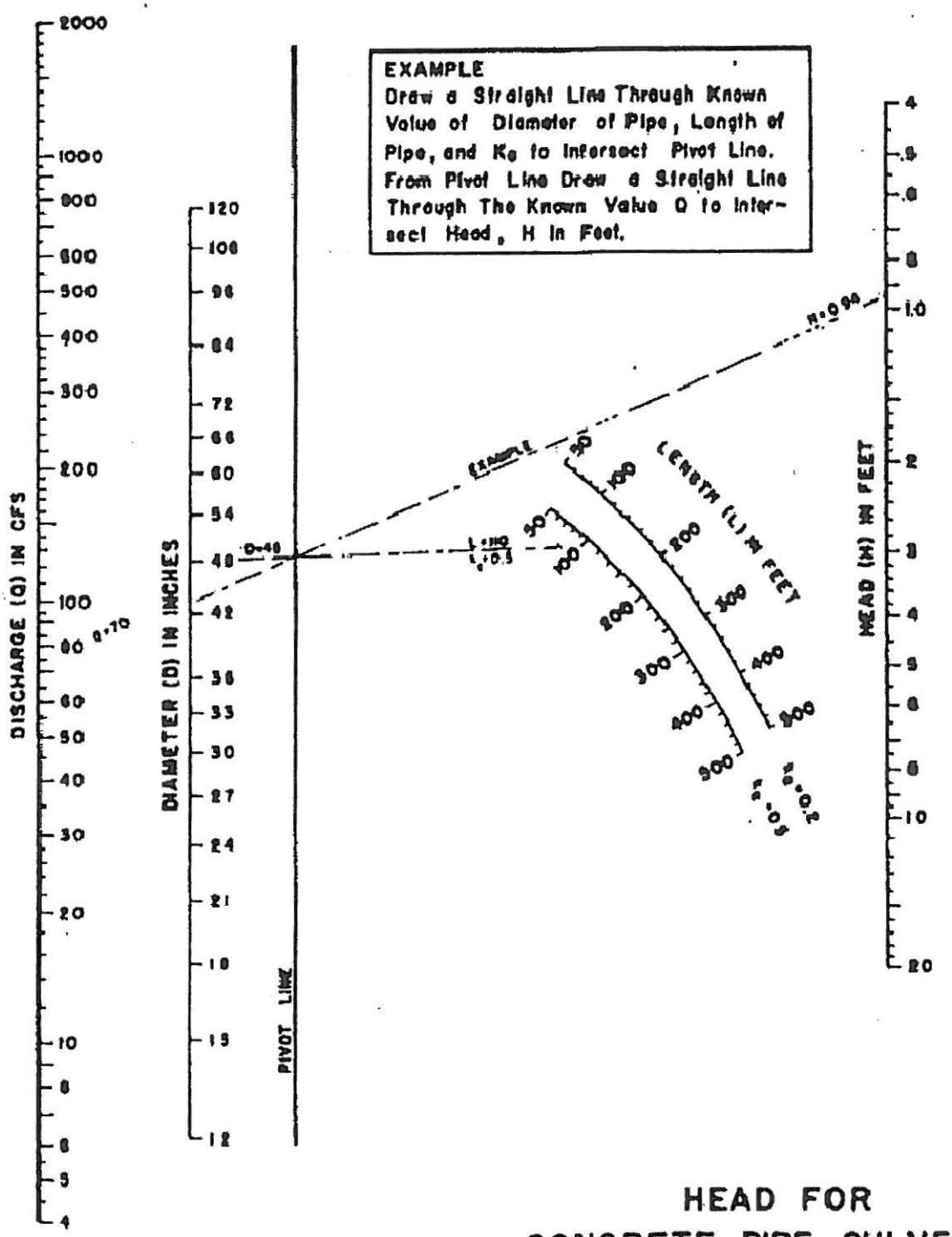
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN 1963



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

n = 0.012



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

EXAMPLE

Known:

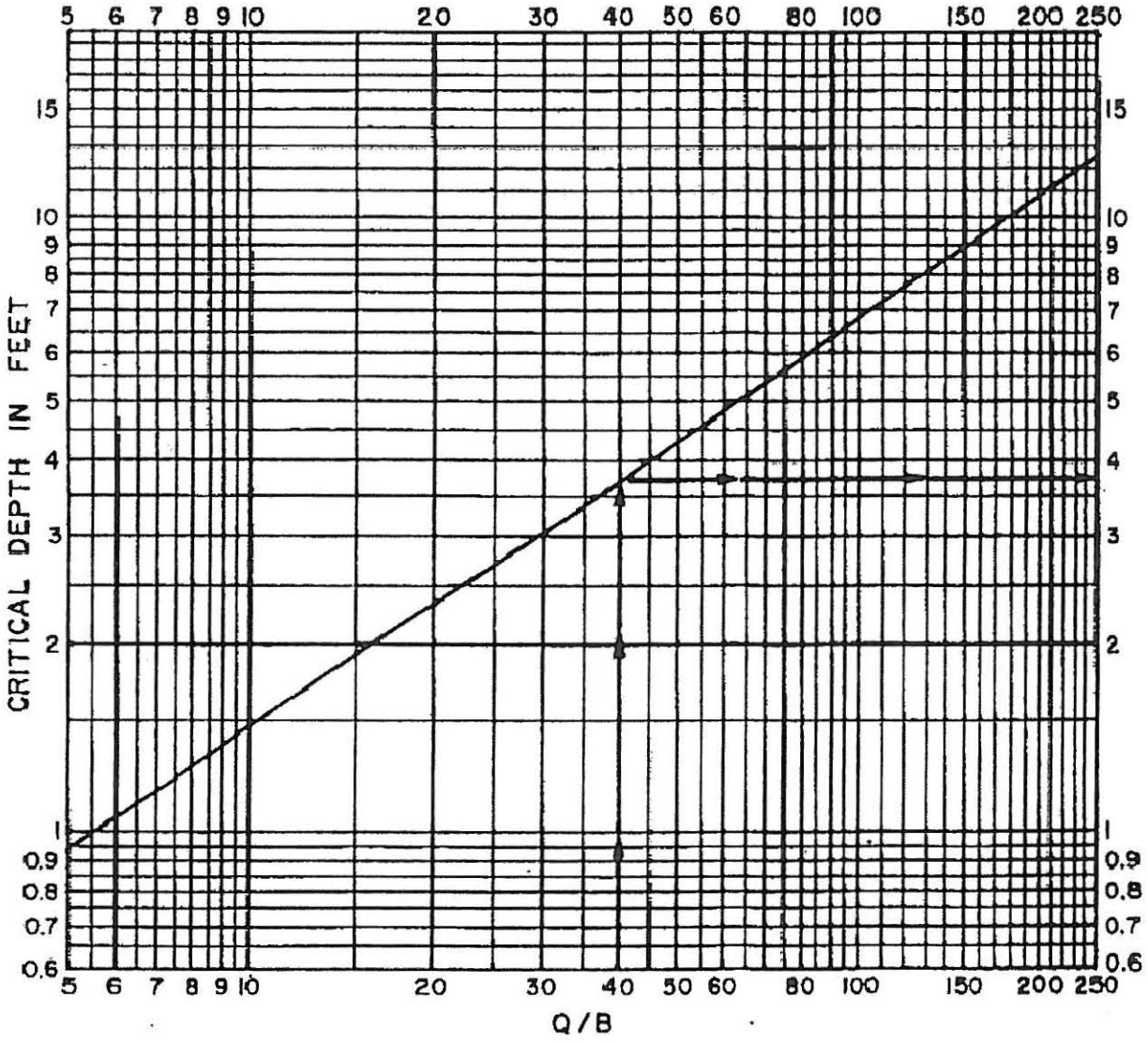
Discharge = 200 c.f.s.
Width of Conduit = 5'
Q/B = 40

Find:

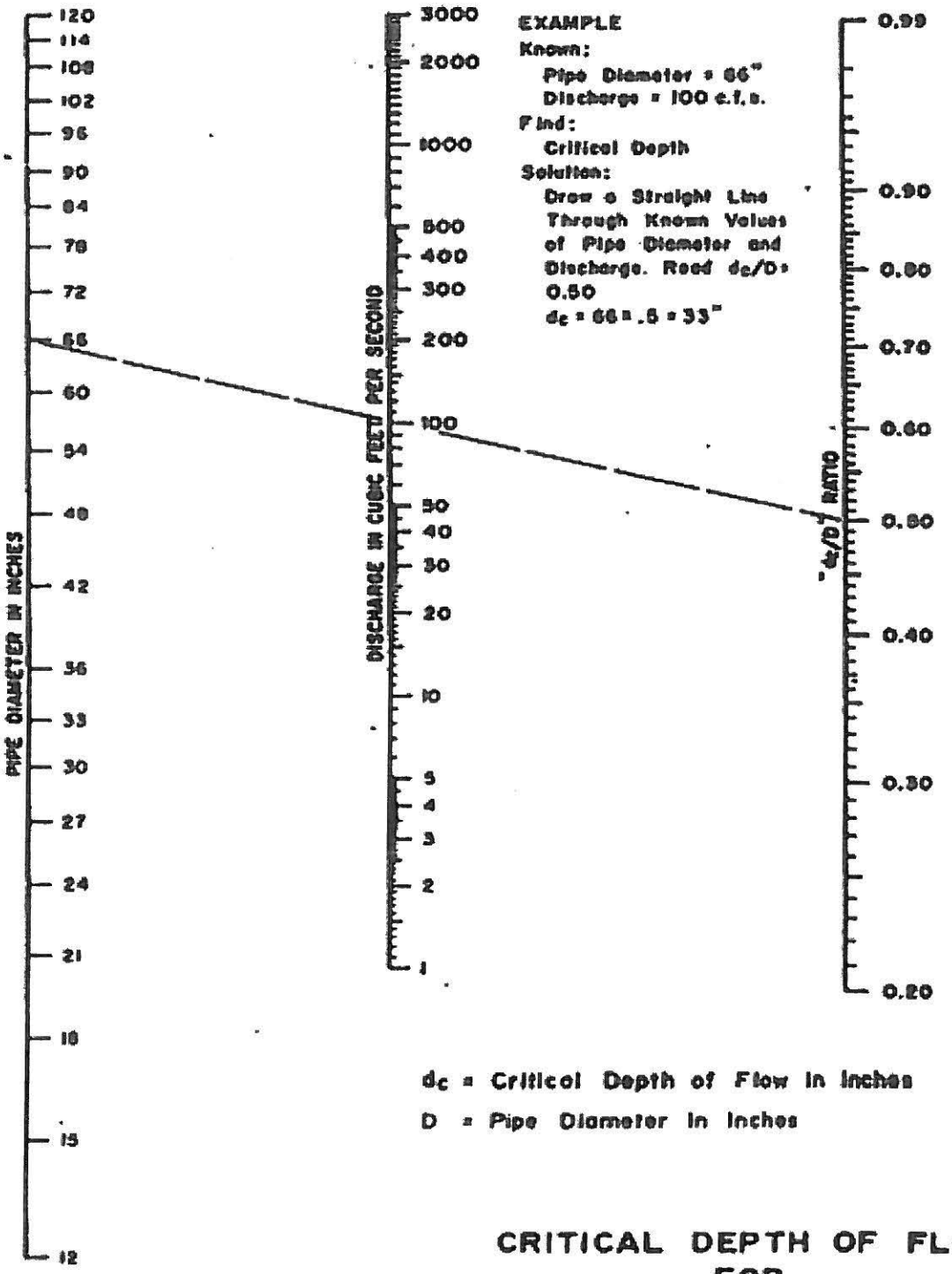
Critical Depth

Solution:

Enter Graph at Q/B = 40
Intersect Critical Depth
at 3.7



CRITICAL DEPTH
OF FLOW FOR
RECTANGULAR CONDUITS



dc = Critical Depth of Flow in Inches

D = Pipe Diameter in Inches

CRITICAL DEPTH OF FLOW FOR CIRCULAR CONDUITS

911.01 LIST OF FORMS

Form

A ..... Storm Water Runoff Calculations

B ..... Inlet Design Calculations

C ..... Storm Sewer Calculations

D ..... Water Surface Profile Calculations

E ..... Open Channel Calculations

F ..... Hydraulic Design of Culverts

G ..... Bridge Design Calculations

NOTE: A copy of each applicable form must be submitted with the drainage plans to the City to review.

STORM WATER RUNOFF CALCULATIONS - FORM "A"

Column 1	Location of the drainage structure for which the runoff calculation is being made or a design point on an open channel.
Columns 2 through 6	Are to be used in calculating runoff by the Rational Method.
Column 2	Obtained from TABLE 1, or FIGURE 2
Column 3	Using the appropriate Design Storm Frequency, and the Time of Concentration in Column 2, the Intensity is obtained from FIGURE 1.
Column 4	Size of the drainage area tributary to the point of design shown in Column 1.
Column 5	Taken from TABLE 1 and is a weighted composite value if several different zoning districts fall within the drainage area.
Column 6	Column 3 multiplied by Columns 4 and 5.
Columns 7 through 19	Are to be used in calculating runoff by the Unit Hydrograph Method.
Column 7	Taken from TABLE 2.
Column 8	Measured distance along the stream course from the upper-most limit of the drainage area to the point of design shown in Column 1.
Column 9	Measured distance along the stream course from the point of design shown in Column 1 to the measured center of gravity of the drainage area.
Column 10	A computed value using the values shown in Columns 7, 8 and 9.
Column 11	Taken from TABLE 2.
Column 12	Column 11 divided by Column 10.
Column 13	Size of the drainage area tributary to the plant of design shown in Column 1.
Column 14	Column 12 multiplied by Column 13.
Column 15	Using the appropriate Design Storm Frequency and a duration of two hours, this value is obtained from FIGURE 1.
Column 16	Obtained by multiplying the value in Column 15 times two.
Column 17	Constant value of 1.11 inches for the Cedar Hill geographic area.
Column 18	Result of subtracting Column 17 from Column 16.
Column 19	Column 14 multiplied by Column 18.
Column 20	The flow used for design depends on the size of the drainage area. If the size of the drainage area is less than 600 acres, Q_R should be entered. If the drainage area is larger than 600 acres and smaller than 1200 acres, the larger of the two flows (Q_R and Q_u) should be entered. If the drainage area is larger than 1200 acres, Q_u should be entered.

CITY OF CEDAR HILL, TEXAS

STORM WATER RUNOFF CALCULATIONS

DESIGN STORM FREQUENCY_____

BY_____

DATE_____

LOCATION	DESIGN FLOW (Q_R) BY RATIONAL METHOD					DESIGN FLOW (Q_u) BY UNIT HYDROGRAPH METHOD													FLOW USED FOR DESIGN
	Time of Concentration (minutes)	Intensity "I" (in./hr.)	Drainage Area "A" (Acres)	Runoff Coefficient "C"	Design Flow $Q_R = C \times I \times A$	Coefficient "C_t"	Length "L" (miles)	Length "L_{ca}" (miles)	Lag Time $t_p = C_t(L \times L_{ca})^{.3}$ (hours)	Coefficient C_p 640	Peak Unit Flow $q_p = \frac{Cp640}{tp}$ (c.f.s./sq.mi.)	Drainage Area "A" (sq. miles)	Peak Flow $Q_p = q_p \times A$ (c.f.s.)	Intensity "I" at 2 Hours (in./hr.)	Design Storm "S_p" = "I" x 2 (inches)	Initial and Subsequent Losses "L_{is}" (inches)	Total Runoff $R_T = S_p - L_{is}$ (inches)	Design Flow $Q_u = R_T \times Q_p$ (c.f.s.)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

900-70

SAMPLE FORM A

INLET DESIGN CALCULATIONS - FORM "B"

Column 1	Inlet number or designation. The first inlet shown is the most upstream.
Column 2	Construction plan station of the inlet.
Column 3	Design Storm Frequency is same as the Design Storm Frequency of the storm sewer.
Column 4	Time of concentration for each inlet is taken from TABLE 1, or FIGURE 2.
Column 5	Using the time of concentration and the Design Storm Frequency, rainfall intensity is taken from FIGURE 1.
Column 6	Runoff Coefficient is taken from TABLE 1 according to the zoning of the drainage area.
Column 7	Area drained by the specific inlet. Care should be taken to keep the drainage area flow separate into the appropriate street gutters.
Column 8	Product of Column 5 multiplied by Columns 6 and 7.
Column 9	If there is any flow which was not fully intercepted by an upstream inlet, it should be entered here.
Column 10	Sum of Columns 8 and 9.
Column 11	Capacity of the street gutter, in which the inlet is located, from either FIGURES 3, 4, 5 or 6. If the total gutter flow shown in Column 10 is in excess of the value in Column 11 the inlet should be moved upstream. If it is substantially less than the value in Column 11, an investigation should be made to see if the inlet can be moved downstream.
Column 12	Street gutter slope to be used in selecting the proper size inlet.
Column 13	Crown type of the street on which the inlet is located.
Column 14	Selected size of the inlet taken from FIGURES 8 through 22.
Column 15	Inlet type taken from FIGURE 7.
Column 16	If the selected inlet does not intercept all of the gutter flow, the difference between the two values should be entered here and in Column 9 of the inlet which will intercept the flow.

CITY OF CEDAR HILL, TEXAS

INLET DESIGN CALCULATIONS

BY _____

DATE _____

INLET		Design Storm	AREA RUNOFF Q = CIA					Carry-Over From Upstream Inlet (c.f.s.)	Total Gutter Flow (c.f.s.)	Gutter Capacity (c.f.s.)	Gutter Slope (ft./100ft.)	Crown Type	SELECTED INLET		Carry-Over To Downstream Inlet (c.f.s.)
No.	Location	Frequency (yrs.)	Time Of Conc. (min.)	Intensity I (in./hr.)	Runoff Coeff. "C"	Area (Ac.)	"Q" (c.f.s.)						Length "Ll" (Feet)	Type	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

900-72

SAMPLE FORM B

STORM SEWER CALCULATIONS - FORM "C"

Column 1	Upstream station of the section of conduit being designed. Normally, this would be the point of a change in quantity of flow, such as an inlet, or a change in grade.
Column 2	Downstream station of the section of conduit being designed.
Column 3	Distance in feet between the upstream and downstream stations.
Column 4	Drainage sub-area designation from which flow enters the conduit at the upstream station.
Column 5	Area in acres of the drainage sub-area entering the conduit.
Column 6	Runoff coefficient, obtained from TABLE 1, based on the characteristics of the subdrainage area.
Column 7	Column 5 multiplied by Column 6.
Column 8	Obtained by adding the value shown in Column 7 to the value shown immediately above in Column 8.
Column 9	This time in minutes is transposed from Column 19 on the previous line of calculations. The original time shall be equal to the time of concentration as shown on TABLE 1 or FIGURE 2, whichever value has been used.
Column 10	Design Storm Frequency.
Column 11	Using the time at the upstream station shown in Column 9 and the Design Storm Frequency shown in Column 10, this value is taken from FIGURE 1.
Column 12	Column 8 multiplied by Column 11.
Column 13	This slope should be computed from the profile of the ground surface. Normally, the hydraulic gradient will have a slope approximately the same as the proposed conduit and will be located above the inside crown of the conduit.
Column 14	Utilizing the values in Columns 12 and 13, a conduit size should be selected. In the case of concrete pipe, FIGURE 23 may be used.
Column 15	Velocity in the selected conduit based on the values in Columns 12, 13 and 14. Taken from FIGURE 23 for concrete
Column 16	Friction head loss is the product of Column 3 times Column 13.
Column 17	Calculation is made utilizing the values of Column 15: V_1 = Upstream Velocity V_2 = Downstream Velocity Head gains shall be taken to zero (0) in the storm sewer design.
Column 18	Calculation is based on the values of Columns 3 and 15.
Column 19	Sum of Columns 9 and 18.
Column 20	Special design comments may be entered here.

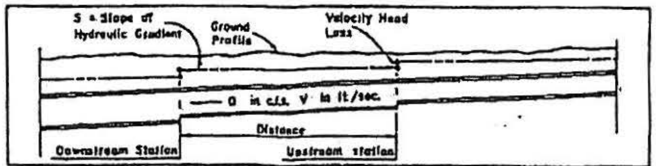
CITY OF CEDAR HILL, TEXAS

____

____

STORM SEWER LINE ______________________________

INITIAL INLET TIME_____MINUTES



STORM SEWER CALCULATIONS

BY ______________________________

DATE ______________________________

RUNOFF COLLECTION POINT (Inlet or Manhole)		Distance Between Collection Points	INCREMENTAL DRAINAGE AREA				Accumulated "CA"	Time at Upstream Station (minutes)	Design Storm Frequency (yrs.)	Intensity "I" (inches/hr)	Storm Water Runoff "Q" (c.f.s.)	Slope of Hydraulic Gradient "S" (ft./ft.)	Selected Storm Sewer Size	Velocity in Sewer Between Collection Points "V" (f.p.s.)	Head Loss Coeff. K_j	Velocity Head Loss at Upstream Station $K_j \frac{V^2}{2g}$ (feet)	Flow Time in Sewer $\frac{\text{Distance}}{V \times 60}$ (minutes)	Time at Downstream Station (minutes)	REMARKS
UPSTREAM STATION	DOWNSTREAM STATION		Area No.	Drainage Area "A" (Acres)	Runoff Coeff. "C"	Incremental "CA"													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

SAMPLE FORM C

WATER SURFACE PROFILE CALCULATIONS - FORM "D"

Column 1	At each point where a water surface elevation is desired, a cross section must be obtained. The sections are numbered and subdivided according to the assigned roughness coefficient.
Column 2	Known or assumed water surface elevation at the particular section.
Column 3	Distance along the channel between sections.
Column 4	Area of sub-section calculated from plotted cross sections.
Column 5	Wetted perimeter of each sub-section exclusive of the water interfaces between adjacent sub-sections.
Column 6	Column 4 divided by Column 5. (Hydraulic Radius)
Column 7	Column 6 raised to 2/3 power.
Column 8	Roughness coefficient for Manning's formula from TABLE 7.
Column 9	Column 4 multiplied by 1.486 and the product divided by Column 8.
Column 10	Column 9 multiplied by Column 7.
Column 11	The total flow shown in the upper left of the calculation form divided by Column 10 and squared, which is the friction slope.
Column 12	Average friction slope between sections.
Column 13	Column 12 multiplied by Column 3.
Column 14	Flow in each individual sub-section. Varies directly with the conveyance factor shown in Column 10. The sum of the values must equal the total flow.
Column 15	Column 14 divided by Column 4.
Column 16	Column 15 squared.
Column 17	Column 16 multiplied by Column 14.
Column 18	Sum of the values in Column 17 of a particular section divided by twice the acceleration of gravity and multiplied by the total flow.
Column 19	Algebraic difference in velocity heads between sections.
Column 20	Eddy losses are calculated as 10 percent of the value of Column 19 when such value is positive and 50 percent of the absolute value of Column 19 when such value is negative.
Column 21	Sum of Column 13, Column 19 and Column 20.
Column 22	The sum of the value shown in Column 2 for the previous section and the value in Column 21. If the elevations calculated for subsequent sections do not agree within a reasonable limit with the assumed elevations shown in Column 2 for that particular section, then the assumed elevations for such section must be revised and the section properties recomputed until the desired accuracy is obtained. An accuracy of $\pm$ 0.3 feet is considered a reasonable limit.

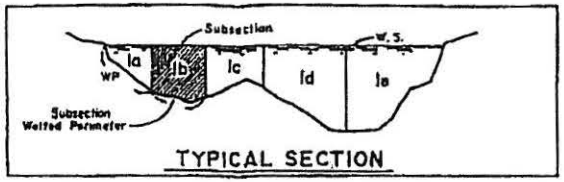
CITY OF CEDAR HILL, TEXAS

_____

_____

OPEN CHANNEL _____

TOTAL FLOW, Q_T = _____ c.f.s.



TYPICAL SECTION

WATER SURFACE PROFILE CALCULATIONS

FOR UNIMPROVED CHANNELS

BY _____

DATE _____

Section and Subsection	Known or Assumed W.S. Elevation	Distance Between Sections "L" (feet)	Subsection Area "A_s" (sq./ft.)	Subsection Wetted Perimeter "WP" (feet)	Subsection Hydraulic Radius "$R = \frac{A}{WP}$"	$R^{2/3}$	Subsection Roughness Coefficient "n"	$\frac{1.486A}{n}$	Conveyance Factor "K": $\frac{1.486A}{n}(R^{2/3})$	Friction Slope "$S_f = \left(\frac{Q_T}{K}\right)^2$" (ft./ft.)	Avg. S_f Between Sections (ft./ft.)	Friction Head Loss Between Sections "h_f" = Avg. S_f(L) (feet)	Subsection Flow "Q_s" (c.f.s.)	Subsection Velocity "$V_s = \frac{Q_s}{A_s}$" (f.p.s.)	V_s^2	$V_s^2(\alpha_s)$	Weighted Velocity Head "$h_v = \frac{\Sigma(V_s^2 Q_s)}{2gQ_T}$" (feet)	Velocity Head Loss "h_{vel}" = $h_{vL} - h_{vE}$ (feet)	Eddy Losses "E_L" = .10(+h_{vel}) or .50(−h_{vel}) (feet)	Total Loss "ΔH" = $(h_f)+(h_{vel})+(E_L)$ (feet)	WATER SURFACE ELEVATION
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

900-76

SAMPLE FORM D

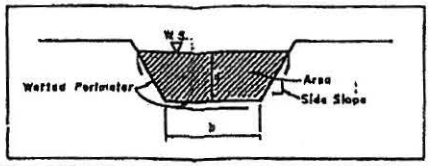
OPEN CHANNEL CALCULATIONS - FORM "E"

Column 1	Downstream limit of the section of channel under consideration.
Column 2	Upstream limit of the section of channel under consideration.
Column 3	Type of channel as shown in FIGURE 24 is entered here.
Column 4	Flow in the section of channel under consideration.
Column 5	Roughness coefficient of the channel cross section taken from TABLE 7.
Column 6	Slope of the channel which is most often parallel to slope of the hydraulic gradient.
Column 7	Square root of Column 6.
Column 8	Calculation is made using the values in Columns 4, 5 and 7.
Column 9	Assumed width of the bottom width of the channel.
Column 10	Assumed depth of flow.
Column 11	Assumed slope of the sides of the channel.
Column 12	Areas of flow which is calculated based on Columns 9, 10 and 11.
Column 13	Wetted perimeter calculated from Columns 9, 10 and 11.
Column 14	Value is calculated from Columns 12 and 13.
Column 15	Column 14 raised to 2/3 power.
Column 16	Product of Column 13 times Column 15. When the value of Column 16 equals the value of Column 8 the channel has been adequately sized. When the value of Column 16 exceeds the value of Column 8 by more than five percent then the channel width or depth should be decreased and another trial section analyzed.
Column 17	Calculation is based on the values of Columns 4 and 12.
Column 18	Calculation is based on Column 17.
Column 19	Remarks concerning the channel section analyzed may be entered.

NOTE: Form "E" should be used only to size open channels. Form "D" should be used to calculate stream profile.

CITY OF CEDAR HILL, TEXAS

OPEN CHANNEL _____



OPEN CHANNEL CALCULATIONS

BY _____

DATE _____

CHANNEL STATION From	CHANNEL STATION To	Channel Type	Flow "Q" (c.f.s.)	Roughness Coeff. "n"	Slope "S" (ft./ft.)	"$S^{1/2}$"	$\frac{Q \times n}{1.486 \times S^{1/2}}$	Width "b" (feet)	Depth "d" (feet)	Side Slope	Area "A" (sq. ft.)	Wetted Perimeter "WP" (feet)	Hydraulic Radius "$R = \frac{A}{WP}$" (feet)	$R^{2/3}$	$A \times R^{2/3}$	Velocity $V = \frac{Q}{A}$ (f.p.s.)	Velocity Head $\frac{V^2}{29}$ (ft.)	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

900-78

SAMPLE FORM E

HYDRAULIC DESIGN OF CULVERTS, FORM "F"

INFORMATION IN UPPER RIGHT OF SHEET:

Culvert Location: .....This is a word description of the physical location.

Length: .....The actual length of the culvert.

Total Discharge, QT: .....This is the flow computed on FORM "A".

Design Storm Frequency: ....Obtained from TABLE 1 and used on FORM "A".

Roughness Coefficient, n: ....Obtained from TABLE 5.

Maximum Velocity: .....Obtained from TABLE 4.

Tailwater: .....This is the design depth of water in the downstream channel and is obtained in connection with the channel design performed on FORM "D" or FORM "E".

D. S. Channel Width: .....This is the bottom width of the downstream channel obtained from the calculations on FORM "E". The culvert should be sized to approximate this width whenever possible.

Entrance Description: .....This is a listing of the actual condition as shown in the "Culvert Entrance Data" shown on the calculation sheet.

Roadway Elevation: .....The elevation of the top of curb at the upstream end of culvert.

U. S. Culvert F. L.: .....The flow line of the culvert at the upstream end.
Difference: .....The difference in elevations of the roadway and the upstream flow line.

Required Freeboard: .....The vertical distance required for safety between the upstream design water surface and the roadway elevation or such other requirements which may occur because of particular physical conditions.

Allowable Headwater: .....This is obtained by subtracting the freeboard from the difference shown immediately above.

D.S. Culvert F.L.: .....The flow line elevation of the downstream end of the culvert.

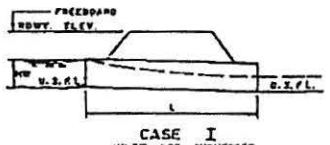
Culvert Slope, So: .....This is the physical slope of the structure calculated as indicated.

Columns 1 through 10 deal with selection of trial culvert size and are explained as follows:

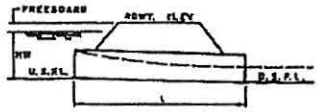
Column 1	Total design discharge, Q, passing through the culvert divided by the allowable maximum velocity gives trial total area of culvert opening.
Column 2	Culvert width should be reasonably close to the channel bottom width, W, downstream of the culvert.
Column 3	Lower range for choosing culvert depth is trial area of culvert opening, Column 1, divided by channel width, Column 2.
Column 4	Allowable headwater obtained from upper right of sheet.
Column 5	Trial depth, D, of culvert corresponding to available standard sizes and between the numerical values of Columns 3 and 4.
Columns 6, 7 and 8 are solved simultaneously based on providing a total area equivalent to the trial area of opening in Column 1.	
Column 6	Number of culvert openings.
Column 7	Inside width of one opening.
Column 8	Inside depth of one opening if culvert is box structure or diameter if culvert is pipe.
Column 9	Column 6 multiplied by Column 7 and Column 8.
Column 10	Total discharge divided by number of openings shown in Column 6.
Columns 11 through 15 (Inlet Control) and 16 through 27 (Outlet Control) deal with Headwater Calculations which verify hydraulics of trial culvert selected and are explained as follows:	
Column 11	Obtained from upper right of sheet.
Column 12	When the allowable headwater is equal to or less than the value in Column 8, enter Case I. When the allowable headwater is more than the value in Column 8, enter Case II.
Column 13	Column 10 divided by Column 7.
Column 14	Obtained from FIGURE 25 for box culverts or FIGURE 26 for pipe culverts.
Column 15	Column 14 multiplied by Column 8.
Column 16	Obtained from upper part of sheet.
Column 17	Obtained from FIGURE 27 for box culverts and FIGURE 28 for pipe culverts.
Column 18	Tailwater depth from upper right of sheet.
Column 19	So, culvert slope, multiplied by culvert length, both obtained from upper right of sheet.
Column 20	Sum of Columns 17 and 18 minus Column 19.

Column 21	Obtained from FIGURE 27 for box culverts and FIGURE 28 for pipe culverts.
Column 22	Critical depth obtained from FIGURE 29 for box culverts and FIGURE 30 for pipe culverts.
Column 23	Sum of Columns 22 and 8 divided by two.
Column 24	Tailwater depth from upper right of sheet.
Column 25	Enter the larger of the two values shown in Column 23 or Column 24.
Column 26	Previously calculated in Column 19 and may be transposed.
Column 27	The sum of Columns 21 and 25 minus Column 26.
Column 28	Enter the larger of the values from either Column 15, Column 20 or Column 27. This determines the controlling hydraulic conditions of the particular size culvert investigated.
Column 29	When the Engineer is satisfied with the hydraulic investigations of various culverts and has determined which would be the most economical selection, the description should be entered.

INLET CONTROL

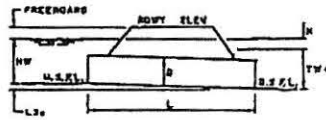


CASE I
INLET NOT SUBMERGED

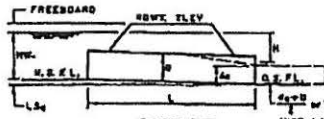


CASE II
INLET SUBMERGED

OUTLET CONTROL



CASE III
OUTLET SUBMERGED



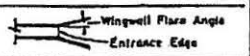
CASE IV
OUTLET NOT SUBMERGED

TYPICAL BOX CULVERT

TYPICAL PIPE CULVERT

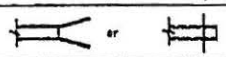
CULVERT ENTRANCE DATA

CONCRETE BOX CULVERT



TYPE	FLARE ANGLE	ENTRANCE EDGE	K_e
1A	30° to 75°	Square	0.4
1B	30° to 75°	Round	0.3
2A	15° to 30° & 75° to 90°	Square	0.5
2B	15° to 30° & 75° to 90°	Round	0.3
3A	0° (Extension of Sides)	Square	0.7
3B	0° (Extension of Sides)	Round	0.5

CONCRETE PIPE



TYPE	ENTRANCE DESCRIPTION	K_e
4	Spigot End With Headwall	0.5
5	Bell End With Headwall	0.2
6A	Bell End Projecting With No Headwall	0.3
6B	Spigot End Projecting With No Headwall	0.6

CULVERT DESIGN CALCULATIONS

CITY OF CEDAR HILL, TEXAS

CULVERT LOCATION _____

_____ LENGTH, L _____

TOTAL DISCHARGE, Q _____ DESIGN STORM FREQ. _____

ROUGHNESS COEFF., n _____ MAX. VEL. _____

TAILWATER _____ D. S. CHANNEL WIDTH _____

ENTRANCE DESCRIPTION _____

ROWY. ELEV. _____ U.S. CULV. F.L. _____

U.S. CULV. F.L. _____ D.S. CULV. F.L. _____

DIFFERENCE _____ DIFFERENCE _____

REQD. FREEBOARD _____ FT. CULV. SLOPE, $S_o = \frac{\text{DIFF. FT.}}{\text{LENGTH FT.}}$

ALLOW. HEADWATER _____ FT. Use _____

TRIAL CULVERT										HEADWATER CALCULATION																		The Greater Corresponding Head Water (Inlet or Outlet) (Feet)	SELECTED CONDUIT SIZE
										INLET CONTROL (See Figure 25&26)					OUTLET CONTROL (See Figure 27, 28, 29, & 30)																
																CASE III $HW = H + TW - L \pm S_o$ (feet)					CASE IV $HW = H + h_o - L \pm S_o$ (feet)											
Trial Area of Opening $\frac{Q}{V_{max.}} = A_o$ (sq. ft.)	Channel Width "W" (feet)	DEPTH RANGE D. R. $\frac{1.5 A_c}{W}$ (feet)	AHW (feet)	Try Depth "D" (feet)	POSSIBLE CULVERT SIZES No. Openings	Width of Box "B" (feet)	Box Depth or Pipe Dia. "D" (feet)	Total Culvert Area "A_c" (sq. ft.)	"Q" Each Opening (c.f.s.)	Entrance Type	Case No.	$\frac{Q}{U}$ (c.f.s.)	$\frac{HW}{D}$ (Figure 25&26)	HW	Entrance Coeff. K_e	"H" (feet) (Figure 27&28)	"TW" (feet)	$L \pm S_o$ (feet)	"HW" (feet)	"H" (feet) (Figure 27&28)	$h_o = \frac{d_c+D}{2}$ or h_o = TW (use larger) $\frac{d_c}{2}$ (Figure 29&30) (feet)	$\frac{d_c+D}{2}$ (feet)	TW (feet)	h_o (feet)	$L \pm S_o$ (feet)	"HW" (feet)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

BRIDGE DESIGN CALCULATIONS - FORM "G"

Columns 1 & 2	Obtained from calculations on FORM "A".
Column 3	Assume an average velocity that is less than the maximum allowable velocity and more than 4 feet per second. Maximum velocities are equal to those specified for open channels.
Column 4	Total flow as shown on upper part of sheet divided by Column 3.
Column 5	Column 4 divided by Column 2.
Column 6	Selected bridge length utilizing standard span lengths.
Column 7	Calculated from bridge and channel geometrics.
Column 8	Total flow through bridge divided by Column 7.
Column 9	Selected head loss coefficient based upon specific conditions.
Column 10	Calculated utilizing values in Columns 8 and 9.

CITY OF CEDAR HILL, TEXAS

BRIDGE DESIGN CALCULATIONS

_____

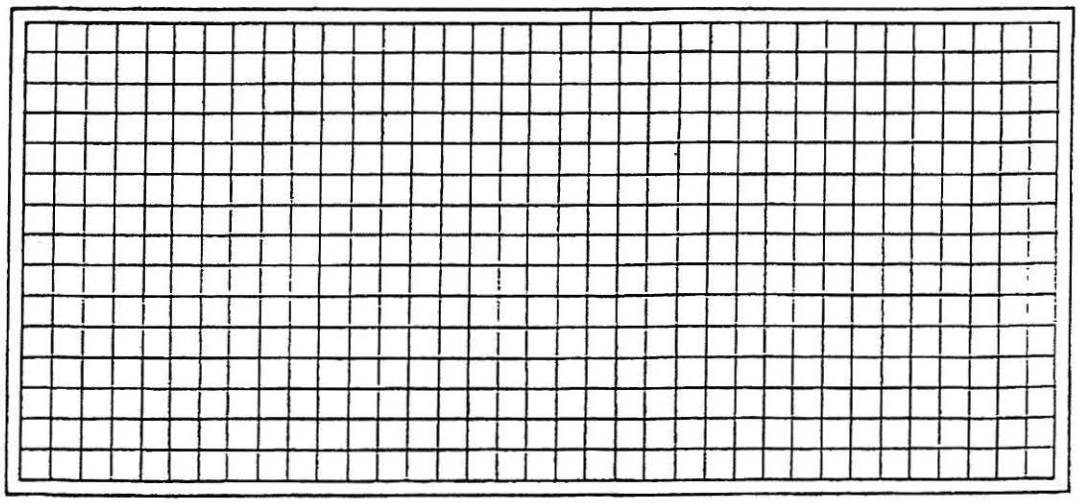
_____

Q= _____

BY _____

DATE _____

Velocity in Downstream Channel "V_c" (f.p.s.)	Depth of Flow in Downstream Channel "D_c" (feet)	Trial Velocity through Bridge "V_T" (f.p.s.)	Trial Opening Area "A_T"$=\frac{Q}{V_T}$ (sq./ft.)	Trial Length of Opening "L_T"$=\frac{A_T}{D_c}$ (feet)	Actual Length of Opening "L" (feet)	Actual Area of Opening Below Highwater "A" (sq./ft.)	Actual Velocity through Bridge "V"$=\frac{Q}{A}$ (f.p.s.)	Head Loss Coefficient "K_b"	Head Loss through Bridge "h_f"$=K_b\left(\frac{V^2}{2g}\right)$ (feet)
1	2	3	4	5	6	7	8	9	10



APPENDIX A

CITY OF
CEDAR HILL
PUBLIC WORKS

PUBLIC WORKS
PRE-CONSTRUCTION PACKET

Revised December 2011

PUBLIC WORKS
PRE-CONSTRUCTION PACKET

Table of Contents

	Page #
Overview	3
Pre-Construction Agenda	4
Pre-Construction Checklist	6
Confirmation Receipt	7
Permit Application for Public Improvements	8
Contact List	9
ROW Checklist	10
ROW Permit (Right-of-Way)	11
Early Release Request	13
TDLR Flow Chart (TPDES General Permit)	14
Approved Materials List	15
Sample Forms	
Final Acceptance Checklist	16
Private Development Agreement	17
Certificate of Insurance	20
Payment Bond	21
Performance Bond	24
Maintenance Bond	27
Cost Estimate Breakdown	29

PUBLIC WORKS
PRE-CONSTRUCTION PACKET

OVERVIEW

- The purpose of the Pre-Construction Meeting is to ensure that all required documents are received and accepted prior to construction. It is also an opportunity for the contractors to meet with the City inspector(s) and Public Works officials that will be involved during the construction of the project. The pre-construction packet contains a checklist, agenda, required forms and sample documents. These documents will assist the contractor in the submission of the required items prior to construction. Questions pertaining to the submission of these items should be discussed and resolved prior to or during the pre-construction meeting.
- It is to the contractor's advantage to submit these documents for review prior to the pre-construction meeting. Pending items must be resolved during the meeting or within two weeks of the meeting or the contractor will be required to schedule another pre-construction meeting. No project will be permitted to start until all required documents are received and accepted.
- If there are changes to any of the documents during the construction of a project it will be the responsibility of the contractor to notify the City in writing within 30-days.
- The contractor or project representative present at the pre-construction meeting will be required to sign a confirmation receipt acknowledging that all items were reviewed and that the City's expectations were made clear during that meeting.

CITY OF CEDAR HILL
PUBLIC WORKS

285 Uptown Blvd., Cedar Hill, TX 75104
Phone: 972-291-5126
Facsimile: 972-291-7250

PRE-CONSTRUCTION AGENDA

DATE:			
PROJECT NAME:			
CASE #		PW #	

A. Introductions – Attendees sign-in
B. Outstanding pre-construction items: review submitted items against checklist
C. Construction schedule – construction start dates and projected end date
D. Equipment and material deliveries
   a. Staging site location and limits of construction confirmed
   b. Materials must meet City approved material list: Submit manufacturer's certifications and cut sheets on non-standard items for approval by City
   c. Alternate equipment & materials
E. Construction Standards
   a. OSHA requirements (Competent Person).
   b. No more than 100' of trench shall be open at any given time and orange safety fencing shall be utilized for trench left open during non-working hours.
   c. Job site conditions shall be routinely kept clean; sanitary conveniences required on site and off any paved surfaces.
   d. All water required for construction, including flushing, shall be metered by a City construction meter available at the Public Works Service Center. Deposit required and should be paid for at the Utility Billing offices at the Government Center prior to picking up a construction meter. Water metered during the project shall be paid for by the contractor.
   e. 24 hour advance notice to City Engineer or his representative prior to starting construction.
   f. Approved plans and City Standard Details to be kept onsite at all times.
   g. As-Built/Record plans to be kept onsite and updated at all times.
   h. 48 hour advance notice to residents/business owners for water shut-off, driveway closure, access limitations (city personnel may assist if given 48 hour notice)
   i. Work zone delineation per Texas Manual of Uniform Traffic Control Devices - TMUTCD
   j. Street repair per Standard Details
      - Open cutting of public streets is prohibited.
   k. Pavement preservation techniques shall be utilized (no track equipment on pavement)
   l. Material Testing Labs shall be scheduled 48 hours in advance and set up through the city inspector.
      - Overtime for inspectors to be paid by Contractor.
F. Personnel on site:
   a. Roster of emergency contacts – must include phone numbers
   b. Compliance with SWPPP at all times
   c. Laborers shall not loiter on private property (no littering or using private hose bibs, etc.)
   d. Adequate personnel on site each working day
   e. Safety First
G. Coordination with local, state, federal and other agencies
   a. Fire & Police Dept.'s (Dispatch #: 972-223-6111)
H. Invoice/Payment Application Submittals
I. Revisions to projects, change orders: changes must be submitted in writing to Public Works for approval and must be identified on contractor's as-builts/record drawings
J. Inspection and daily construction reports
K. Final acceptance issues: refer to the Final Acceptance Checklist (NEW ITEMS: Evaluation Forms)
L. Questions regarding plans/specifications
M. Assign action items
N. TPDES Flow Chart (attached in Packet)
O. TLDR Certification (if required)
P. Provide copies of documents to the contractor
Q. Have contractor sign the Confirmation Receipt – provide a copy to the contractor

CITY OF
CEDAR HILL
PUBLIC WORKS

285 Uptown Blvd., Cedar Hill, TX 75104
Phone: 972-291-5126
Facsimile: 972-291-7250

Pre-Construction notes for **PW#**_____

NOTES: _____

CITY OF CEDAR HILL
PUBLIC WORKS

285 Uptown Blvd., Cedar Hill, TX 75104
Phone: 972-291-5126
Facsimile: 972-291-7250

PRE-CONSTRUCTION CHECKLIST

DATE:			
PROJECT NAME:			
CASE #		PW #	

Req.	Recv'd Date:	Requirement:	Accepted by:
		Permit Application for Public Improvements	
		List of Contractors – must include contact information	
		Letter from Planning Dept. stating that the Final Plat has been executed and filed with the County and all conditions are met.	
		Letter from Planning Dept. stating that the Site Plan has been approved	
		Filed Easements for off-site work	
		Early Release Request	
		Payment of Pro Rata	
		Payment of 3.5% Inspection Fee	
		Escrow for sidewalks	
		Original Certificate of Insurance *$1,000,000 general liability per occurrence (Ord. Sec. 19.21(b)8)*	
		Private Development Agreement between Owner & General Contractor (in General Contractor's name)	
		Performance Bond (in General Contractor's name) - provide proof of license in State of Texas	
		Payment Bond (in General Contractor's name) - provide proof of license in State of Texas	
		Unit Breakdown of Construction Cost – in City format	
		Construction Documents – First original set signed by City Then the owner shall provide (3) full size and (5) reduced (11 x 17) sets signed copies to the City. Additional signed copies shall be provided by the owner to contractor and others deemed necessary for their use. Only signed copies of the plans are authorized in the field	
		Provide concrete batch designs; 1 for machine finish and 1 for hand finish	
		Sealed geotechnical report for lime stabilization under city paving	
		Trench Safety Affidavit	
		Traffic Control Plan	
		Completed NOI (EPA's Notice of Intent) and SWPPP if req.	
		L.O.M.R.	
		Escarpment Development Plan	
		TxDOT coordination letter / Permit Approved	
		City ROW Permit (Right-of-way) *Any staging outside of City ROW requires a letter from affected property owner	
		Submittals / Approved Materials List	

CITY OF
CEDAR HILL
PUBLIC WORKS

PW #_____

CONFIRMATION RECEIPT

By signing the document you are acknowledging that the following items were reviewed with you during the pre-construction meeting and that copies have been provided to you:

- Pre-Construction Agenda
- Pre-Construction Checklist
- Final Acceptance Checklist
- ROW Permit
- Early Release Request (if applicable)
- Sample Copy of the Final Acceptance Checklist
- Sample copy of the Standard Form of Agreement
- Sample copy of the Certificate of Insurance
- Sample copy of the Payment Bond
- Sample Copy of the Performance Bond
- Sample Copy of the Maintenance Bond
- Sample Copy of the Cost estimate breakdown
- Copy of the sign-in sheet (provided at the end of the meeting)

Additional items that were reviewed and/or additional items that you have received as part of the pre-construction meeting:

- _____
- _____
- _____
- _____

Acknowledgement:

_____ _____

Printed Name Signature

_____

Date

PERMIT APPLICATION FOR PUBLIC IMPROVEMENTS

(Private Development Only)

CEDAR HILL
PUBLIC WORKS

1. DATE: _____ PW #_____

2. PROJECT NAME: _____

3. DATE PLAT APPROVED: _____

4. OWNER'S NAME: _____

   ADDRESS: _____

   CITY:_____ STATE:_____ ZIP:_____

   PHONE: _____ FAX: _____ Email: _____

5. AMOUNT OF WATER IMPROVEMENTS TO BE DONE $_____
   (Attach Proposal Tabulation sheet with unit breakdown)
6. AMOUNT OF SEWER IMPROVEMENTS TO BE DONE $_____
   (Attach Proposal Tabulation sheet with unit breakdown)

7. **SUBTOTAL (LINES 1 & 2)** $_____

8. AMOUNT OF DIRT WORK FOR PAVING, EROSION CONTROL & DRAINAGE IMPROVEMENTS TO BE DONE
   (Attach Proposal Tabulation sheet with unit breakdown) $_____

9. AMOUNT OF DRAINAGE IMPROVEMENTS TO BE DONE $_____
   (Attach Proposal Tabulation sheet with unit breakdown)
10. AMOUNT OF PAVING IMPROVEMENTS TO BE DONE $_____
    (Attach Proposal Tabulation sheet with unit breakdown)

11. **SUBTOTAL (LINES 8 TO 10)** $_____

12. **GRAND TOTAL** $_____

13. ATTACHED IS A CHECK IN THE AMOUNT OF $_____, THE TOTAL OF * 3.5% OF LINE 7 _____ PLUS ** 3.5% OF LINE 11 _____.

14. 3 SETS OF APPROVED CONSTRUCTION PLANS HAVE BEEN PROVIDED

I hereby certify that I have read and examined this application and know the same to be true and correct. All provisions of laws and ordinances governing this type of work will be complied with whether specified herein or not. The granting of a permit does not presume to give authority to violate or cancel the provisions of any other state or local law regulating construction or the performance of construction.

_____
Applicant Name (Print)

_____ _____
Signature Date

PW#_____

CONTRACTOR CONTACT LIST

1. General Contractor_____

   Address: _____

   Work to be performed _____

   Phone: _____Emergency Phone: _____

2. Sub-Contractor: _____

   Address: _____

   Work to be performed _____

   Phone: _____Emergency Phone: _____

3. Sub-Contractor: : _____

   Address: _____

   Work to be performed _____

   Phone: _____Emergency Phone: _____

4. Sub-Contractor: _____

   Address: _____

   Work to be performed _____

   Phone: _____Emergency Phone: _____

5. Sub-Contractor: : _____

   Address: _____

   Work to be performed _____

   Phone: _____Emergency Phone: _____

RIGHT OF WAY PERMIT FOR NEW CONSTRUCTION CHECKLIST
DATE: _____

- ☐ **CURRENT LIABILITY INSURANCE ($1,000,000 min.)**
- ☐ **CONSTRUCTION PERMIT ISSUED BY THE CITY**
- ☐ **EMERGENCY 24 HR CONTACT INFORMATION**
- ☐ **3' x 3' PROJECT SIGN WITH PERMITTEE'S AND CONTRACTOR'S NAME, TELEPHONE NUMBER**
- ☐ **ENGINEEREDTRAFFIC CONTROL PLAN WHERE APPLICABLE (must be sealed by a registered professional engineer)**
- ☐ **TRENCH SAFETY PLAN**
- ☐ **THREE (3) COPIES OF PLANS WHERE THE WORK IS TO BE PERFORMED. PLANS SHALL CONTAIN THE FOLLOWING:**
  1. **Approximate location and route of proposed facilities**
  2. **Description of project, limits of construction and impact on existing City of Cedar Hill facilities and traffic control**
  3. **Show scale, name(s) of adjacent streets/intersections, north arrow and a legend for symbols used in the plans**
  4. **Details for proposed manholes, access points, pavement cuts, repairs to pavement, bores, trenches, electrical or signal facilities**

CEDAR HILL
PUBLIC WORKS

CITY OF CEDAR HILL

PUBLIC WORKS DEPARTMENT – ENGINEERING DIVISION

TRACKING NO

_____

ASSIGNED BY PUBLIC WORKS DEPT

PERMIT

PERMIT NO

_____

ASSIGNED BY PUBLIC WORKS DEPT

PERMIT MUST BE APPROVED PRIOR TO COMMENCING WORK
48 HOURS NOTICE IS REQUIRED FOR CITY LINE LOCATES
PERMIT NUMBER IS REQUIRED
FOR LINE LOCATE REQUESTS CALL (972) 291 - 5126

LINE LOCATE TRACKING NO

_____

ASSIGNED BY PUBLIC WORKS DEPT

EMERGENCY? YES ☐ NO ☐ If Yes, Describe: _____

LOCATES NEEDED?: ☐ WATER/SEWER ☐ SIGNS/SIGNALS **Line locates must be complete prior to project start date.**

- Failure to fill in ALL information may result in delay of permit approval.
- Three sets of plans MUST be submitted with this application.
- The Inspector MUST be notified prior to starting and at the completion of the job.
- Failure to obtain a permit, show proof of permit or violation of special conditions may result in a citation and/or fines.
- Contact the City of Cedar Hill Public Works office at (972)291-5126 to request marking of existing City utility lines.
- This permit will expire on the project completion date listed below – if a project exceeds the estimated completion date the contractor MUST apply for a new permit.
- Permit will be voided if work does not commence within 10 days of permit approval. *
- Read the "Conditions of the Permit" on the reverse side, sign and date at the bottom – failure to do so may delay permit approval
- Permit Does Not Relieve The Owner/Contractor The Responsibility Of Contacting Dig Tess and Other Utility Owners.

DATE OF APPLICATION: _____

PERMITEE: _____
CONTRACTOR COMPANY NAME ADDRESS CITY STATE ZIP COMPANY PHONE NUMBER

CONTACT FOR PERMITEE: _____ PHONE: _____ FAX: _____
NAME DIRECT NUMBER

CONTRACTING PARTY: _____
UTILITY OWNER COMPANY NAME ADDRESS CITY STATE ZIP COMPANY PHONE NUMBER

CONTACT FOR CONTRACTING PARTY: _____ PHONE: _____
NAME DIRECT NUMBER

DEVELOPMENT: _____
PROJECT NAME ADDRESS

EMERGENCY CONTACT: _____
NAME COMPANY AFTER HOURS PHONE NUMBER

JOB FOREMAN: _____

LOCATION OF PROJECT: _____
MAPSCO NUMBER NEAREST INTERSECTION

_____
CITY OWNED LINE LOCATES WILL BE DONE AT THE LOCATION SHOWN ON PLANS

DESCRIPTION OF PROJECT: _____
UTILITY TYPE SIZE & CONSTRUCTION METHOD (BORE / OPEN TRENCH)

_____

PROJECT START DATE: _____ ESTIMATED COMPLETION DATE: _____

SIGNATURE OF APPLICANT: _____ PRINTED NAME OF APPLICANT _____

For City use below this line

3 SETS OF PLANS SUBMITTED?: ☐ YES ☐ NO **PERMIT APPROVED BY:** _____

ENGINEERING NOTES : _____ **DATE OF APPROVAL: *** _____

INSPECTOR: ☐ **COREY LAWSON 469 - 853-3463**

THIS PERMIT IS COMPLETED & ACCEPTED: _____ **DATE:** _____

COMMENTS: _____

CC: Water Tech/Signs & Signals Contractor Inspector ORIGINAL to Active File "SIGN BACK OF FORM"

CEDAR HILL
PUBLIC WORKS

CITY OF CEDAR HILL

PUBLIC WORKS DEPARTMENT – ENGINEERING DIVISION

CONDITIONS OF THE PERMIT

1. Contractor shall comply with City of Cedar Hill Right-of-Way management ordinance No. 2001-54. Plans shall clearly show the proposed facilities with respect to existing roadway, driveways, street intersections and visible structures within 10' of project. Plans shall also include a traffic control plan signed and sealed by a "Licensed Texas Professional Engineer". In addition, the plans shall clearly show the limits of construction. Street names and other pertinent labels to describe the location of the proposed facilities shall be legible.
2. Contractor shall furnish, install and maintain erosion control devices per plans along project, comply with all Cedar Hill Storm Water Pollution Prevention specifications and with NCTCOG's storm water management practices for construction activities.
3. Contractor shall repair all areas disturbed, damaged and destroyed which shall include, but is not limited to the following:
    a) All yards with sods shall be re-sodded.
    b) Contractor shall re-install iron rods and other property markers disturbed by construction.
    c) All sprinkler systems shall be repaired immediately after back fill is complete.
    d) Manholes, inlets and other structures must be replaced or repaired if damaged.
4. Contractor shall keep street free of dirt, silt and other debris and sweep street at the end of the working day.
5. Contractor shall Curlex & seed and/or hydro mulch all disturbed areas and include 4" of top soil. Seeding shall be as required by City specifications.
6. Contractor shall comply with MUTCD traffic control for work areas and per the traffic control plan for the project.
7. Clean up shall be conducted every 5' behind excavation crew.
8. All excavation within City ROW requires mechanical compactions. Compaction test reports must be turned in to Public Works Department.
9. At the end of each work day, the contractor shall erect a temporary security fence at all excavations.
10. Contractor will not be issued another permit until all work (current & previous) has been approved by the City.
11. Contractors listed on permits are responsible for all sub-contractors.
12. Non-conformance with the previously listed requirements will initiate a stop work order until corrections are made.
13. Upon completion of construction, make an appointment with Construction Inspector for Final Inspection.
14. A copy of the work permit MUST be kept with the Contractor on the job site for review by an Inspector, if requested.

☐ SEE ATTACHED SPECIAL CONDITIONS

I hereby acknowledge and agree to the conditions of the permit.

_____	_____
CONTRACTOR	TITLE
_____	_____
SIGNATURE	DATE

Date and Time Received By Public Works:_____

CITY OF CEDAR HILL
PUBLIC WORKS

285 Uptown Blvd., Cedar Hill, TX 75104
Phone: 972-291-5126
Facsimile: 972-291-7250

EARLY RELEASE REQUEST

DATE:			
PROJECT NAME:			
CASE #		PW #	

We (the Owner/Contractor) hereby request permission to begin construction of utilities in the subject subdivision prior to the Final Plat being approved by the City of Cedar Hill. We understand that for the granting of such permission, we hereby assume all responsibility for all construction; and we understand that utilities will not be accepted by the City and paving releases will not be issued until said plat is approved.

Therefore, we understand the City of Cedar Hill has the right to withhold building permits for any building or house in subject subdivision, until subject subdivision plat has been approved and filed for record, and applicable right-of-way and easements required for utilities have been granted and acquired.

Furthermore, we understand the City of Cedar Hill has the right to withhold Certificates of Occupancy of any buildings or houses constructed in subject subdivision, until utilities constructed (both on-site and off-site) have been completed and approved by the City.

Date: _____ Date: _____

Owner: _____ Contractor: _____

Address: _____ Address: _____

_____ _____

_____ _____

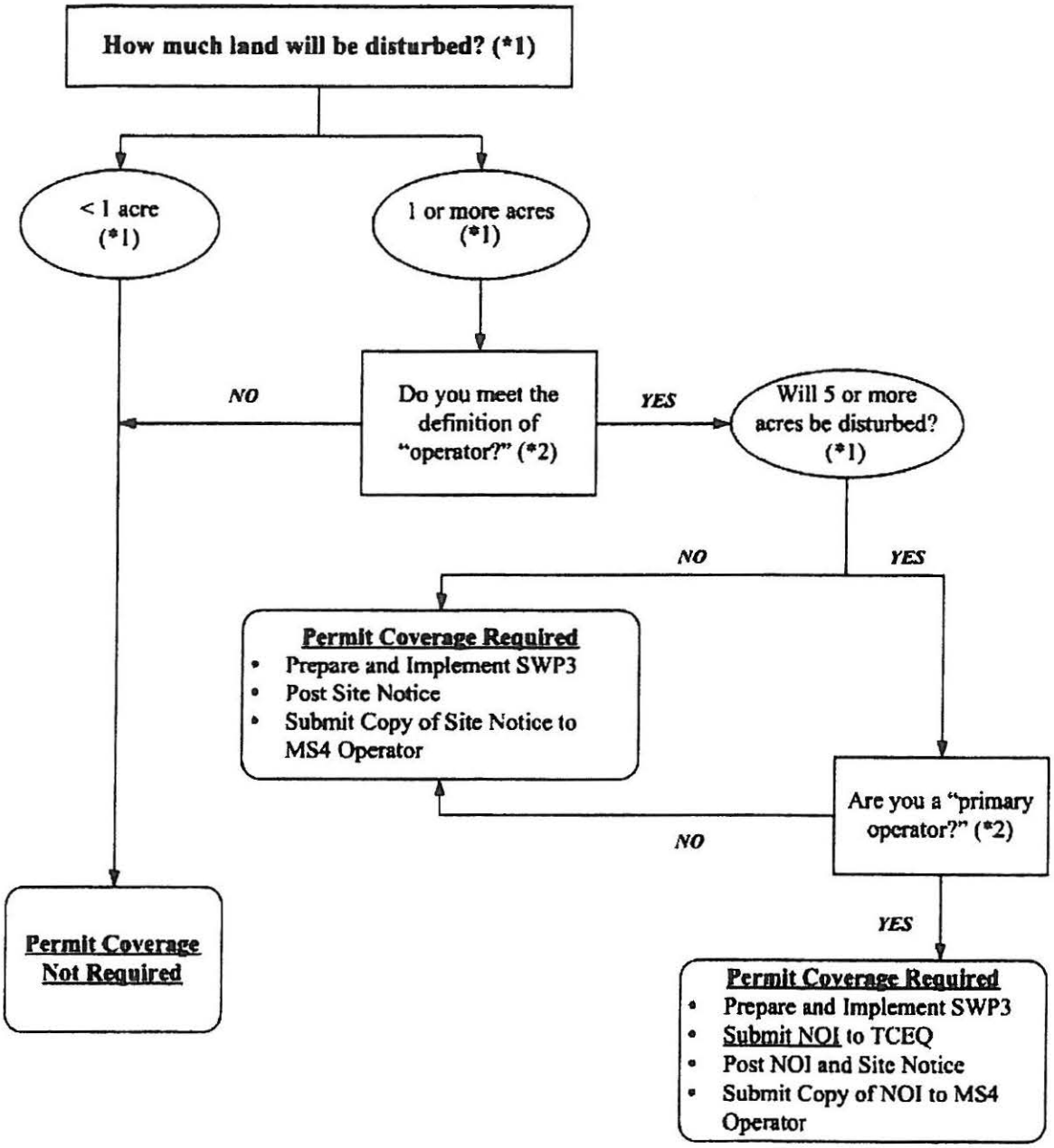
By: _____ By: _____

Title: _____ Title: _____

Approved By: _____ Date: _____
Director of Public Works

Part I. Flow Chart and Definitions

Section A. Flow Chart to Determine Whether Coverage is Required



*(*1) To determine the size of the construction project, use the size of the entire area to be disturbed, and include the size of the larger common plan of development or sale, if the project is part of a larger project (refer to Part I.B., "Definitions," for an explanation of "larger common plan of development or sale").*

*(*2) Refer to the definitions for "operator," "primary operator," and "secondary operator" in Part I., Section B. of this permit.*

CITY OF CEDAR HILL
APPROVED MATERIALS LIST

ITEM	SPECIFICATIONS[1]	MANUFACTURER 1	MANUFACTURER 2	MANUFACTURER 3	SPECIAL CONDITIONS - APPLICATIONS
WATER FACILITIES					
PVC WATER PIPE 6" -8"	AWWA C-900, DR14, PRESSURE CLASS 305	DIAMOND	JM EAGLE		
PVC WATER PIPE 10" -12"	AWWA C-900, DR18, PRESSURE CLASS 235	DIAMOND	JM EAGLE		
PVC WATER PIPE 14" -24"	AWWA C-905, DR21, PRESSURE CLASS 200	DIAMOND	JM EAGLE		
DUCTILE IRON PIPE (12" -24")	AWWA C150 &C151, PRESSURE CLASS 350	AMERICAN	US PIPE		
CONCRETE CYLINDER STEEL PIPE (21"+)	AWWA C303	HANSON	AMERON INTERNATIONAL		
DI FITTINGS	AMERICAN MADE - MECH. JOINT, C153 & CLASS 350<12", C110 14" OR LARGER, THRUST BLOCKED AND MECHANICALLY RESTRAINED BY RETAINER GLANDS -	TYLER, DOMESTIC MADE	AMERICAN		
RETAINER GLANDS	AMERICAN MADE	EBAA IRON			
GATE VALVES (4" -12")		MUELLER			
GATE VALVES (14" -24") W/ BYPASS		MUELLER			
VALVE BOXES	CAST IRON LIDS	BASS & HAYES MODEL #340-1			
BUTTERFLY VALVES 16" OR LARGER	MECHANICAN SEAL -	VAL-MATIC Tri-Loc RESILLENT SEAT	M&H		
TAPPING SLEEVES	STAINLESS STEEL				
FIRE HYDRANTS		MUELLER CENTURIAN	AMERICAN WATEROUS PACER		
FIRE HYDRANT MARKERS		STIMSONITE FIRE-LITE			
BACKFLOW PREVENTER		WATTS	FEBCO	CONBRACO	
CURB STOPS		MUELLER	FORD		
PIPE TO SERVICE METERS	NSF 61, AWWA C901 1" & 2" ONLY	ENDOT INDUSTRIES	DriscoPlex 5100		
METER BOXES		DFW PLASTICS 1300RB			
METER VAULTS		HANSON	PARK		
VALVES COVERS					
VALVE STACKS					
AIR VALVES		VAL-MATIC	CRISPIN	APCO	
SANITARY SEWER FACILITIES					
PVC SANITARY SEWER PIPE	SDR 35 FOR PIPE DEPTHS LESS THAN 14'; SDR 26 FOR PIPE DEEPER THAN 14'	DIAMOND	JM EAGLE		
CONCRETE MANHOLES	5' DIAMETER WITH 30" MANHOLE LID AND FRAME	HANSON	TURNER	RINKER	
MANHOLE LID AND FRAME	30" LID & FRAME WITH CITY'S LOGO, STAINLESS STEEL RAINSTOPPERS	BASS $ HAYS (# VRM30 WT)			
INSIDE DROP BOWL FOR DROP MANHOLES	6" - 10" DROP BOWL AT THE UPPER TRANSITION END OF DROP PIPE TO BOTTOM	RELINER / DURAN INC.			
STORM DRAINS					
STORM DRAIN PIPE		HANSON	TURNER	RINKER	
STORM DRAIN PRE-CAST CONCRETE STRUCTURES		HANSON	TURNER	RINKER	
CAST IRON INLET RINGS & COVERS	LOCKING 24" MANWAY LIDS WITH CITY LOGO	BASS AND HAYS MODEL # 225 L			
RUBBER GASKETS		RINKER OMNI-FLEX	UNI-FLEX		

1- Unless otherwise expliciantly specified, the specifications for City Standard materials list the major governing requirements. Other minor specifications are listed in the contract documents, approved submittals, City's Standard Details or General Notes.

2. Mixtures of pipe manufacturers is prohibited. Selection of materials shall be by manufacturer and consistent through out the life of the project. If a subsitution is desired, a written shop drawing or techinal specification shall be submitted to the City.

3. Approved Equal materials - The items listed above are materials typically used within the City for public improvements, Other materials, including shop drawings, not list above shall be submitted to the City for approval.

FINAL ACCEPTANCE LIST

PROJECT NAME: _____

City Case No: _____

Public Works Project No: _____

CEDAR HILL

	Required?	Received?	Date/Initials
GIS Department Release:	☐	☐	_____
Filed Plat (Cabinet __ Slide _____)	☐		
As-Built Plans:	☐		
1 bound black line sets		☐	
AutoCAD Release 2000 or later version		☐	
Scanned Plans in Adobe Acrobat format (*.pdf)		☐	
Filed Easements for Off-site work	☐	☐	_____
Approval letter from affected adjacent property owners	☐	☐	_____
Payment of 3.5% Inspection Fee	☐	☐	_____
Escrow	☐	☐	_____
Sidewalks (@ $15.00 per linear ft.)	☐	☐	$_____
Utilities	☐	☐	$_____
Other	☐	☐	$_____
Water Meter Connection Form (to be completed and sent to Utility Billing for Acct. set-up)	☐	☐	_____
Maintenance Bond (provide proof of license in State of Texas)	☐	☐	_____
Street Sign Fee	☐	☐	_____
Street sign fee @ $250.00 per set	☐	☐	$_____
Street Signs in Place	☐	☐	_____
Street Lighting *(in place or Developer Agreement from Oncor)*	☐	☐	_____
Final Walkthrough Approval from Inspector	☐	☐	_____
TDLR Certification Letter	☐	☐	_____
Environmental Department Release:	☐	☐	_____
• *Requires disturbed areas to be at least 70% vegetated and temporary erosion control devices removed.*			
• *Backflow Prevention in Compliance*			
• *Inlet markers in place*			
• *Copy of N.O.T. if required (or SWPPP for CIP projects)*			
Lien Release from Contractor(s)	☐	☐	_____
Engineer's Certification of As-built Drawings & Construction	☐	☐	_____
Architect/Engineer/Consultant Evaluation	☐	☐	_____
Construction Contractor Evaluation	☐	☐	_____
Other: _____	☐	☐	_____

_____ _____

Public Works Representative **Date**

PRIVATE DEVELOPMENT AGREEMENT

This Private Development Agreement (the "Agreement") is, made and entered into this day of _____ 20____, by and between _____,(the "OWNER")and _____ _____, (the "CONTRACTOR").

WITNESSETH: That for and in consideration of the payments and agreements hereinafter mentioned, to be made and performed by the OWNER, and under the conditions expressed in the bonds attached hereto and made a part hereof, the CONTRACTOR hereby agrees to commence and complete the construction of certain improvements described herein for the OWNER and for the benefit of the City of Cedar Hill (herein the "CITY").

The improvements to be constructed by the CONTRACTOR shall be referred to herein as the WORK. The WORK shall be identified and described as follows:

Project Name: _____

Description of Project: _____
_____
_____
_____

Additional or amplified descriptions of the WORK may be described and set forth in an Exhibit to this Agreement if necessary. Such Exhibit will become a part of this Agreement when attached.

The CONTRACTOR agrees to furnish all labor, materials, supplies, machinery, equipment, tools, superintendence, insurance, and other accessories and services necessary to complete the said WORK, in accordance with the conditions and prices stated in the Proposal attached hereto, in accordance with the plans and other drawings and printed or written explanatory matter thereof, and the specifications accepted by the CITY, and as prepared by _____(herein OWNER'S ENGINEER). CONTRACTOR also agrees, by execution of this Agreement, to abide by the CITY's Standard Construction Details Design Manual, and the Standard Specifications for Public Works Construction – North Central Texas Council of Governments, latest edition. The above referenced documents are incorporated herein by reference and made a part of this Agreement for all purposes. The OWNER and CONTRACTOR each have the above referenced documents in their personal possession.

The CONTRACTOR hereby agrees to commence the WORK within ___days from the date of execution of this AGREEMENT, and shall be completed within ____ days thereafter.

The CONTRACTOR agrees and guarantees to complete the WORK in accordance with the

terms and specifications approved by the CITY. CONTRACTOR agrees, represents and warrants that it shall repair and/or replace all defects due to faulty materials and/or workmanship that occur within a period of one (1) year from the date of the CITY's final acceptance of the WORK. The CONTRACTOR agrees to furnish Performance, Maintenance and Payment Bonds for the benefit of the OWNER and the CITY . The bonds shall be with a corporate surety or sureties authorized to do business in the State of Texas, and otherwise acceptable to the OWNER and the CITY. The bonds shall designate a resident agent in Dallas County, Texas for delivery of notice and service of process. The Performance and Maintenance Bonds shall name the CITY as Obligee and shall be for an amount equal to not less than 100 percent of the amount of the Proposal, guaranteeing the full and faithful execution of the WORK and performance under this Agreement, and for the protection of the CITY and all other persons against damage by reason of negligence of the CONTRACTOR, or improper execution of the WORK or the use of inferior or defective materials. The Payment Bond shall guarantee the payment for all labor, materials, equipment, supplies and services used in the construction of the WORK and shall remain in full force and effect until provisions as above stipulated are accomplished, final payment is made on the project by the OWNER and upon acceptance by the CITY. The Payment Bond shall name the OWNER and the CITY as Obligees, in an amount equal to not less than 100 percent of the amount of the Proposal

The OWNER agrees, in consideration of the WORK performed by CONTRACTOR, to pay a sum not-to-exceed _____ ($_____) Dollars, to be paid as follows:

Upon completion of the WORK, the OWNER will furnish an affidavit to the CITY verifying that OWNER has made final payment to the CONTRACTOR. CONTRACTOR understands and agrees that nothing in this AGREEMENT shall be construed to render the CITY liable for any payments owed by the OWNER to the CONTRACTOR, or by the CONTRACTOR to any subcontractor, supplier, laborer or materialmen in the course of the WORK performed under this AGREEMENT. OWNER and CONTRACTOR agree that the CITY is a third-party beneficiary to this Agreement and that the CITY has no duties or obligations hereunder. The OWNER and the CONTRACTOR mutually agree to indemnify and hold harmless the CITY from any and all claims, demands, lawsuits or judgments arising from or related to: (1) a failure of the OWNER to pay the CONTRACTOR in accordance with the terms of this AGREEMENT; (2) failure of the CONTRACTOR to pay any subcontractors, suppliers, laborers or materialmen; (3) any personal injury, death, or property damage suffered by the OWNER, the CONTRACTOR, or any other person or entity that arises from or relates to this Agreement; and (4) any liens that are placed upon any property as a result of the WORK under this Agreement.

Upon final acceptance of the WORK by the CITY, the WORK shall become the sole property of the CITY, free and clear of all liens and encumbrances.

This AGREEMENT is performable in Dallas County, Texas, and exclusive venue for any legal action arising from or related to this Agreement shall be the State District Courts of Dallas County, Texas.

This AGREEMENT is binding upon the OWNER and the CONTRACTOR, and their respective successors, assigns, heirs and representatives.

IN WITNESS WHEREOF, the parties to these presents have executed this AGREEMENT in the year and day first above written.

OWNER:

By: _____

_____
Printed Name

_____
Title

ATTEST:

_____

CONTRACTOR:

By: _____

_____
Printed Name

_____
Title

ATTEST:

_____

APPROVED AS TO FORM ONLY BY THE CITY OF CEDAR HILL, TEXAS:

By: _____

_____
Printed Name

_____
Title

CERTIFICATE OF INSURANCE

TO: CITY OF CEDAR HILL, TEXAS Date: _____

NAME OF PROJECT: _____

PROJECT NUMBER: _____

THIS IS TO CERTIFY THAT _____
(Name and Address of Insured)

is, at the date of this certificate, Insured by this Company with respect to the business operations hereinafter described, for the type of insurance and in accordance with the provisions of the standard policies used by this Company, and further hereinafter described. Exceptions to standard policy noted on reverse side hereof.

TYPE OF INSURANCE

	Policy No.	Effective	Expires	Limits of Liability
Worker's Compensation				
Comprehensive General Liability Insurance (Public Liability)				Bodily Injury: Ea. Occurrence: $_____ Property Damage: Ea Occurrence: $
Blasting				Ea. Occurrence: $
Collapse of Buildings or structures adjacent to excavations				Ea. Occurrence: $_____
Damage to Underground Utilities				Ea. Occurrence: $
Builder's Risk				
Comprehensive Automobile Liability				Bodily Injury: Ea. Person: $_____ Ea. Occurrence: $_____ Property Damage: Ea Occurrence: $
Contractual Liability				Bodily Injury: Ea. Occurrence: $_____ Property Damage: Ea. Occurrence: $
Other				

Locations covered: _____
Description of operations covered: _____

The above policies either in the body thereof or by appropriate endorsement provide that they may not be changed or canceled by the insurer in less than five (5) days after the insured has received written notice of such change/or cancellation.

Where applicable local laws or regulations require more than five (5) days actual notice of change or cancellation to be assured, the above policies contain such special requirements, either in the body thereof or by appropriate endorsement thereto attached.

Agency _____ _____

Cedar Hill Agent _____ By _____

Address _____ Title _____

PAYMENT BOND

STATE OF TEXAS)
)
COUNTY OF DALLAS)

KNOW ALL MEN BY THESE PRESENTS: That we (1) _____ _____, a (2)_____, whose address is _____ _____ hereinafter called Principal, and (3) _____, a corporation organized and existing under the laws of the State of _____, and fully authorized to transact business in the State of Texas, as Surety, are held and firmly bound unto _____, hereinafter called Owner, and the City of Cedar Hill, a municipal corporation organized and existing under the laws of the State of Texas, hereinafter called City, and unto all persons, firms and corporations who may furnish materials for, or perform labor upon the building or improvements hereinafter referred to, in the penal sum of _____ _____ DOLLARS ($ _____) in lawful money of the United States, to be paid in Dallas County, Texas, for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators and successors jointly and severally, firmly by these presents. This Bond shall automatically be increased by the amount of any Change Order or Supplemental Agreement which increases the Contract price, but in no event shall a Change Order or Supplemental Agreement which reduces the Contract price decrease the penal sum of this Bond.

THE OBLIGATION TO PAY SAME is conditioned as follows: WHEREAS, the Principal entered into a written Contract with the Owner, dated the _____ day of _____, AD 20___, a copy of which is hereto attached and made a part hereof, for the construction of _____ _____ designated as _____ project, such project and construction in the City of Cedar Hill, together with the necessary grading and excavation, being hereinafter referred to as the "Work", and such agreement and contract and the specifications therein mentioned adopted by the City are expressly made a part hereof, as though written here in full.

NOW THEREFORE, if the Principal shall well, truly and faithfully perform its duties and make prompt payment to all persons, firms, subcontractors, corporations and claimants supplying labor and/or materials in the prosecution of the Work provided for in said Contract and any and all duly authorized modifications of said Contract that may hereafter be made, notice of which modification to the Surety is hereby expressly waived, then this obligation shall be void; otherwise it shall remain in full force and effect.

PROVIDED FURTHER, that if any legal action be filed upon this Bond, exclusive venue shall lie in Dallas County, Texas.
AND PROVIDED FURTHER, that the said Surety, for value received, hereby stipulates and agrees that no change, extension of time, alteration or addition to Contract, or to

the Work performed thereunder, or the Plans, Specifications, Drawings, etc., accompanying the same, shall in anywise affect its obligation on this Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the Contract, or to the Work to be performed thereunder.

The undersigned and designated agent is hereby designated by the Surety herein as the Resident Agent in Dallas County to whom any requisite notices may be delivered and on whom service of process may be had in matters arising out of such suretyship, as provided by Article 7.19-1 of the Insurance Code, Vernon's Annotated Civil Statutes of the State of Texas.

IN WITNESS WHEREOF, this instrument is executed in _____ copies, each one of which shall be deemed an original, this the _____ day of _____, 20____.

_____
Principal (4)

By: _____ ATTEST:

_____ _____
(Principal) Secretary

Address:

_____ (SEAL)

_____

_____
Witness as to Principal

_____

_____
Address

_____
Surety

By: _____ ATTEST:
Attorney-in-Fact (5)

_____
(Surety) Secretary

Address:

_____ (SEAL)

_____

_____
Witness as to Surety

_____

_____
Address

NOTE: Date of bond must not be prior to date of Contract.

(1) Correct name of General Contractor.
(2) A Corporation, a Partnership, or an individual, as case may be.
(3) Correct name of Surety.
(4) If General Contractor is a Partnership, all Partners should execute bond.
(5) A true copy of Power of Attorney shall be attached to bond by Attorney-in-Fact.

PERFORMANCE BOND

STATE OF TEXAS)
)
COUNTY OF DALLAS)

KNOW ALL MEN BY THESE PRESENTS: That we (1) _____ _____, a (2)_____, whose address is _____ _____ hereinafter called Principal, and (3) _____, a corporation organized and existing under the laws of the State of _____, and fully authorized to transact business in the State of Texas, as Surety, are held and firmly bound unto the City of Cedar Hill, a municipal corporation organized and existing under the laws of the State of Texas, hereinafter called "City", and _____ _____, hereinafter called "Owner", in the penal sum of _____ DOLLARS ($_____) plus 10% of the stated penal sum as an additional sum of money representing additional court expenses, attorney's fees, and liquidated damaged arising out of or connected with the below identified Contract in lawful money of the United States, to be paid in Dallas County, Texas, for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators and successors jointly and severally, firmly by these presents. This Bond shall automatically be increased by the amount of any Change Order or Supplemental Agreement which increases the Contract price, but in no event shall a Change Order or Supplemental Agreement which reduces the Contract price decrease the penal sum of this Bond.

THE OBLIGATION TO PAY SAME is conditioned as follows: WHEREAS, the Principal entered into a written Contract with the Owner, dated the _____ day of _____, AD 20__, a copy of which is hereto attached and made a part hereof, for the construction of _____ _____ designated as _____ project, such project and construction in the City of Cedar Hill, together with the necessary grading and excavation, being hereinafter referred to as the "Work", and such agreement and contract and the specifications therein mentioned adopted by the City are expressly made a part hereof, as though written here in full.

NOW THEREFORE, if the Principal shall well, truly and faithfully perform and fulfill all of the undertakings, covenants, terms, conditions and agreements of said Contract in accordance with the plans, specifications and Contract Documents during the original term thereof and any extensions thereof which may be granted by the Owner, with or without notice to the Surety, and during the life of any guaranty or warranty required under this Contract, and shall also well and truly perform and fulfill all the undertakings, covenants, terms, conditions and agreements of any and all duly authorized modifications of said Contract that may hereafter be made, notice of which modifications to the Surety being hereby waived; and, if the Principal shall repair and/or replace all defects due to faulty materials and workmanship that appear within a period of one (1)

year from the date of final completion and final acceptance of the work by the City; and, if the Principal shall fully indemnify and save harmless the Owner (or the City in the case of the one-year warranty period) from all costs and damages which Owner (or the City in the case of the one-year warranty period) may suffer by reason of failure to so perform herein and shall fully reimburse and repay Owner all outlay and expense which the Owner (or the City in the case of the one-year warranty period) may incur in making good any default or deficiency, then this obligation shall be void; otherwise, it shall remain in full force and effect.

PROVIDED FURTHER, that if any legal action be filed upon this Bond, exclusive venue shall lie in Dallas County, State of Texas.

AND PROVIDED FURTHER, that the said Surety, for value received, hereby stipulates and agrees that no change, extension of time, alteration or addition to the terms of the Contract, or to the Work to be performed thereunder, or the Specifications accompanying the same shall in anywise affect its obligation on this Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the Contract, or to the Work or to the Specifications.

The undersigned and designated agent is hereby designated by the Surety herein as the Resident Agent in Dallas County to whom any requisite notices may be delivered and on whom service of process may be had in matters arising out of such suretyship, as provided by Article 7.19-1 of the Insurance Code, Vernon's Annotated Civil Statutes of the State of Texas.

IN WITNESS WHEREOF, this instrument is executed in _____ copies, each one of which shall be deemed an original, this the _____ day of _____, 20____.

_____
Principal (4)

By: _____

_____

Address:

_____

_____

ATTEST:

_____
(Principal) Secretary

(SEAL)

_____
Witness as to Principal

_____

_____
Address

_____
Surety

By: _____
Attorney-in-Fact (5)

ATTEST:

_____
(Surety) Secretary

Address:

_____

_____

(SEAL)

_____
Witness as to Surety

_____

_____
Address

NOTE: Date of bond must not be prior to date of Contract.

(1) Correct name of General Contractor.
(2) A Corporation, a Partnership, or an Individual, as case may be.
(3) Correct name of Surety.
(4) If General Contractor is a Partnership, all Partners should execute bond.
(5) A true copy of Power of Attorney shall be attached to bond by Attorney-in-Fact.

MAINTENANCE BOND

THE STATE OF TEXAS §
COUNTY OF DALLAS §

KNOW ALL BY THESE PRESENTS:

That _____, hereinafter called Contractor, as principal, and _____, a corporation organized under the laws of the State of _____, as surety, do hereby acknowledge themselves to be held and bound to pay unto the City of Cedar Hill, a Municipal Corporation chartered by virtue of Constitution and laws of the State of Texas, at Cedar Hill, in Dallas County, Texas, the sum of _____ _____($_____), lawful money of the United States, (which is 50% of the construction cost) for payment of which sum well and truly be made unto said City of Cedar Hill and its successors, said Contractor and surety do hereby bind themselves, their heirs, executors, administrators, assigns and successors, jointly and severally.

This obligation is conditioned, however, that

WHEREAS, said Contractor has this day entered into a written Contract with _____ _____, the Developer, dated the ___ of _____, 20___, a copy of which is hereto attached and made a part hereof, for the construction of _____ _____, designated as _____ project, such project and construction in the City of Cedar Hill, together with the necessary grading and excavation, being hereafter referred to as the "Work", and such Agreement and Contract and the Specifications therein mentioned adopted by the City are expressly made a part hereof, as though written herein in full; and,

WHEREAS, in said Contract, Contractor binds itself to use such materials and to so construct the Work that it will remain in good repair and condition for and during the period **two (2) years** after the date of the final acceptance of the Work by the City; and

WHEREAS, said Contractor binds itself to maintain said Work in good repair and condition for said term of **two (2) years**; and

WHEREAS, said Contractor binds itself to repair or reconstruct the Work in whole or in part at any time within said period, if in the opinion of the Director of the City of Cedar Hill Department of Public Works, it be necessary; and,

WHEREAS, said Contractor binds itself, upon receiving notice of the need therefor to repair or reconstruct said Work as herein provided.

NOW THEREFORE, if said Contractor shall keep and perform its said agreement to maintain, repair or reconstruct said Work in accordance with all the terms and conditions of said Contract, these presents shall be null and void, and have no force or effect. Otherwise, this Bond shall be and remain in full force and effect, and said City shall have and recover from the said Contractor and its surety damages in the premises as prescribed by said Contract.

This obligation shall be a continuing one and successive recoveries may be had hereon for successive breaches until the full amount hereof is exhausted.

IN WITNESS WHEREOF, the Contractor has caused these presents to be executed in _____ counterparts and _____, as surety, has caused these presents to be executed in _____ counterparts by its duly authorized Attorney-in-Fact, and attested by its corporate seal, this ___ day of_____ A.D. 20___.

_____
Contractor

By: _____

_____
Surety

By: _____

Address

_____
_____
_____

ATTEST:
(S E A L)

_____
Secretary

EXAMPLE

UNIT BREAKDOWN OF CONSTRUCTION COST ESTIMATE
Project Name:
City File Number:
Developer Name:

ITEM NO.	QUANTITY	UNIT	DESCRIPTION & PRICE IN WORDS	UNIT PRICE	TOTAL PRICE
			Sanitary Sewer		
(FURNISH AND INSTALL, INCLUDING ALL APPURTENANT WORK, COMPLETE IN PLACE, THE FOLLOWING ITEMS):					
1	?	SF	Sawcut Remove & Replace Ex. Asphalt Pavement w/ concrete sub-base complete in place for the sum of _____ Dollars and _____ Cents per square foot	$	$
2	?	SF	Replace Pavement w/ HMAC & Reinforced Concrete Base complete in place for the sum of Six Dollars and 80 cents per square foot	$	$
3	?	EA	Cut & Plug Ex. San. Sewer @ M.H. and at Curb Line complete in place for the sum of _____ Dollars and _____ Cents per each	$	$
4	?	EA	Connect to Ex. Drop Connection @ M.H. complete in place for the sum of _____ Dollars and _____ Cents per each	$	$
5	?	EA	Construct 4' DIA. San. Sewer M.H. with Concrete Collars & Water tight Inserts complete in place for the sum of _____ Dollars and _____ Cents per each	$	$

EXAMPLE

UNIT BREAKDOWN OF CONSTRUCTION COST ESTIMATE
Project Name:
City File Number:
Developer Name:

ITEM NO.	QUANTITY	UNIT	DESCRIPTION & PRICE IN WORDS	UNIT PRICE	TOTAL PRICE
			Sanitary Sewer		
(FURNISH AND INSTALL, INCLUDING ALL APPURTENANT WORK, COMPLETE IN PLACE, THE FOLLOWING ITEMS):					
6	?	EA	Construct 4' DIA. M.H.with a 6" Drop Connection over Ex. 8" San. Sewer complete in place for the sum of _____ Dollars and _____ Cents per each	$	$
7	?	LF	10" SDR 35 PVC San. Sewer Pipe complete in place for the sum of _____ Dollars and _____ Cents per linear foot	$	$
8	?	LF	8" SDR 35 PVC San. Sewer Pipe complete in place for the sum of _____ Dollars and _____ Cents per linear foot	$	$
9	?	LF	6" SDR 35 PVC San. Sewer Pipe complete in place for the sum of _____ Dollars and _____ Cents per linear foot	$	$
10	?	LF	10" SDR 26 PVC San. Sewer Pipe with Concrete Encasement complete in place for the sum of _____ Dollars and _____ Cents per linear foot	$	$

EXAMPLE

UNIT BREAKDOWN OF CONSTRUCTION COST ESTIMATE
Project Name:
City File Number:
Developer Name:

ITEM NO.	QUANTITY	UNIT	DESCRIPTION & PRICE IN WORDS	UNIT PRICE	TOTAL PRICE
			Sanitary Sewer		
(FURNISH AND INSTALL, INCLUDING ALL APPURTENANT WORK, COMPLETE IN PLACE, THE FOLLOWING ITEMS):					
11	?	LF	8" SDR 26 PVC San. Sewer Pipe with Concrete Encasement complete in place for the sum of _____ Dollars and _____ Cents	$	$
12	?	LF	City Approved Detectable Metallic Tape complete in place for the sum of _____ Dollars and _____ Cents per linear foot	$	$
14	?	LS	Embedment & Backfill complete in place for the sum of _____ Dollars and _____ Cents per lump sum	$	$
15	?	LS	Trench Safety for Sanitary Sewer complete in place for the sum of _____ Dollars and _____ Cents per lump sum	$	$
16	?	LS	Testing For Sanitary Sewer complete in place for the sum of _____ Dollars and _____ Cents per lump sum	$	$
				TOTAL	$ -

APPENDIX B

CITY OF CEDAR HILL
PUBLIC WORKS DEPARTMENT
PAVING AND DRAINAGE PLAN REVIEW CHECKLIST
FOR CIP PROJECTS

Revised January 30, 2012

Project Name and limits: _____

Public Works Project # _____ Plans Prepared by: _____

PART I - PAVING PLANS	ENG.	CITY
A. General (Use Design Criteria Specified in Design Manual)		
1. North Arrow shown on each sheet		
2. Minimum of 2 Bench Marks shown on each sheet		
3. Title Blocks		
a. Complete		
b. Title agrees with project name and limits		
c. Sheets numbered		
d. Engineer's seal and signature		
4. Street Names		
a. Street under design		
b. Intersecting streets		
c. Show sight distance easements on alley intersections with streets		
d. Corner Clips are needed at street intersections.		
e. Make sure appropriate right-of-way for streets is dedicated as per zoning and thoroughfare plan.		
f. Check centerline radius. Is it appropriate for the design speed for the street.		
g. Show on-site drainage easements		
h. Check cul-de-sac for minimum radius		
i. If a creek or floodplain is involved, show Floodway Easement		
j. The minimum fill and floor elevations must be specified when the project is involved in the flood plain.		
B. Cover Sheet		
1. Provide all appropriate information		
C. Survey Information		
1. Show complete survey data for construction.		
2. Centerline stationing shown and related to profile.		
3. Stationing shown on centerline.		
4. Show ROW (Right-of-way) map and property ownership		
D. Topography		
1. Perimeter topography is sufficient for the design.		
2. Show any existing fences and landscaping		
3. Show location of all trees in close proximity to offsite work or easements		
4. Intersecting streets. Type and width of pavement and walks. Show spot elevations in ditches or gutters sufficient distance to clarify drainage and transitions.		
5. Existing concrete paving clearly shown according to standard symbols and accurately dimensioned. Curbs and gutters dimensioned.		

PLAN REVIEW CHECK LIST
Page 2

	ENG.	CITY

6. Existing storm drains and inlets shown by standard symbols.
7. Existing travelway shown.
8. Show and label existing elevations for existing driveways and walkways. Verify adequate slope for accesibility and visibility.

E. Utilities

1. Show all existing facilities, including public and/or private
2. Clarify status of existing facilities whether to remain in service, abandon, or remove and by whom.
3. Add caution notes when construction operations will come close to any facility; give phone # of company to call for assistance in locating.

F. Storm Drains

1. Proposed storm inlets must be shown. Use recessed inlet for major/minor arterials. Drainage pattern should be clear without having to refer to storm drain plans.
2. For each inlet, show size, paving station at center, and top elevation.

G. Plan

1. All proposed pavement, wide drives, etc., are properly dimensioned.
2. Limits of new paving, adjustments to intersecting streets and drives clearly defined by stations and dimensions, as necessary.
3. Drainage clarified by flow arrows, spot elevations inditches and gutters, other notations.
4. Traffic control items shown. Striping, traffic buttons, and street signs must be provided
5. Show street lighting. The street lighting design must be coordianted with Oncor.
6. Provide for barrier free ramps at intersections. (ADA compliance)
7. Specify wall types, beginning, end, and top elevations. Drainage behind walls handled? Show walls in plan and profile. Provide design.
   Note: All retaining walls within Public ROW must be standard concrete retaining walls, unless approved otherwise by the Director of Public Works.
8. Check all drives, intersections and other locations of the wall(s) involving cross traffic for possible hazardous situations. Watch for obstructed sight distance, hindrances to safe operation at design speed, danger to pedestrians, etc.
9. Make sure there are intermediate tangents between the double reverse curves based on the design speed along the centerline of the proposed streets.
10. Check transitions at ends of project and at intersections for safety, complete design, drainage, etc.
11. Will exclusive right-turn lanes be needed at the intersection(s) of major/minor arterials?

H. Profiles and Grades

1. Profiles plotted showing ground at proposed property lines.
2. Top of curb grades should be below ground profiles at the property line. Check fill areas for drainage.

PLAN REVIEW CHECK LIST
Page 3

	ENG.	CITY
3. Check cross-fall for compliance with standards. Provide adequate cross-fall to inlets on thoroughfare paving projects.		
4. Design thoroughfare to thoroughfare intersections to provide smooth grades.		
5. Complete vertical curves information. Do vertical curves meet minimum sight distance requirements for design speed?		
6. Check carefully for any place water might pond. Are inlets located at sag points of vertical curves? Minimum size for sag inlet is 10 ft.		
7. Design horizontal curves to meet Paving Design Standards for the design speed.		
8. Check ends of project for drainage.		
9. Check that curb P.I.s for intersecting streets are shown on profiles.		
10. Make sure there are no visibility obstructions (both vertically and horizontally).		
11. The roadway should be at least 2 ft. above the 100-year floodplain elevation.		

I. Typical Section

1. Centerline dimensioned to property lines and curbs.		
2. Pavement slopes or crown specified.		
3. Slopes in parkway area, cut and fill slopes shown.		
4. Drive grades from gutter to property line and behind property line shown for thoroughfare paving projects involving existing access.		
5. Usual type and depth of existing pavement and base shown.		
6. Lime/cement base if proposed, show lime/cement content.		
7. Type and thickness of proposed pavement shown and in conformance with standards.		
8. Sidewalks (show location and when it will be built).		
9. Show appropriate cross sections. For Thoroughfares, a cross section needs to be shown every 50'		

J. Left-Turn Lanes and Median Modifications

1. Driveways must be centered on median openings.		
2. Traffic buttons must be provided.		
3. Show median top of curb elevations at critical points on left-turn lanes. Check median cross-fall.		
4. Provide median pavement and monolithic median noses for left-turn lanes.		
5. Provide typical paving section for left-turn lanes.		
6. Show existing driveways and inlets on both sides of street at all proposed median openings.		
7. Avoid inlets across from median openings.		
8. Provide reverse curve median geometry.		
9. Property ownership must be shown.		

PLAN REVIEW CHECK LIST
Page 4

PART II - WATER/SANITARY SEWER

	ENG.	CITY
1. Show all existing facilities, including public and/or private		
2. Clarify status of existing facilities whether to remain in service, abandon, or remove and by whom.		
3. Add caution notes when construction operations will come close to any facility; give phone # of company to call for assistance in locating.		
4. Show and label existing and proposed water and wastewater mains *(Size and type of pipe)*. Clearly show and label the connection to the system.		
5. Easements for off-site public utilities are executed, filed at the County and document numbers provided. Existing easements shown accurately and labeled. Contact information provided for the owners of private or franchise utilities of each easement shown on the planse.		
6. Water shall be DR14, C900 for 8" and DR18 for 10"-12" pipe. Provide SDR26 for wastewater pipe installed deeper than 14 ft. and at sewer crossings. Minimum pipe size for both water and sanitary sewer is 8".		
7. Verify of proposed water distribution and sanitary sewer systen complies with City's Master Plan.		
8. Loop water lines where possible. Stub-out water and sanitary sewer lines to edge of project for future extensions.		
9. Proposed and existing valves and fire hydrants shown and called out.		
10. Water mains 12" and greater and all sanitary sewer mains to be shown in a profile view. Include all other underground utilities crossings. Water mains shall be shown to be above other utilities.		
11. Wastewater service area map with calculations (onsite & offsite) if determined applicable.		
12. Verify if manholes are not located in gutters or in drainage ways. Provide gaskets and bolted lids and frames for locations prone to flooding.		
13. Manholes shall be 5 ft. in diameter with 30-inch lid frames with gasket and rain stopper pans.		
14. Install manholes at each junction, bend, & at ends of each line (no cleanouts). Stub-outs with no attached services do not require a manhole but should extend to the property line.		
15. Specify and show outside drop connections for all drops over 2 ft. for drop manholes.		
16. Long 6" fire hydrant leads extending 35' in length or is proposed to be under a paved street shall be 8" PVC pipe.		
17. Provide a concrete cap as required for crossings or special conditions.		
18. Include City of Cedar Hill details as part of the full executed constructions set.		
19. Include benchmarks on all plan/profile sheets.		
20. Plan size scale: 1" = 40' horizontal, 1" = 4' vertical (minimum)		
21. Verify if all adjacent parcels are provided water and sanitary sewer service.		
22. A note shall be added on th eplans that the franchise underground utilities crossing water and sanitary sewer mains shall be adequately marked and protected in the trench and shown and labeled in the construction plans.		

	ENG.	CITY
23. A manhole for commercial connection		
24. No trees/large shrubs, irrigation system or signs should be placed right above the W/WW lines .		

PART III - DRAINAGE

A. Drainage Area Map

1. Use proper scale (no smaller than 1":200') for impacted watershed and for creeks offsite and show match lines between any two or more maps.		
2. Show and label existing and proposed storm drains and inlets.		
3. Indicate sub areas for each alley, street and offsite area.		
4. Indicate existing/proposedcontours on map for onsite and offsite clearly.		
5. Use design criteria as shown in design manual.		
6. Indicate zoning on drainage area.		
7. Show points of concentration.		
8. Show calculation table andinclude runoff at all inlets, streets, alleys, etc.		
9. Show runoff calculations including time of concentration.		
10. For cumulative runoff, show calculations.		
11. Indicate all crests, sags and street and alley intersections with flow arrows.		
12. Make sure the outfall is adequate for Q 100-year runoff.		

B. Storm Drains

1. Show plan and profile of all storm drains, including size and capacity.		
2. Specify class pipe.		
3. Provide inlets where street capacity is exceeded. Provide inlets where alley runoff exceeds intersecting street capacity. For major and minor arterials one lane must stay dry in each direction.		
4. Indicate property lines along storm drain and show easements with dimensions.		
5. Indicate proposed ground line and improvements on all street, alley, and storm drain profiles.		
6. Show all hydraulics, velocity head changes, gradients, computations and profile outfall with typical section and computations. Make sure velocities do not exceed the maximum allowed velocities. Also, check velocities of Q 100-year and Q 200-year runoff for erosion,.		
7. Show laterals on trunk profile with stations.		
8. Indicate size of inlet on plan view, lateral size and flow line, paving station and top of curb elevation.		
9. Indicate the runoff concentrating at all inlets and direction of flow. Show runoff for all stubouts, pipes and intakes.		
10. Show future streets and grades where applicable.		
11. No 90 degree turns on storm drains or outfall. Provide junction structure or manhole as required.		
12. Discharge storm drains at the flow line of creeks and channels with proper erosion control devices.		
13. Show 100 year water surface at outfall of storm drain.		
14. Where fill is proposed or trench cut in creeks or outfall ditches, specified compacted fill.		

PLAN REVIEW CHECK LIST

	ENG.	CITY
15. Use Type "Y" or Special "Y" inlets in ditches unless otherwise directed.		
16. Where connections are made to existing storm drain, show computations of existing system, when available.		
17. Manholes need to be at intervals of no greater than 500 feet.		
18. Design for heavier pipes when crossing railroads, deep fill and heavy loads.		
19. Show details of all connection boxes, headwalls on strom drain, flumes or any other item not a standard detail.		
20. Use proper size inlet(s)		
21. Provide lateral profiles for laterals.		
22. Provide headwalls for all storm drains at outfall except sumps.		
23. Intersect laterals at 60 degrees with trunk line, if possible.		
24. Provide curbing in alleys where the capacity is exceeded.		
25. Provide flat grade alleys and streets to discharge into streets.		
26. Check for curbing at all alley turns and "T" intersections. Flatten grades ahead of turns and intersections.		
27. Provide 1.5(VT)**2/2g or 1, whichever is larger, between the gutter of all proposed and existing inlets and hydraulic gradient of trunk line at the lateral connection where VT is the velocity in the trunk line just downstream of the lateral.		
28. Where inlets are placed in alley, provide curbing for 10' on each side of inlet and on other side of alley where the top of inlet elevation is even with high edge of alley pavement.		
29. Use standard curb inlets in streets and alleys. Use recessed inlets in major and/or minor arterial streets. Do not use grate or curb/grate combination inlet unless other solution is n ot available.		
30. Provide 7 1/2" curb on alleys parallel to creek or channel on creek side of alley.		
31. Indicate flow line elevations of storm drains on profile, show percent grade. Match top inside of pipe where adjacent to other size pipe.		
32. Where laterals tie into trunk line, channel or creek, place at 60 degree angle with center lines. Connect them so that the longitudinal centers intersect.		
33. Show data for all storm drains.		
34. Tie storm drain stationing with paving stations.		
35. Do not flow storm water from streets into alleys.		
36. On all dead-end streets and alleys, show grade out for drainage on the profiles and provide erosion control, and proper drainage easement.		
37. Specify concrete strength for all structures.		
38. Where quantities of runoff are shown on plan or profile, indicate storm frequency design.		
39. Use standard curb inlets and laterals. For major and minor arterials, use recessed inlets.		
40. Provide sections for road, railroad and other ditches with profiles and hydraulic computations. Show design water surface on profile.		
41. Do not use high velocities in storm drain design. Refer to Drainage Manual for allowed velocities.		

	ENG.	CITY
42. Inlets must be located at sag points. Minimum size inlet in sag points is 10-foot.		
43. The size of inlets must be as per the Storm Drainage manual.		
44. The minimum pipe slope is 0.30% unless otherwise directed.		
45. Outfall ditch must have adequate capacity to carry the discharge. Provide erosion control facilities with hydraulic data along with the drainage easement as applicable.		
46. When grate inlets have been specifically permitted, capacity criteria shall be adhered to.		
47. Don't use bends for pipe sizes less than 30-inch diameter unless specifically authorized by the Director of Public Works.		
48. Design inlet junction structures with extra depth to prevent submergence of intake.		
49. Any offsite drainage work or discharge to downstream property will require a drainage easement. Submit field notes for applicable drainage easements that may be required.		
50. May need to provide written statement from principal certifying that your company has analyzed the proposed storm drainage outfall effects on the adjoining property owner and that your discharge will not adversely affect or place his property in jeaopardy.		
51. Provide drainage easements from adjoining property owner if post development discharges exceed pre-development rates, and/or if the drainage outfall pattern is changed.		
52. Proposed driveway turnouts must be 10' from any existing or proposed inlet.		
53. Check for Escarpment Area restrictions. If in the escarpment, design in accordance with escarpment ordinance.		
54. All the utility conflicts have been satisfactorily addressed and resolved.		

C. Bridges

1. Clear the lowest member of the deck bridge by two feet above the Q 100-year water surface elevation.		
2. Indicate borings on plans.		
3. Show bridge sections upstream and downstream as well as the bridge itself.		
4. Provide hydraulic calculations on all sections.		
5. Provide structural details and calculations with dead load deflection diagram.		
6. Provide vertical and horizontal alignment.		

D. Creeks and Channels

1. Show stationing in plan and profile.		
2. Indicate flow line, banks, design water surface. Show hydraulic computations.		
3. Indicate erosion control measures/energy dissapators.		
4. Provid drainage area map and show all computations for runoff quantities.		

	ENG.	CITY
5. Provide cross-sections at transitions.		
6. Check velocities for Q 2-year and Q 100-year runoff for erosion, and ensure the velocities do not exceed maximum allowed velocities.		
7. Are access easements provided? Note: Access easements are needed whne any floodway, dentention/retention, or drainage easement do not border a public right-of-way.		

E. Detention/Retention Basins

1. Provide drainage area map and show all computations for runoff affecting the detention basin.		
2. Provide a plan view with existing and proposed contours for the detention basin and plan for structural measures.		
3. Where earth embankment is proposed for impoundment furnish a typical embankment section and specifications for fill; include profile for the structural outflow structure, emergency spillway, including erosion control measures.		
4. Provide structural details and calculations for any item not a standard detail.		
5. Provide detention/retention basin volume calculations and elevation vs. storage curve.		
6. Provide hydraulic calculations for outflow structure and elevation vs. discharge curve.		
7. Provide "Dual Outlet Control Structure" per drainage criteria		

F. Storm Water Pollution Prevention Plan (SWP3) and Erosion Control Plans as applicable

Please note that it is the full responsibility of the developer and/or his engineer to comply with all the current up-to-date rules and regulations of EPA and other applicable federal and state agencies for the preparation of the SWP3. Copies of the operator's NOI as well as the owner's NOI must be submitted to this office as well as Storm Water Management Section of Public Works and Transportation Department.		

"I, the undersigned, am the Engineer of the Record for this project and certify that the information provided herein is correct to the best of my knowledge."

"I understand and agree that the Chief Engineer will require that the infrastructure plans be resubmitted for review and approval if he determines that the checklist contained incorrect information and the plans were approved based on incorrect information supplied.

Signature: _____ *Date:* _____

Printed Name: _____

CITY OF CEDAR HILL – PUBLIC WORKS DEPARTMENT
PLAN REVIEW CHECKLIST FOR DEVELOPMENT PROJECTS

Project Name: _____ Public Wks #: _____

Plans Prepared By: _____ Subdivision Plan: _____

Preliminary Plat (Date): _____ Site Plan: _____

ITEMS RELATED TO CONSTRUCTION DRAWINGS

This is not an all-inclusive checklist. The purpose of this checklist is to expedite the review process by highlighting common areas of concern.

☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	1. Is this property being platted? If yes, has the plat been filed? (A copy of the plat must be attached to the paving, drainage, water & sewer plans)
_____ % _____ %	2. What percent of the site is **currently** impervious? What percent of the site is **proposed** to be impervious?
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	3. Are City benchmarks shown on the plans? **Note**: Small projects need (1) benchmark shown & larger projects need (2) benchmarks shown. If no, were surveyor established benchmarks set?
☐ Yes ☐ No	4. Does the drainage outfall address the 100-year flood?
☐ Yes ☐ No	5. Is the drainage runoff from the site or any portion of the site being diverted to or from another drainage area?
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	6. Is this development within the escarpment? If yes, has an escarpment permit and packet been obtained?
☐ Yes ☐ No	7. Is any part of the area of development being drained into adjacent cities? **Note**: If yes, the engineer of the record must coordinate with the affected City and provide documentation of notification.
☐ Yes ☐ No _____ ft. ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No	8. Are there any retaining walls or fences being proposed? If yes, what is the maximum height of proposed wall/fence? Is the wall/fence in: ☐ Private Property ☐ Public ROW Is there an easement for the retaining wall? Has the drainage been addressed? **Note:** All private retaining walls exceeding 4' in height require a permit from Building Inspections prior to construction.

☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	9. *Is there any proposed screening walls?* *If yes, is the wall obstructing/intruding upon the visibility triangle?* *Is there an easement for the screening wall?*
☐ Yes ☐ No	10. Will the retaining and/or screening wall, as designed, adversely impact drainage?
☐ Yes ☐ No	11. Any utilities crossing the retaining and/or screening wall?
☐ Yes ☐ No	12. Any utilities under the retaining and/or screening wall?
☐ Yes ☐ No ☐ Yes ☐ No	13. Is there any proposed "On-Street-Parking"? If yes, is there any proposed parking space within the visibility triangles?
☐ Yes ☐ No	14. Have you used proper C values, t_c, and I values for the calculation of drainage runoff?
☐ Yes ☐ No ☐ Yes ☐ No	15. Does grading match the drainage area map? Does the drainage area map show clear contours for the entire drainage basin, including off-site drainage areas?
☐ acres	16. What is the total drainage area, including offsite? **Note:** For drainage areas over 600 acres, the Rational Method should not be used for drainage calculations.
☐ Yes ☐ No	17. Is the direction of the runoff shown by arrows, particularly along the areas adjacent to the area being developed? **Note:** Please make sure that the intent for the direction of runoff is shown accurately and clearly on the plans, particularly along the boundaries of the area that is being developed, **otherwise plans will not be reviewed/accepted. Adequate grading information shall be provided to verify the intent of the drainage patterns.**
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	18. Is the development site currently accepting any drainage runoff from adjacent private properties? If yes, are the proposed grades such that the development site continues to receive the drainage runoff from the adjacent private properties? If yes, will there be a proposed stub-out for future development? And, if yes, will there be a drainage easement dedicated? Does the project redirect runoff? **Note:** To grade a development site that existing drainage would be blocked is not allowed. **Note:** Any private drainage easements must be filed by separate instrument and the recording information/documents must be provided to the City and must be shown on the plat and the engineering plans. Public drainage easements can be dedicated as part of the platting process.

☐ Yes ☐ No	19. Is the drainage runoff from this development site currently being conveyed through the adjacent private property(ies) to the downstream?
☐ Yes ☐ No	20. Is hydraulic data for each line segment, pipe size, type, flow, velocity, slope, and HGL provided?
☐ Yes ☐ No	21. Will there be any lot-to-lot drainage post development (regardless of the current drainage pattern)? **Note:** Lot-to-lot drainage is not allowed unless a private drainage easement is obtained and recorded from the downstream property owner.
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	22. Any off-site drainage easements required? If yes, has the offsite easement been acquired, recorded, and information indicated on the plat?
☐ Yes ☐ No	23. Are all on-site drainage easements dedicated and shown on the plat and engineering plan sets?
☐ Yes ☐ No	24. Is there any proposed connection to the storm sewer system that would discharge anything other than rainfall runoff? **Note:** The storm sewer system is primarily for collection of rainfall runoff. Discharging ground water, water fountain features, and anything other than rainfall runoff into the storm sewer system must be disclosed and approved by the Public Works Department.
☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	25. If there is a detention pond proposed, is the design of the pond based on dual outlet control for 100-year and 2-year storm event? Is the emergency spillway properly designed? Is there a private drainage easement for the detention pond? Does the detention pond have a stage, storage discharge table?
☐ Yes ☐ No	26. Regarding erosion, are there velocities of Q100-year and Q2-year runoff at or above the maximum allowed velocities for specified control devices per the City's drainage criteria?
☐ Yes ☐ No	27. Is there any PD or Specific Use Permit (SUP) related to this development?
☐ Yes ☐ No	28. Are there any particular conditions to the PD or SUP regarding sidewalks, paving and/or drainage? If yes, attach a description and list of items.
☐ Yes ☐ No	29. Does the minimum width of pavement(s) and right-of-way comply with the City's Comprehensive Plan and Standard Details?
☐ Yes ☐ No	30. Is the paving section and designed thickness as well as street and alley horizontal alignments and geometrics including curb radii in compliance with the Paving Manual and meets minimum requirements?
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	31. Does this development project require any state and/or federal permits? If yes, have the necessary requirements been incorporated into the construction documents?

☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	32. Is any work proposed within a flood plain? If yes, will there be any fill/alteration done within the flood plain? Status of LOMR letter? ☐ Obtained ☐ In Process ☐ N/A
☐ Yes ☐ No _____ ft. ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	33. Is there any fill proposed within any portion of the site? If yes, what is the maximum depth of the proposed fill? If yes, is this fill going to cause the diversion of storm water runoff? If yes, is this fill going to cause any visibility problem at the driveways or street/alley intersections.
☐ Yes ☐ No _____ ft. ☐ Yes ☐ No ☐ N/A	34. Is there any excavation proposed within any portion of the site? If yes, what is the maximum depth of the proposed excavation? If yes, is this excavation going to cause the diversion of storm water runoff?
☐ Yes ☐ No	35. Has any part of this site ever been part of an environmental impact study (i.e. underground storage tanks, etc.)?
☐ Yes ☐ No	36. Have the plans been distributed to the franchise utilities? **Note:** The engineer of the record must obtain "utility clearance" from all utilities, prior to the start of any construction.
☐ Yes ☐ No ☐ N/A	37. Are trench pavement repairs shown and labeled as either open cut or bore per City Standard Details (if applicable)?
☐ Yes ☐ No	38. Do all the streets have curbs? **Note:** If any driveway approach is proposed along a street where there is no curb, the Engineer of Record needs to design the line and grade and size of pipe under the approach.
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	39. Are sidewalks proposed as part of the submitted plans? If yes, is the proposed sidewalk in compliance with the ADA requirements?
☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	40. Are all proposed sidewalks within dedicated public ROW and/or within a dedicated sidewalk easement? **Note:** Public sidewalks must be built within public ROW or within a dedicated sidewalk easement. Has the "Mutual Access Easement" with the adjacent property owner been worked out? **Note:** It is the responsibility of the developer and/or his representative to inform the adjacent property owners of the development.
☐ Yes ☐ No ☐ N/A	41. Has the Storm Water Pollution Prevention Plan been prepared?

☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A	42. Do plans clearly show signage, street lighting, and striping design (if applicable)? If the plans have street lights, have they been submitted to and received approval from Oncor?
☐ Yes ☐ No ☐ Yes ☐ No ☐ N/A	43. Is there any thoroughfare per the City's Comprehensive Plan adjacent to the proposed development? If yes, are the paving and drainage plans for this thoroughfare included?
WATER & SANITARY SEWER	
☐ Yes ☐ No	44. Are public utility lines adequately sized?
☐ Yes ☐ No	45. Does the water and sanitary sewer layout comply with and reflect the City's water and sanitary sewer master plan?
☐ Yes ☐ No	46. Does the layout provide opportunities for further connections to adjacent properties not currently being served by public water and sanitary sewer facilities?
☐ Yes ☐ No ☐ N/A	47. Are the floodplains and floodway clearly shown and labeled?
☐ Yes ☐ No ☐ N/A	48. Are the water lines looped where applicable?
☐ Yes ☐ No	49. Are all water/sanitary sewer and storm sewer crossings shown and labeled in both plan and profile views?
☐ Yes ☐ No	50. Are all existing water/sanitary sewer facilities shown with their type and size of pipe labeled in both the plan and profile views?
☐ Yes ☐ No	51. Is the connection to the existing system clearly shown and labeled?
☐ Yes ☐ No	52. Is each individual service shown for each lot and tabulated and accounted for?
☐ Yes ☐ No	53. Verify if all adjacent parcels are provided water and sanitary sewer service.
☐ Yes ☐ No ☐ Yes ☐ No	54. Are sanitary sewer manholes out of the drainage ways, gutters, and flumes? Provide gaskets and bolted lids and frames for locations prone to flooding.
☐ Yes ☐ No	55. Manholes shall be 5 ft. in diameter with 30-inch lid frames with gasket and rain stopper pans.
☐ Yes ☐ No ☐ Yes ☐ No	56. Install manholes at each junction, bend, and the ends of each line (no cleanouts). Stub-outs with no attached services do not require a manhole but shall extend to the property line.

☐ Yes ☐ No	57. Specify and show outside drop connections for all drops over 3 ft. for drop manholes.
☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No	58. Have easements for off-site public utilities been executed, filed at the County and document numbers provided? Are the existing easements shown accurately and labeled? Is contact information provided for the owners of private or franchise utilities of each easement shown on the plans?
☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No	59. Water shall be DR14, C900 for 8" and DR18 for 10"-12" pipe. Provide SDR 26 for wastewater pipe installed deeper than 14 ft. and at sewer crossings. Minimum pipe size for both water and sanitary sewer is 8".
☐ Yes ☐ No	60. Proposed and existing valves and fire hydrants are shown and called out.
☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No	61. Water mains 12" and greater and all sanitary sewer mains to be shown in profile view. Include all other underground utilities crossings. Water mains shall be shown to be above other utilities.
☐ Yes ☐ No	62. Wastewater Service Area Map with calculations (onsite and offsite) if applicable.
☐ Yes ☐ No	63. Long 6" fire hydrant leads exceeding 35' in length or is proposed to be under a paved street shall be 8" PVC pipe.
☐ Yes ☐ No	64. Provide a concrete cap as required for crossings or special conditions.
☐ Yes ☐ No	65. Are water lines that are shown in profile view to be installed above storm and sanitary sewer mains?
☐ Yes ☐ No ☐ N/A	66. Does the "Trench Safety Plans" for storm sewer pipes/waterlines and sanitary sewer lines adhere to the requirements of OSHA?
☐ Yes ☐ No ☐ N/A	67. A note shall be added on the plans that franchise underground utilities crossing water and sanitary sewer mains shall be adequately marked and protected in the trench and shown and labeled in the construction plans.
GENERAL	
☐ Yes ☐ No	68. Will you submit, as part of your final submittal, all applicable City Standard Details and General Construction Notes to be included in the plan set? **Note:** A final set of complete plans shall be provided to the City for signature and returned to you for reproduction for distribution per the preconstruction requirements.
☐ Yes ☐ No	69. Include benchmarks on all plan/profile sheets.

☐ Yes ☐ No	70. Plan size scale: 1" = 40' horizontal; 1" = 4' vertical (minimum)
☐ Yes ☐ No	71. Will you confirm that the contractor will contact the City for requirements regarding construction, approved materials, and documents prior to the pre-construction meeting?
☐ Yes ☐ No	72. Are you conforming to Texas Board of Professional Engineer Board Rules 137.33 & 137.77? Board Rules §137.33 and §137.77 have been changed to require that all engineering documents released, issued, and submitted by or for a registered engineering firm, including preliminary documents, must clearly indicate the engineering firm name and registration number. It is both the responsibility of the PE that signs and seals a document and the firm that releases the document to verify that the firm name and number appear on the engineering work.

"I, the undersigned, am the Engineer of the Record for this project and certify that the information provided herein is correct to the best of my knowledge."

"I understand and agree that the Public Works Director will require that the infrastructure plans be resubmitted for review and acceptance if he determines that the checklist contained incorrect information and the plans were accepted based on incorrect information supplied."

"I further understand this is not an all-inclusive checklist and the Director of Public Works may require additional information above and beyond this checklist."

Signature:_____ **Date:** _____

Printed Name:_____

CEDAR HILL

City of Cedar Hill
285 Uptown Blvd. Bldg. 100
Cedar Hill, Texas 75104
972-291-5100
fax 972-291-7250

INFORMATION CHECK LIST for
SITE PLAN REVIEW

The following checklist is provided to assist the plan preparer in submitting an application for SITE PLAN APPROVAL. The plan preparer should consult City of Cedar Hill Zoning Code, Subdivision Regulations, and Public Works Design Manual before submitting an application of Site Plan Approval.

PRE-PLANNING

- Consult with Planning Department with sketch plan before beginning detailed plans.
- **Successfully completed or concurrently submitted Final Plat.**

SUBMITTALS

- **Application form** - Completed & signed along with this checklist.
- **Application fee.**
- **Separate Copy of Verification of Taxes**
- **8 - Sets of SITE PLAN & BUILDING ELEVATIONS** - 24" x 36" blue or black line prints with the following information.

GENERAL

- Scale: 1" = 100' (or larger size) in City approved form graphic scale, as appropriate.
- Bold Title near lower right hand corner with Lot, Block & Addition name, and street address;
- Vicinity or location map, date, north point, graphic scale; and
- Names, address and phone & FAX numbers of the plan preparers, project manager, owner, and applicant.

PROPERTY LAYOUT

- Bearings & Distances of subject property;
- Building lines & easements;
- Lot numbers and block letters;
- Location, size and purpose of easements;
- Horizontal clear triangles at all driveways; and
- 25'x 25' sight visibility & pedestrian easements at arterial intersections.

BUILDING LAYOUT

- Building foot print;
- Distance from property lines & between buildings;
- Minimum Finished Floor Elevations (when adjacent to flood prone areas);
- Gross Floor area of each building; and
- Harmonious design with adjacent property setback.

BUILDING ELEVATIONS

- Building Elevations with exterior facade indicated & percentage of building elevation; and
- Building height and roof slopes indicated.

PARKING LOT LAYOUT

- Parking table indicating the minimum number of parking spaces required vs. provided;
- Parking space design showing - lot layout, number and size of parking spaces, handicapped spaces, & loading zones;
- Parking lot maneuvering showing – fire lanes, curb stops, and pavement material;
- Sidewalks and pedestrian areas, existing & proposed; and
- Note lighting and noise controls, if any, in conformance with City of Cedar Hill Code of Ordinance.

ON-SITE & OFF-SITE CIRCULATION

- Pavement lines, street medians, street intersections, street names, sidewalks, and driveways in the vicinity;
- Proposed driveway locations, widths, curb radii;
- Distances between driveways and between driveways and street intersections; and
- Parking lot maneuvering and firelanes, with dimensions.

GRADING

- Existing topography (2' contours);
- Escarpment Zone, if applicable;
- Generally proposed protection and erosion controls for wind, water, and drainage;
- Proposed protection and erosion controls for water courses or flood prone areas if applicable; and
- Proposed grading.

STREETS and DRAINAGE

- Show existing & proposed street lines, fire lanes, & ROWs;
- Limits of 100 year frequency storm water run-off;
- Boundaries and elevations of flood prone areas as identified on the Flood Insurance Rate Maps (FIRM);
- Areas subject to flooding and areas to be reclaimed;
- Layout and capacity of drainage system, on & off-site;
- Locations of proposed detention / retention areas, inlets, lines, outfalls & other drainage structures; and
- Locations and size of drainage easements.

UTILITIES

- Utility facilities and easements indicating location, type and size; and
- Proposed water & sewer mains and tap size, type and locations

LANDSCAPING

- Location of existing trees 8" in dia. or greater with type & size indicated;
- Location of existing stands of trees or vegetation;
- Indication of trees to be retained vs. removed & a description of the tree removal mitigation.
- Delineate the "street yard" as defined by City of Cedar Hill Code and indicate it's size in square feet;
- Landscape table indicating the minimum amount of land area to be landscaping required vs. provided; (See typical table attached)
- Locate all landscaped area & indicate their square footage;
- Type & size of proposed landscaping (large & ornamental trees, shrubs, ground cover, grass); and
- Note stating that underground irrigation system plans will conform to the City of Cedar Hill Ordinances and will be submitted along with Building Permit applications.

SCREENING

- Trash receptacle areas and recycling areas along with required screening;
- Screening as required by ordinance;
- Vehicle maneuvering area screening;
- Detail of proposed screening walls and fences; and
- Proposed minimization of any negative impacts to adjacent properties.

PLAN PREPARERS ACKNOWLEDGMENT:

I have reviewed the City of Cedar Hill's Codes *and have prepared the attached Site Plan in accordance with these regulations.*

X _____ _____

Plan preparers' signature *Print name & title*

APPENDIX C

City of Cedar Hill
Public Works Department
Traffic Impact Worksheet

This worksheet will help you determine if a Traffic Impact Analysis (T.I.A.) needs to be submitted with your proposed development. **Please read the following paragraphs before filling out this worksheet.**

First, read all of the uses listed in column A and check the box to the right of each use that characterizes the proposed development.
Next, fill in the number of units or gross square footage of each use in column 'C' :

* If the development has a Number of Units, then multiply that number by the Trip Rate (column 'B' times column 'C') and indicate the total in column 'D',
* If the development has a Gross Square Footage, then divide the gross square footage in column 'C' by 1,000, then multiply the result by the Trip Rate in column 'B' and indicated the total in column 'D'.

Finally, total all the trips generated per day to the space at the bottom of column 'D'.

If the total exceeds 1,000 trips per day, then either a Traffic Impact Analysis (T.I.A.) or a Waiver of the T.I.A. is required. Traffic Impact Analysis waivers will be considered on a per case basis by the Director of Public Works.

The developer is obligated to implement the recommended mitigation measures as shown on the T.I.A.

A		B	C	D
Use		**Trip Rates[1]**	**Number of Units/ SQ. FT.**	**Trip Generated**
Lodging	☐	9.11 per room		
Residential				
Single Family	☐	9.57 per dwelling unit		
Other	☐	6.59 per dwelling unit		
Industrial	☐	6.96 per 1,000 gsf		
Office				
Financial Institution w/o drive-in	☐	156.48 per 1,000 gsf		
Financial Institution with drive-in	☐	246.49 per 1,000 gsf		
Other: 10,000 gsf or less	☐	26.59 per 1,000 gsf		
10,001-50,000 gsf	☐	22.64 per 1,000 gsf		
50,000-100,000 gsf	☐	15.58 per 1,000 gsf		
100,001-150,000 gsf	☐	13.27 per 1,000 gsf		
150,001-200,000 gsf	☐	12.08 per 1,000 gsf		
Retail/ Personal Service				
General Merchandise > 3,500 sq.ft.	☐	177.59 per 1,000 gsf		
General Merchandise < 3,500 sq.ft.	☐	863.10 per 1,000 gsf		
Restaurant w/o drive-in	☐	158.37 per 1,000 gsf		
Restaurant with drive-in	☐	722.03 per 1,000 gsf		
Other: 10,000 gsf or less	☐	278.24 per 1,000 gsf		
10,001-50,000 gsf	☐	215.39 per 1,000 gsf		
50,000-100,000 gsf	☐	118.36 per 1,000 gsf		
100,001-150,000 gsf	☐	91.46 per 1,000 gsf		
150,001-200,000 gsf	☐	78.65 per 1,000 gsf		
Church	☐	36.63 per 1,000 gsf		
School (**1.29** Elem., **1.62** JH, **1.71** H.S.)	☐	Per Student @ 22 Student/Class	25 Student/ JH & HS	
Day care	☐	79.26 per 1,000 gsf		
Wholesale/ Distribution/ Storage				
Mini-warehouse	☐	2.50 per 1,000 gsf		
Warehouse	☐	4.96 per 1,000 gsf		
			Total trips generated	

1. All rates are based on ITE Trip Generation Report, 7th edition, November 2003
2. These rates may change based on new data / publications, directional distribution and specific developments.

Applicant	**Phone Number**
Location	**Size (in Acres)**

CITY OF
CEDAR HILL

PUBLIC WORKS DEPARTMENT
WAIVER OF TRAFFIC IMPACT ANALYSIS

Applicant:	Telephone #:
Project Name:	
Lot/Block #:	
Description/Location of Project:	
EXISTING Zoning: ____, Maximum trips/day: _____based on existing Zoning. PROPOSED Zoning: ____, Maximum trips/day: _____based on proposed Zoning.	

The Public Works Department has been requested to determine if a Traffic Impact Analysis (TIA) will be required for this proposed development project. Based on the information provided to us, we have determined that a TIA is not required for the following reason(s):

[ ] The development consists of low/medium density residential uses and will not have a significant impact on the street system.

[ ] The development generates more than 1000 additional trips per day; however, the street system will have sufficient capacity.

[ ] The development generates more than 1000 additional trips per day; however, a previous study provides enough information for us to properly review the request.

COMMENTS:

Public Works Director: _____ Date: _____

[ ] Approved **[ ] Not Approved**

NOTE: This waiver, if approved, is valid for the development projects within 180 days of approval date of the Engineering plans or site plan.

FLOODPLAIN – GRADING PERMIT APPLICATION

CEDAR HILL
PUBLIC WORKS

PERMIT NUMBER:

APPLICATION DATE:_____

PROJECT NAME: _____

APPLICANT: _____ **(phone #**_____**)**

ADDRESS: _____

_____

_____

NAME OF PROPERTY OWNER: _____ **(phone #**_____**)**
ENGINEER: _____ **(phone #**_____**)**
ENGINEER'S FIRM: _____
NAME OF RESPONSIBLE PERSON ON SITE: _____
(phone # _____ **)**

Description of Project:						
Street address						
Legal description	Lot -	Block -	Name of Plat -			
Name of impacted stream						
Total acres in tract		Number of acres in floodplain		Number of acres involve grading		
				Percent (%) acres of floodplain impacted by grading		

Intended Use of Property:			
Development permits and requirements	Zoning change pending?	yes	no
	Has the property been plated?	yes	no
	Grading/Site Plan required and approved?	yes	no
	USACE 404 permit required and approved?	yes	no
	Storm water prevention plan submitted?	yes	no
	CLOMR / LOMRf required?	yes	no
	City R.O.W. permits required and approved?	yes	no

Pertinent Information*:			
Site layout / Grading plans	Existing / proposed floodplain & floodway data provided?	yes	no
	Two set of plans submitted?	yes	no
	Existing and proposed elevations shown and labeled?	yes	no
	Environmental or historical impacts?	yes	no
	Correct scale, north arrow, and vicinity map provided?	yes	no
	Existing and proposed utilities shown and labeled?	yes	no
	City R.O.W. and easements shown and labeled?	yes	no
	Tree mitigation plan and SWPPP included?	yes	no
	FEMA FIRM panel number and zone type included?	yes	no

*See City of Cedar Hill's Design Manual, 902.04-902.09 for complete list of required information.

PERMIT CONDITIONS **PERMIT NUMBER**

- Approval of hydrology & hydraulic analysis and engineering plans
- Contractor shall have engineering plans released for construction authorized by the City before and during construction.
- Adjacent adjoining property owners and downstream property owners shall not be adversely impacted by new flow rate, flow velocities, new flood elevations, erosion and sediment.
- Diversion of runoff shall not be allowed.
- Any adverse erosion and/or sediment impact along the perimeter of the project shall be resolved as soon as possible. Conditions and requirements set forth in the SWPP shall be adhered to.
- Public utilities shall be located and protected from damage by excavation or fill by the contractor.
- Trees designated to remain shall be marked with survey tape and protected as per City ordinance and mitigation/landscape plans.
- Foundations to buildings shall be elevated and subgrade compacted as specified. The building shall be flood proofed to withstand flood depths, pressures, velocities and erosion. The building shall have access to a public roadway and constructed per terms in the building permit.
- Equipment, storage containers, and portable sanitary facilities shall not be placed in a flood zone.
- Finish grading shall flow runoff away from buildings and vertical structures.
- Finish grading shall not impede or trap drainage from adjacent properties.
- Drainage shall flow towards a street, an established natural drainage ways or dedicated drainage easement.

I understand to comply with the City of Cedar Hill's ordinances for floodplains and tree mitigation and protection. Trees shall not be removed until a tree survey has been conducted and approval by the city of Cedar Hill. Grading or the placement of fill shall not be performed until after this permit has been approved. All erosion control measures are installed per plans.

I, the undersigned, I will adhere to the conditions of this permit for this project and certify that the information provided herein is correct to the best of my knowledge.

Signature: _____ **Date:** _____

Printed Name: _____

Title: _____

Owner's Signature: _____ **Date:** _____

Printed Name: _____

To be completed by City of Cedar Hill.

This permit is complete & accepted for construction by:

_____ Date:_____

Engineering Notes: